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Editor: Harvey A. Miller
Department of Biological Sciences
Florida Technological University
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EDITORIAL

THIS issue of the QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES carries a new rubric, FLORIDA SCIENTIST, which is consistent with the contemporary trend to utilize titles which are brief and easily cited. However, more than a title change has been undertaken in production of the journal. Ever higher printing and paper costs have prompted adoption of computer composition for text and enlargement of the type block. These changes do not affect readability but they do make possible presentation of more scientific information in the same number of pages.

The duties of the editor of a scholarly journal are many and demanding of time and dedication. For the past ten years, Dr. Pierce Brodkorb of the University of Florida carried the editorship of our QUARTERLY JOURNAL with selfless dedication before requesting relief from his responsibilities. He has given us a publication which is properly a source of pride for the Academy. Every effort will be made to uphold and enhance the FLORIDA SCIENTIST as we bring the issues up to date over the next few months. Meanwhile, Dr. Brodkorb, we thank you for a job well done and wish you all the best in continuation of your chosen work.—H. A. Miller

BCH FORMULAS IN SUPERFLUID PHYSICS[1]

Robert Gilmore

Department of Physics, University of South Florida
Tampa, Florida 33620

Assume the set of operators $X_1, X_2, \ldots, X_n$ span an n-dimensional linear vector space, and in addition are closed under commutation

$$[X_i, X_j] = c_{ij}{}^k X_k \tag{1}$$

A linear vector space which is also closed under commutation is called a Lie algebra. The operator

$$\mathrm{EXP}\ (\Sigma\ a^i X_i) = \sum_{k=0}^{\infty} \frac{1}{k!} \left(\sum_{i=1}^{n} a^i X_i\right)^k \tag{2}$$

is an element in Lie group.

Many quantum mechanical systems are described by operators which close under commutation. Such systems form Lie algebras, and therefore they can be treated according to well known techniques of Lie algebra theory (Gilmore, 1973). These comments indicate why Lie algebras and Lie groups play such an important role in physical theory.

Now assume Γ is an $r \times r$ matrix representation of the Lie algebra spanned by the X_i. A matrix representation of an algebraic system preserves all of the algebraic properties of the system. For a Lie algebra

$$\Gamma\ (\Sigma\ a^i X_i) = \Sigma\ a^i\ \Gamma(X_i) \tag{3}$$

$$\Gamma([X_i, X_j]) = [\Gamma(X_i), \Gamma(X_j)] = \Gamma(c_{ij}{}^k X_k) = c_{ij}{}^k \Gamma(X_k) \tag{4}$$

A matrix representation of Lie algebra is faithful if

$$\Gamma\ (\Sigma\ a^i X_i) = \Sigma\ a^i\ \Gamma(X_i) = 0 \Rightarrow a^i = 0 \tag{5}$$

for all parameters a^i.

---

[1]Special paper by invitation.

Since Γ $(\Sigma a^i X_i)$ is an $r \times r$ matrix, the $r \times r$ matrix EXP Γ $(\Sigma a^i X_i)$ can be computed explicitly. We write the result symbolically

$$\Gamma\left(e^{\Sigma a^i X_i}\right) = e^{\Gamma(\Sigma a^i X_i)} \tag{6}$$

Within any matrix representation of a Lie algebra, many formulas can be derived relating products of exponential operators taken in various orders. When Γ is faithful, any formula derived in this way is valid for *all* representations. The reason for this is the following: the value of a product of exponential operators depends only on the commutation relations, and on no other properties of a representation.

To illustrate these cryptic remarks, we carry out two examples. In the first, we derive the prototype BCH relation. In the second, we derive a BCH formula of use in a certain model of superfluidity.

EXAMPLE 1: Assume the three operators A, B, C obey the commutation relations

$$[A, B] = C, [C, A] = [C, B] = 0. \tag{7}$$

A faithful matrix representation for these three operators is given in terms of 3×3 matrices by

$$A \rightarrow \Gamma(A) = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad B \rightarrow \Gamma(B) = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{pmatrix} \quad C \rightarrow \Gamma(C) = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \tag{8}$$

By a straight forward exponential expansion it is possible to compute Γ (EXP aA + bB), where a and b are arbitrary parameters:

$$\Gamma\left(e^{aA + bB}\right) = e^{\Gamma(aA + bB)} = \sum_{k=0}^{\infty} \frac{1}{k!} \begin{pmatrix} 0 & a & 0 \\ 0 & 0 & b \\ 0 & 0 & 0 \end{pmatrix}^k \tag{9}$$

All terms in (9) with $k > 2$ vanish. Only the zeroth, first, and second order terms contribute to the sum:

$$e^{\Gamma(aA + bB)} = \begin{pmatrix} 1 & a & \frac{1}{2}ab \\ 0 & 1 & b \\ 0 & 0 & 1 \end{pmatrix} \tag{10}$$

In the same way we compute

$$e^{\Gamma(aA)} e^{\Gamma(bB)} = \begin{pmatrix} 1 & a & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & b \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} 1 & a & ab \\ 0 & 1 & b \\ 0 & 0 & 1 \end{pmatrix} \tag{11}$$

By comparing (10) and (11), we see that

$$e^{\Gamma(aA + bB)} \neq e^{\Gamma(aA)} e^{\Gamma(bB)} \tag{12}$$

However, we can set

$$e^{\Gamma(aA+bB)} = e^{\Gamma(aA)} e^{\Gamma(bB)} e^{\Gamma(X)} \tag{13}$$

where X is a linear combination of the operators A, B, C. It is easily verified that

$$\begin{pmatrix} 1 & a & \frac{1}{2}ab \\ 0 & 1 & b \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} 1 & a & ab \\ 0 & 1 & b \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & -\frac{1}{2}ab \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \tag{14}$$

thus

$$e^{\Gamma(X)} = \begin{pmatrix} 1 & 0 & -\frac{1}{2}ab \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \tag{15a}$$

and

$$\Gamma(X) = \begin{pmatrix} 0 & 0 & -\frac{1}{2}ab \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \tag{15b}$$

Since the representation (8) is faithful, we have the operator identities

$$e^{(aA+bB)} = e^{aA} e^{bB} e^{-\frac{1}{2}[aA,bB]} = e^{-\frac{1}{2}[aA,bB]} e^{aA} e^{bB} \tag{16}$$

$$= e^{\frac{1}{2}[aA,bB]} e^{bB} e^{aA} = e^{bB} e^{aA} e^{\frac{1}{2}[aA,bB]} \tag{17}$$

Example 2: The Lie algebra for the non compact group SU(1, 1) is spanned by three operators J_+, J_-, J_3 with commutation relations

$$\begin{aligned} [J_3, J_\pm] &= \pm J_\pm \\ [J_+, J_-] &= -2J_3 \end{aligned} \tag{18}$$

A faithful representation for this algebra is given by the 2×2 matrices

$$\overset{J_+}{\downarrow}\begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix} \quad \overset{J_-}{\downarrow}\begin{pmatrix} 0 & 0 \\ -1 & 0 \end{pmatrix} \quad \overset{J_3}{\downarrow}\frac{1}{2}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \tag{19}$$

It is useful to "disentangle" the exponential operator EXP $\alpha(J_+ - J_-)$ as follows

$$e^{\alpha(J_+-J_-)} = e^{xJ_+} e^{yJ_3} e^{zJ_-} \tag{20}$$

The evaluation of the parameters x, y, z proceeds easily

$$\begin{aligned} &\mathrm{EXP}\begin{pmatrix} 0 & \alpha \\ \alpha & 0 \end{pmatrix} = \\ &\mathrm{EXP}\begin{pmatrix} 0 & x \\ 0 & 0 \end{pmatrix} \quad \mathrm{EXP}\begin{pmatrix} y/2 & 0 \\ 0 & -y/2 \end{pmatrix} \quad \mathrm{EXP}\begin{pmatrix} 0 & 0 \\ -z & 0 \end{pmatrix} \end{aligned} \tag{21}$$

$$\begin{aligned} \begin{pmatrix} \cosh\alpha & \sinh\alpha \\ \sinh\alpha & \cosh\alpha \end{pmatrix} &= \begin{pmatrix} 1 & x \\ 0 & 1 \end{pmatrix} \begin{pmatrix} e^{y/2} & 0 \\ 0 & e^{-y/2} \end{pmatrix} \begin{pmatrix} 1 & 0 \\ -z & 1 \end{pmatrix} \\ &= \begin{pmatrix} e^{y/2} - xze^{-y/2} & xe^{-y/2} \\ -ze^{-y/2} & e^{-y/2} \end{pmatrix} \end{aligned} \tag{22}$$

The matrix equation easily allows us to compute the functions $x(\alpha)$, $y(\alpha)$, $z(\alpha)$. The BCH formula that results is

$$\mathrm{EXP}\ \alpha(J_+ - J_-) = \mathrm{EXP}\ \tanh\alpha J_+\ \mathrm{EXP}(-2\ln\cosh\alpha)J_3\ \mathrm{EXP} - \tanh\alpha J_- \tag{23}$$

This result has been derived within the 2×2 matrix representation of SU(1, 1). This representation is faithful. Therefore this formula is valid in *any* representation of SU(1, 1).

THE FOLDY MODEL OF A SUPERFLUID—We turn our attention now to superfluid systems. A system containing a total of N bosons interacting weakly with each other can be described by a model hamiltonian of the form (Bassichis and Foldy, 1964)

$$H = H'_o + H'_{pert}$$

$$H'_o = \sum_k \varepsilon_k b_k^\dagger b_k \qquad \varepsilon_k = \frac{\hbar^2 k^2}{2m}$$

$$H'_{pert} = \tfrac{1}{2}\sum_k \sum_{p,q} V_k\, b^\dagger_{p+k}\, b^\dagger_{q-k}\, b_p\, b_q \tag{24}$$

Here, H'_o describes the kinetic energy of the non-interacting bosons. The term $\varepsilon_k = \hbar^2 k^2/2m$ is the kinetic energy of a boson with momentum $\hbar k$ in mode k. The perturbation term H'_{pert} describes the scattering of two bosons out of the momentum states (p, q) and into the momentum states (p+k, q-k). The creation and annihilation operations obey the usual commutation relations:

$$[b_p, b_q^\dagger] = \delta_{p,q} \tag{25}$$

This scattering proceeds through an interaction potential V(x) whose Fourier components are V_k. We will also assume $V_k = V_{-k}$.

In a superfluid system the k = 0 state is macroscopically occupied at the expense of states with k ≠ 0. We therefore linearize the hamiltonian H under the following two assumptions (Solomon, 1971):

1. the operators $b_o^\dagger$, b_o can be replaced by the number $N_o^{1/2}$, where $N_o = \langle b_o^\dagger\, b_o\rangle$;
2. terms higher than quadratic in operators $b_k^\dagger$, b_k $(k \neq 0)$ may be neglected.

Under these two simplifying assumptions the hamiltonian becomes

$$H = \tfrac{1}{2}V_0 N_0^2 + \Sigma' \, (\varepsilon_k + N_0 V_k + N_0 V_0) b_k^\dagger b_k$$

$$+ \tfrac{1}{2}\Sigma' N_0 V_k (b_k^\dagger b_{-k}^\dagger + b_k b_{-k}) \qquad (26)$$

In these expressions, Σ' indicates the summation excludes the case $k = 0$. The occupation number N_0 in the ground state can be replaced by the total number N of bosons present using

$$N = N_0 + \Sigma' b_k^\dagger b_k \qquad (27)$$

Within the terms of the approximation above the hamiltonian can be expressed

$$H = \tfrac{1}{2}V_0 N^2 + \Sigma' \, (H_0)_k + \Sigma' \, (H_{pert})_k$$

$$(H_0)_k = (\varepsilon_k + NV_k) b_k^\dagger b_k$$

$$(H_{pert})_k = \tfrac{1}{2}NV_k (b_k^\dagger b_{-k}^\dagger + b_k b_{-k}) \qquad (28)$$

Aside from the constant term, the hamiltonian is the direct sum of single mode hamiltonians, each of which has the form

$$H = (\varepsilon + NV) \; (b_+^\dagger b_+ + b_-^\dagger b_-) + NV(b_+^\dagger b_-^\dagger + b_+ b_-) \qquad (29)$$

We have been careful to include terms with both +k and −k into a single k mode. In addition, k has been dropped as a subscript.

As a result, the wave function $|\psi\rangle$ is a direct product of single mode wave functions $|\psi_k\rangle$:

$$|\psi\rangle = \prod_k |\psi_k\rangle \qquad (30)$$

Spectrum Generating Algebra of the Superfluid Hamiltonian—Four kinds of bilinear products of creation and annihilation operators involving opposite momenta modes appear in the single mode hamiltonian (29). These bilinear products can be succinctly summarized using a 1×2 matrix M =

$= b_+, b_-^\dagger$:

$$M^\dagger M = \begin{pmatrix} b_+^\dagger \\ b_- \end{pmatrix} (b_+, b_-^\dagger) = \begin{pmatrix} b_+^\dagger b_+ & b_+^\dagger b_-^\dagger \\ b_- b_+ & b_- b_-^\dagger \end{pmatrix} \qquad (31)$$

We identify the physical operator $b_+^\dagger b_-^\dagger$ which creates an excited pair of bosons in opposite momenta modes with the mathematical operator J_+

$$J_+ = b_+^\dagger b_-^\dagger$$

$$J_- = J_+^\dagger = b_- b_+ = b_+ b_-$$

$$[J_+, J_-] = [b_+^\dagger b_-^\dagger, b_+ b_-] = -(b_+^\dagger b_+ + b_- b_-^\dagger) = -2J_3 \tag{32}$$

The operators J_3, $J_\pm$ obey the su(1, 1) commutation relations

$$[J_3, J_\pm] = \pm J_\pm$$

$$[J_+, J_-] = -2J_3 \tag{33}$$

It is useful to define the following hermitian linear combinations:

$$J_1 = \tfrac{1}{2}(J_+ + J_-) = \tfrac{1}{2}(b_+^\dagger b_-^\dagger + b_+ b_-)$$

$$J_2 = -\frac{i}{2}(J_+ - J_-) = \frac{1}{2i}(b_+^\dagger b_-^\dagger - b_+ b_-)$$

$$J_3 = \quad = \tfrac{1}{2}(b_+^\dagger b_+ + b_-^\dagger b_- + 1) \tag{34}$$

These hermitian operators have the commutation relations

$$[J_3, J_1] = iJ_2$$

$$[J_3, J_2] = -iJ_1 \qquad J_k^\dagger = +J_k$$

$$[J_1, J_2] = -iJ_3 \tag{35}$$

The one remaining independent operator that can be formed from the operators appearing in (31) is the difference operator

$$\Delta = b_+^\dagger b_+ - b_-^\dagger b_- = \Delta^\dagger$$

$$[J, \Delta] = 0 \tag{36}$$

Since the operator Δ commutes with the J_k, it is:

1. Mathematically, an invariant which will serve to label the unitary representations of SU(1, 1).
2. Physically, a constant of the motion.

ALGEBRAIC SOLUTION OF THE SUPERFLUID HAMILTONIAN—The single mode hamiltonian (29) can be expressed as a linear superposition of the elements J_1, J_3 in the su(1, 1) Lie algebra:

$$H = 2NV\{\mu J_3 - \tfrac{1}{2}\mu + J_1\} \qquad \mu = \frac{\varepsilon+NV}{NV} \tag{37}$$

One of these two generators can be eliminated by applying the unitary transformation $U(\theta) = e^{+i\theta J_2}$ to this hamiltonian using

$$e^{i\theta J_2}\begin{pmatrix} J_1 \\ J_3 \end{pmatrix} e^{-i\theta J_2} = \begin{pmatrix} \cosh\theta & -\sinh\theta \\ -\sinh\theta & \cosh\theta \end{pmatrix}\begin{pmatrix} J_1 \\ J_3 \end{pmatrix} \tag{38}$$

The transformed hamiltonian is

$$U(\theta)HU^{-1}(\theta) = 2NV\{(\mu\cosh\theta - \sinh\theta)J_3 + (-\mu\sinh\theta + \cosh\theta)J_1\} - (\varepsilon+NV) \tag{39}$$

By a suitable choice of θ, either J_3 or J_1 can be eliminated from the equation.

Recall that $\varepsilon = \hbar^2k^2/2m>0$. Therefore

1. Attractive potential, $V<0$:

$$\tanh\theta = \mu;\ U(\theta)HU^{-1}(\theta) = 2NV\ \mathrm{sech}\,\theta\ J_1-(\varepsilon+NV) \tag{40}$$

2. Repulsive potential, $V>0$:

$$\tanh\theta = \frac{1}{\mu};\ U(\theta)HU^{-1}(\theta) = 2NV\ \mathrm{csch}\,\theta\ J_3-(\varepsilon+NV) \tag{41}$$

The infinitesimal generators J_1 and J_3 generate subgroups conjugate to SO(1, 1) and U(1), respectively. Since J_1 is a non-compact generator, it has a continuous spectrum. On the other hand, J_3 generates a compact subgroup, and therefore has a discrete spectrum. As a result, there is an energy gap between the ground and first excited state in the second case ($V>0$), which is responsible for macroscopic condensation into the ground state with concomitant superfluidity.

In the superfluid case with hamiltonian proportional to J_3, a lowest lying state must exist which obeys

$$b_+b_-\left|{? \atop \text{gnd}}\right\rangle = 0 \tag{42}$$

The hamiltonian eigenstates must belong to a space which carries a semi-bounded. (Solomon, 1971; Miller, 1968; Vilenkin, 1968) unitary irreducible representation of SU(1, 1): $\uparrow j +$

These representations are characterized by the eigenvalue j(j + 1) of the Casimir operator

$$\zeta_2 = J_3^2 - J_2^2 - J_1^2 \qquad [H, \zeta_2] = 0 \tag{43}$$

Since ζ_2 commutes with the Hamiltonian, it must be related to the difference operator Δ , which also commutes with H , and j is given by

$$j = -\frac{1}{2}|\Delta| - \frac{1}{2} \tag{44}$$

The effect of the diagonal generator J_3 and the shift operators $J_\pm$ on the basis vectors $\left| \begin{matrix} j \\ n \end{matrix} \right\rangle$ is given by

$$J_+ \left| \begin{matrix} j \\ n \end{matrix} \right\rangle = \left| \begin{matrix} j \\ n+1 \end{matrix} \right\rangle \sqrt{(n+1)\ (n-2j)}$$

$$J_- \left| \begin{matrix} j \\ n \end{matrix} \right\rangle = \left| \begin{matrix} j \\ n-1 \end{matrix} \right\rangle \sqrt{n(n-2j-1)}$$

$$J_3 \left| \begin{matrix} j \\ n \end{matrix} \right\rangle = \left| \begin{matrix} j \\ n \end{matrix} \right\rangle (n-j) \qquad n = 0,1,2,\ldots \tag{45}$$

The energy eigenstates of the superfluid hamiltonian are

$$E_n = (2n+1+|\Delta|)E - (\varepsilon+NV)$$

where

$$E^2 = (\varepsilon+NV)^2 - (NV)^2 \tag{46}$$

The eigenstates of the hamiltonian (41) are

$$U(\theta)|\psi_n\rangle = \left| \begin{matrix} j \\ n \end{matrix} \right\rangle$$

$$|\psi_n\rangle = U^{-1}(\theta) \left| \begin{matrix} j \\ n \end{matrix} \right\rangle \tag{47}$$

In particular, the ground state of (41) is the coherent state (Arecchi, et al., 1972) obtained by setting n=0.

The ground state is constructed most easily by applying the BCH formula (23):

$$\left| \begin{matrix} j \\ \text{gnd} \end{matrix} \right\rangle = U^{-1}(\theta) \left| \begin{matrix} j \\ n=0 \end{matrix} \right\rangle$$

$$= e^{-\frac{\theta}{2}(J_+ - J_-)} \left| \begin{matrix} j \\ 0 \end{matrix} \right\rangle$$

$$= e^{-\tanh\frac{\theta}{2} J_+} \, e^{-2\ln\cosh\frac{\theta}{2} J_3} \, e^{\tanh\frac{\theta}{2} J_-} \left| \begin{matrix} j \\ 0 \end{matrix} \right\rangle \qquad (48)$$

Since

$$J_- \left| \begin{matrix} j \\ 0 \end{matrix} \right\rangle = 0$$

$$e^{\tanh\frac{\theta}{2} J_-} \left| \begin{matrix} j \\ 0 \end{matrix} \right\rangle = 1 \left| \begin{matrix} j \\ 0 \end{matrix} \right\rangle \qquad (49)$$

Since

$$J_3 \left| \begin{matrix} j \\ 0 \end{matrix} \right\rangle = (-j) \left| \begin{matrix} j \\ 0 \end{matrix} \right\rangle$$

$$e^{-2\ln\cosh\frac{\theta}{2} J_3} \left| \begin{matrix} j \\ 0 \end{matrix} \right\rangle = e^{2j\ln\cosh\frac{\theta}{2}} \left| \begin{matrix} j \\ 0 \end{matrix} \right\rangle$$

$$= \left| \begin{matrix} j \\ 0 \end{matrix} \right\rangle \{\cosh\tfrac{\theta}{2}\}^{2j} \qquad (50)$$

The single mode ground state is therefore

$$\left| \begin{matrix} j \\ \text{gnd} \end{matrix} \right\rangle = \{\cosh\tfrac{\theta}{2}\}^{2j} \, e^{-\tanh\frac{\theta}{2} b_+^\dagger b_-^\dagger} \left| \begin{matrix} j \\ 0 \end{matrix} \right\rangle$$

$$\tanh\theta = \frac{NV}{\varepsilon + NV} \qquad (51)$$

The ground state of (26) is a direct product of single mode ground states (30), each of the form (51).

GENERATING FUNCTIONS FOR EXPECTATION VALUES—It is at times desirable to compute matrix elements of the form

$$\left\langle \theta' \right| (J_+)^k \left| \theta \right\rangle \tag{52}$$

where

$$\left| \theta \right\rangle = \{\cosh\tfrac{\theta}{2}\}^{2j}\, e^{-\tanh\frac{\theta}{2} J_+} \left| \begin{matrix} j \\ 0 \end{matrix} \right\rangle$$

$$\left\langle \theta' \right| = \{\cosh\tfrac{\theta'}{2}\}^{2j} \left\langle \begin{matrix} j \\ 0 \end{matrix} \right| e^{-\tanh\frac{\theta'}{2} J_-} \tag{53}$$

These can be computed easily by taking the k-th derivative of a particular generating function (Arecchi, et al., 1973; Gilmore, 1972):

$$\left\langle \theta' \right| (J_+)^k \left| \theta \right\rangle = \left(\frac{d}{d\alpha}\right)^k \left\langle \theta' \right| e^{\alpha J_+} \left| \theta \right\rangle \Big|_{\alpha=0} \tag{54}$$

In particular, the generating function

$$f(\alpha,\beta,\gamma) = \left\langle \theta' \right| e^{\alpha J_+ + \beta J_- + \gamma J_3} \left| \theta \right\rangle \tag{55}$$

contains a great deal of information.

This generating function is, moreover, easy to compute, for

$$f(\alpha,\beta,\gamma) = \{\cosh\tfrac{\theta'}{2}\}^{2j} \{\cosh\tfrac{\theta}{2}\}^{2j}$$

$$\times \left\langle \begin{matrix} j \\ 0 \end{matrix} \right| e^{-\tanh\frac{\theta'}{2} J_-} e^{(\alpha J_+ + \beta J_- + \gamma J_3)} e^{-\tanh\frac{\theta}{2} J_+} \left| \begin{matrix} j \\ 0 \end{matrix} \right\rangle \tag{56}$$

The operator product within the bracket can be disentangled within the faithful 2×2 nonunitary representation:

$$e^{-\tanh\frac{\theta'}{2} J_-} \; e^{\alpha J_+ + \beta J_- + \gamma J_3} \; e^{-\tanh\frac{\theta}{2} J_+}$$

$$\downarrow \qquad \downarrow \qquad \downarrow$$

$$\begin{pmatrix} 1 & 0 \\ \tanh\frac{\theta'}{2} & 1 \end{pmatrix} \begin{pmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{pmatrix} \begin{pmatrix} 1 & -\tanh\frac{\theta}{2} \\ 0 & 1 \end{pmatrix}$$

$$= \begin{pmatrix} 1 & x' \\ 0 & 1 \end{pmatrix} \begin{pmatrix} \frac{1}{z} & 0 \\ 0 & z \end{pmatrix} \begin{pmatrix} 1 & 0 \\ -x & 1 \end{pmatrix} \qquad (57)$$

The matrix elements $m_{ij}(\alpha,\beta,\gamma)$ are functions of the parameters α,β,γ, but it is generally not wise to evaluate them explicitly until they are needed. From this equality we find

$$z = m_{22} + \tanh\frac{\theta'}{2} m_{12} - m_{21}\tanh\frac{\theta}{2} - \tanh\frac{\theta'}{2} m_{11}\tanh\frac{\theta}{2} \qquad (58)$$

The values of x,x′ are unimportant. Using the BCH relation derived from (57) and (58) in (56), we find

$$f(\alpha,\beta,\gamma) = \{\cosh\frac{\theta'}{2} \cosh\frac{\theta}{2}\}^{2j}$$

$$\left(\left\langle {j \atop 0} \right| e^{x'J_+} \right) e^{-2\ln z\, J_3} \left(e^{xJ_-} \left| {j \atop 0} \right\rangle \right)$$

$$= \{\cosh\frac{\theta'}{2} \cosh\frac{\theta}{2}\}^{2j} \left\langle {j \atop 0} \right| e^{-2\ln z\, J_3} \left| {j \atop 0} \right\rangle$$

$$= \{\cosh\frac{\theta'}{2} \cosh\frac{\theta}{2}\}^{2j} (z)^{2j} \qquad (59)$$

From this generating function we easily compute

$$\left\langle \theta' \middle| (J_-)^k \middle| \theta \right\rangle = \left(\frac{d}{d\beta}\right)^k f(0,\beta,0) \Big|_{\beta=0}$$

$$= \left\{\cosh \frac{\theta'}{2} \cosh \frac{\theta}{2}\right\}^{2j} \left(\frac{d}{d\beta}\right)^k \left\{1-(-\beta)\tanh \frac{\theta}{2} - \tanh \frac{\theta'}{2} \tanh \frac{\theta}{2}\right\}^{2j}$$

$$= \left(\cosh \frac{\theta'}{2} \sinh \frac{\theta}{2}\right)^k \frac{\Gamma(2j+1)}{\Gamma(2j+1-k)} \{IN\}^{2j-k} \qquad (60)$$

$$IN = \cosh \frac{\theta'}{2} \cosh \frac{\theta}{2} - \sinh \frac{\theta'}{2} \sinh \frac{\theta}{2} \qquad (61)$$

In deriving this result we have used

$$\begin{pmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{pmatrix} \xrightarrow{\alpha,\gamma=0} \begin{pmatrix} 1 & 0 \\ -\beta & 1 \end{pmatrix} \qquad (62)$$

By similar simple means we find

$$\left\langle \theta' \middle| (J_+)^k \middle| \theta \right\rangle = \left\{\sinh \frac{\theta'}{2} \cosh \frac{\theta}{2}\right\}^k \frac{\Gamma(2j+1)}{\Gamma(2j+1-k)} \{IN\}^{2j-k} \qquad (63)$$

These results remain valid for *any* physical system whose spectrum generating algebra is su(1, 1).

SUMMARY—A general mechanism has been presented for constructing BCH formulas, or disentangling theorems, for Lie groups with a faithful matrix representation. As an example of this procedure, two BCH formulas were constructed explicitly, one for the harmonic oscillator algebra, another for the Lie group SU(1,1). The second of these was then used in the Foldy model of a superfluid system to construct ground state wave functions and generating functions for the matrix elements of the operators J_+, J_-, and J_3.

CONCLUSIONS—The methods presented in this work are applicable to a much wider spectrum of problems than just the Foldy model of a superfluid. A very large class of physical problems can be described by the SU(1,1) spectrum-generating non-symmetry group. The generating function (59) is valid for all such systems.

Any hamiltonian which is a polynomial in a finite number of fermion operators, or which contains up to quadratic terms in boson operators for a finite number of modes, can be expressed as an element in some finite dimensional Lie algebra with a finite dimensional faithful matrix representation, and can therefore be solved by these techniques.

BCH relations for such algebras can be constructed with ease. Assume A, B, C are $n \times n$ matrices in a Lie algebra obeying a matrix BCH relation

$$e^{A} = e^{B} e^{C}$$

Let b be the $n \times 1$ matrix of boson operators $\mathrm{col}(b_1, b_2, \ldots, b_n)$. Then the following operator BCH relation is also valid

$$\left(\sinh \frac{\theta'}{2}, \cosh \frac{\theta'}{2} \right) \begin{pmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{pmatrix} \begin{pmatrix} -\sinh \frac{\theta}{2} \\ \cosh \frac{\theta}{2} \end{pmatrix}$$

All generating functions analogous to (59) can be expressed in a very simple and elegant (Arecchi et al., 1973) form. For example. $f(\alpha,\beta,\gamma)(59)$ is the 2j-th power of the 1×1 matrix

$$e^{b^{\dagger} A b} = e^{b^{\dagger} B b} e^{b^{\dagger} C b}$$

LITERATURE CITED

ARECCHI, F. T., E. COURTENS, R. GILMORE, AND H. THOMAS. 1972. Atomic coherent states in quantum optics. Phys. Rev. A6: 2211-2237.

———, R. GILMORE, AND D. M. KIM. 1973. Coherent states for r-level atoms. Lett. Nuovo Cimento 6:219-223.

BASSICHIS, W. H., AND L. L. FOLDY. 1964. Analysis of the Bogoliubov method applied to a simple boson model. Phys. Rev. 113A: 935-943.

GILMORE, R. 1972. Geometry of symmetrized states. Ann. Phys. N. Y. 74: 391-463.

———. 1974. Lie Groups, Lie Algebras, and Some of Their Applications. Wiley. New York.

MILLER, W., JR. 1968. Lie Theory and Special Functions. Academic Press. New York.

SOLOMON, A. I. 1971. Group theory of superfluidity. J. Math. Phys. 12: 390-394.

VILENKIN, N. J. 1968. Special Functions and the Theory of Group Representations. Amer. Mathematical Soc. Providence, R.I.

Florida Sci. 36(1):2-15. 1973.

THE ROLE OF THE AQUATIC EXCHANGE OF CARBON DIOXIDE IN THE ECOLOGY OF THE WATER HYACINTH (EICHHORNIA CRASSIPES)

GORDON R. ULTSCH AND DAVID S. ANTHONY
Departments of Zoology and Botany, University of Florida, Gainesville, Florida 32601

ABSTRACT: *Levels of dissolved carbon dioxide under the mats formed by the floating water hyacinth* (Eichhornia crassipes) *were found to reach levels as high as 60 mmHg. Field data suggest that carbon dioxide is being removed from the water in the daytime by the extensive root system of the water hyacinths and might be available for photosynthesis. Experiments with ^{14}C-labeled bicarbonate verify that the water hyacinth is capable of fixing dissolved carbon dioxide, and this source probably accounts for at least 10% of the total carbon fixed by this plant.*

THE WATER HYACINTH (*Eichhornia crassipes)* is a world wide aquatic weed pest that is noted for its rapid vegetative reproduction (Holm, *et al*, 1969). While definitive data are lacking, most investigators agree that the rate of vegetative growth and reproduction is enormous. Penfound and Earle (1948) found a doubling rate of about two weeks, and extrapolated this rate to state that 10 plants could cover an acre of water in one growing season.

We have measured high levels of dissolved carbon dioxide under mats formed by floating water hyacinths and have determined that the water hyacinths are able to utilize some of this aquatic carbon for photosynthesis. We suggest that this mechanism may partially account for the rapid growth rate of water hyacinths.

Field studies were conducted near Payne's Prairie in Gainesville, Alachua County, Florida. Water samples taken from the surface (upper 5 cm) and the bottom (lower 5 cm) of a hyacinth-covered pond, in areas averaging approximately 60 cm in depth, were transported in an ice chest to the laboratory for analysis of dissolved carbon dioxide with a Radiometer PHA 27 pH meter and Gas Monitor. Figure 1 shows the results over a one-year period. The growing season for water hyacinths in Gainesville is March-October, and the average daily concentrations of dissolved carbon dioxide for that period are 63 ppm for the bottom and 39 ppm for the surface. Expressed in units of mmHg, these rates are 32 and 20, respectively, as opposed to only 0.2-0.3 mmHg CO_2 found in the atmosphere.

Billings and Godfrey (1967) found that hollow-stemmed plants were able to utilize carbon dioxide that accumulated in the stem as an additional carbon source for photosynthesis. The high partial pressures of CO_2 attained in the hyacinth mat during the growing season suggested to us that this additional carbon source might be available to the plant, and partially responsible for the rapid growth rates of water hyacinths. About 50% of the weight of water hyacinths used in this study was represented by the extremely finely divided root mass that projected some 25-50 cm below the water surface, while the floating green part of the plant projected about 20 cm into the air. This situation provides the water hyacinth with an opportunity to be a bimodal gas exchanger, utilizing both air and water.

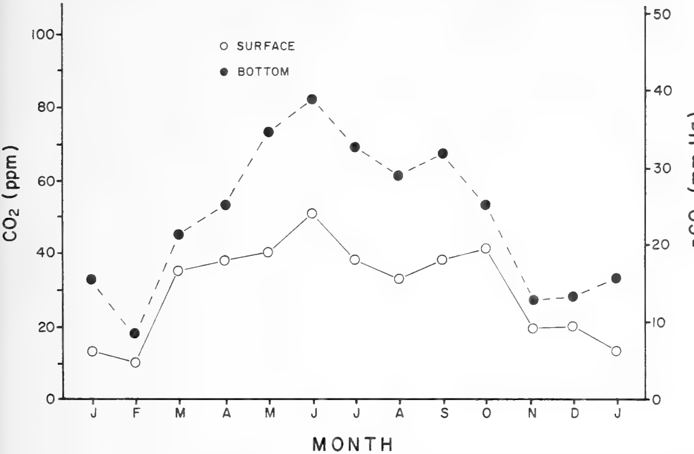

Fig. 1. Concentrations of dissolved carbon dioxide at the surface and bottom of a pond covered by water hyacinths expressed as the average level for a 24-hr sunny day for each month of the year.

The levels of dissolved CO_2 in the water hyacinth community are compared with a euthrophic open water area of the same pond (congested with *Ceratophyllum* growing completely throughout the water column) as a function of the time of day (Fig. 2). Two possible explanations could account for the loss of carbon dioxide in the mat during the daytime. One is that a rise in surface temperature helps drive off the dissolved carbon dioxide, increasing the top to bottom gradient and thus the rate of diffusion from the water column to the atmosphere. The other is that there is uptake of carbon dioxide by the hyacinth roots during the daytime. Temperatures taken during July with the profile data showed a 5°C top to bottom difference for midday in hyacinths intermediate between "thin" and "thick." However, most of the temperature change occurred at the upper levels of the profile, and as soon as the root complex was encountered (at about 10 cm) temperatures became relatively constant from there to the bottom. The mat therefore serves as an effective insulator against thermal changes. When this fact is considered with the very high solubility of carbon dioxide in water (the observed values are far below saturation), it seems unlikely that the driving off of the gas by thermal effects alone can account for the daily losses shown. Some of the loss must be due to uptake of dissolved CO_2 by the hyacinths. Shading by the hyacinths eliminates photosynthetic uptake by other plants as a factor of any major importance.

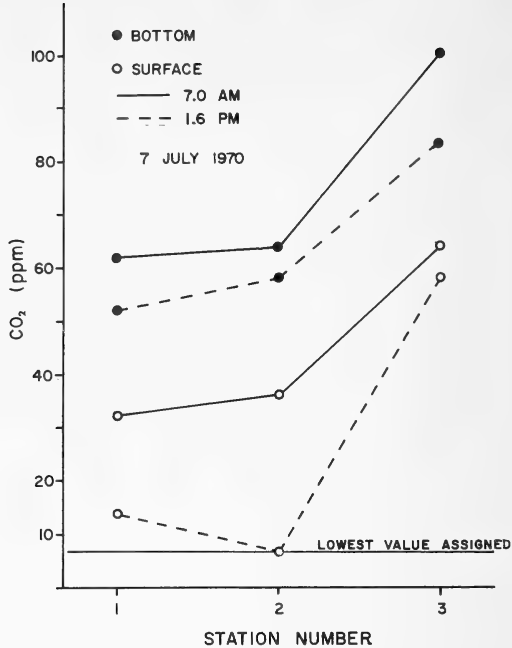

Fig. 2. Sunrise and midday carbon dioxide levels at the surface (upper 5 cm) and bottom (lower 5 cm) of pond containing open water and water covered by water hyacinths. Station one is open water congested with *Ceratophyllum* throughout the water column; station two is an area covered with water hyacinths about 15-25 cm tall, with no peat accumulation in the root mass, and some light penetration to the water surface ("thin" hyacinths); station three is the more common mature water hyacinth mat, with plants 30 cm or taller above the water surface, denser packing, considerable peat accumulation in the root mass, and which allows little or no direct sunlight to reach the water surface ("thick" hyacinths). The line labeled "lowest value assigned" refers to the lower limit of detection of dissolved CO_2 with the instrumentation used.

Assuming that the plant does utilize some of the dissolved carbon dioxide in the water, there are three ways that the CO_2 could be available to it. The first is by loss of CO_2 from the surface waters following the gradient from bottom to surface shown in Fig. 1, with subsequent fixation of CO_2 by the aerial green parts of the plant. Allen, Jensen and Lemon (1971) have simulated plant responses to carbon dioxide enrichment under field conditions and calculated that a terrestrial plant must receive about 100-200 $kgCO_2/ha/hr$ from the soil to show an appreciable increase in photosynthetic uptake of carbon dioxide. Assuming a $pCO_2 = 40$ mmHg at the surface of the mat, a calculation based on Stumm and Morgan (1970) and an experiment we conducted using beakers with CO_2 enriched water left open to the atmosphere indicate that no more than 10 kgCO_2/ha/hr are given off from the water. The work of these authors would suggest that such levels of CO_2 enrichment to the atmosphere would have negligible effect upon photosynthetic uptake by the green portion of the plant. The second means by which dissolved carbon dioxide could be available to the plant is by means of transport with transpired water. Hyacinths have been reported to transpire at a rate about three times the evaporation from a free-water surface, and rates may be as high as 7.8 times free-surface rates (Holm, *et al.*, 1969). The rate for hyacinths in this study pond was determined to be 60 gH_2O/m^2/hr of daylight (Lugo, Ultsch, Brinson and Kane, in preparation). For a pCO_2 of 40 mmHg, the amount of carbon in the transpired water is 1.2×10^{-3} *gC/m²*/hr. Field fixation rates for hyacinths are about 0.4 gC/m^2/hr. Therefore, even if all of the dissolved CO_2 in the transpired water fixed, it would amount to less than 1% of the total fixed carbon. The third method of providing CO_2 from the water to the plant is direct diffusion through the lacunar systems of the plant. Since hyacinths are about 96% water, and the petioles exhibit a high degree of porosity, and the roots provide tremendous plant-water interface, this avenue for CO_2 diffusion could be very important.

To test this last possibility, determinations of carbon uptake by the roots were made utilizing labeled CO_2 derived from bicarbonate. Six plants were each floated in a container with 3000 ml of boiled well water (pH 5.5-6.3) containing dissolved carbon dioxide at 39 mmHg and with the tops in the open air. The surface of the water was covered with a 1-cm layer of mineral oil to inhibit loss of dissolved CO_2 by diffusion, and the plants were arbitrarily divided into two groups of three jars each. In addition, three control jars with water, $NaH^{14}CO_3$, and oil but no plant, were used. Labeled carbon was placed in all containers by adding 0.7 μCi of $NaH^{14}CO_3$ to each. Total dissolved CO_2 was measured with the Radiometer gas electrode. After 120 hours outdoors, the pCO_2 and ^{14}C levels of the water in each container were again measured. Fixed ^{14}C in the plants was determined by alcoholic extraction of soluble components with a technique similar to that of Humphreys and Garrard (1964). The finely ground insoluble residue was filtered and counted directly on the filter paper. All samples were corrected for quenching by the use of internal standards.

The results of the experiments are summarized in Table 1 for each group of three plants and for the 3 controls. Also included in the table are the data for the partitioning of CO_2 exchanges. Both groups of experimental plants fixed similar percentages (8.3 and 7.2) of the original ^{14}C, a majority being recovered in the large petioles. Since all of the original $^{14}CO_2$ was not lost, expressing the fixation as a percentage of $^{14}CO_2$ that was lost results in a higher value (up to 14.4%) and is a better measure of the ability of the plants to fix aqueous carbon dioxide.

The movements of CO_2 (as ccCO_2) are partitioned in Table 1 as follows:

I—D—F—T + MI = Final

where: I = Initial ccCO_2

D = Loss by diffusion (from controls; 56.2% of I)

F = Loss by fixation (from count data: 8.3% of I for Group 1, 7.2% for Group 2)

TABLE 1. Observed fates of $^{14}CO_2$ ($= {}^*CO_2$) and calculated partitioning of CO_2 pathways. Measurements are x ± 2 S.E.

CO_2 DATA

	Initial counts (x10^6)	Final counts (x10^6)	Total % $^*CO_2$ lost	Final counts (x10^6)			% Fixation of original $^*CO_2$	% Fixation of $^*CO_2$ lost
	Water			Petioles	Leaves	Roots & Rhizome		
Group 1	8.581 ±0.670	3.638 ±0.166	58.1	0.537 ±0.327	0.016 ±0.014	0.159 ±0.105	8.3	14.4
Group 2	9.457 ±2.495	1.645 ±0.098	82.6	0.455 ±0.438	0.153 ±0.107	0.077 ±0.025	7.2	9.3
Controls	9.477 ±0.509	4.087 ±0.217	56.9	—	—	—	—	—

$ccCO_2$ DATA

	Initial $ccCO_2$	Final $ccCO_2$	% total $ccCO_2$ lost (see text)	Diffusion loss ($ccCO_2$)	Fixation loss ($ccCO_2$)	Transpiration loss	Metabolic input ($ccCO_2$)
Group 1	123.8 ±3.0	59.9 ±4.7	51.6	69.6	10.3	8.2	24.2
Group 2	111.0 ±2.4	66.4 ±4.3	40.7	62.9	8.1	9.7	35.1
Controls	120.9 ±6.6	52.9 ±2.9	56.2	68.0	—	—	—

T = Transpirative loss (arbitrarily set at 50% of the CO_2 contained in the volume of water transpired, where CO_2 contained is % water loss initial ccCO_2 in the original 3000 ml)
MI = Metabolic input of CO_2 by the roots and associated microorganisms
Final = Final ccCO_2 remaining in the water at the end of the experiment

The ^{14}C uptake data indicate that CO_2 from the water was fixed by the plant. There are several good reasons to believe that the counts accumulated in the plants by the end of the experiment are a sizeable underestimate of the actual amount of carbon dioxide that was fixed from the water. Most importantly, there was undoubtedly considerable $^{14}CO_2$ fixed during the day that was returned to the water or lost to the air during the night by metabolism. Therefore, the percentage fixation values of 9.3-14.4% actually represent net storage values over the 120 hour period of the experiments, which would be lower than the actual total amounts fixed. In addition, we used 60 hours of daylight in our calculations, although most of the afternoons were cloudy. If there had been a full 60 hours of sunlight, the higher daily levels of photosynthesis would have resulted in more of the aqueous CO_2 being fixed. Finally, our plants were in individual containers, and not part of a dense mat as they normally would be in the field. Since crowded hyacinths would have a greater tendency to deplete the air around them of CO_2, our estimate of the importance of the water as a source of carbon dioxide would be low. However, the rates of transpiration in our experiments were high (see Table 1) so delivery of dissolved CO_2 to the plant by this avenue would be greater than in the field. Since we found considerable fixation of the radioactive tracer into the plant, and know from the field results that carbon dioxide is apparently being removed from the water by the hyacinths during the day, we feel qualitatively safe in saying that carbon dioxide fixation from the water is occurring within water hyacinths in the field.

Measurements have been made (Lugo, Ultsch, Brinson and Kane, unpubl.) of the aerial fixation of carbon dioxide by hyacinths. These data show that hyacinths fix about 2×10^{-4} gC/g/hr, where the weights are expressed as grams dry weight, and the hours refer to daylight hours. From Table 1, fixation from the water in our experiments was 10.3 and 8.1 ccCO_2 for a total of 60 hours daylight (allowing 12 hour daylight/day) for Groups 1 and 2 respectively. Experimental aqueous fixation came to 0.24×10^{-4} gC/g/hr for Group 1 plants. When this is added to the aerial fixation figure already given, this produces a total fixation figure of 2.24×10^{-4} gC/g/hr, and the aquatic source accounted for 11% of the total carbon fixation. Group 2 plants give a value for the aqueous carbon source of 8%.

An interesting possibility that emerges from this work is a possible mechanism utilized by the water hyacinth to increase the level of carbon dioxide, often a limiting growth factor, in its microenvironment. An invading population of hyacinths, by growing on the surface, will shade out competitive submerged species. It will therefore eliminate photosynthetic utilization of dissolved carbon dioxide by those species. As a mat is rapidly formed by the vegetative reproduction of the hyacinths, decay of the sloughed leaves of the hyacinth and the submerged plants it has covered raises the CO_2 content of the water, as does the metabolic input of the root system and its associated organisms. As a blanket of hyacinths is rapidly constructed over the water, CO_2 losses to the air from water below the mat are also hindered. These induced increases in dissolved CO_2 coupled with an ability to use some of the carbon in photosynthesis is a positive feedback mechanism that may be one of the reasons for the high growth rates of hyacinths.

LITERATURE CITED

Allen, L. H., S. E. Jensen, and E. R. Lemon. 1971. Plant response to carbon dioxide enrichment under field conditions: a simulation. Science 173: 256-258.

Billings, W., and P. Godfrey. 1967. Photosynthetic utilization of internal carbon dioxide by hollow-stemmed plants. Science 158: 121-123.

Holm, L. G., L. W. Weldon, and R. L. Blackburn. 1969. Aquatic weeds. Science 166: 699-709.

Humphreys, T. E., and L. A. Garrard. 1964. Glucose uptake by the corn scutellum. Phytochem. 3: 647-656.

Penfound, W. T., and T. T. Earle. 1948. The biology of the water hyacinth. Ecol. Monogr. 18: 447-472.

Stumm, W., and J. J. Morgan. 1970. Aquatic chemistry. Wiley Interscience, New York.

Florida Sci. 36(1):16-22. 1973.

Biological Sciences

ECOLOGICAL STUDIES OF THE APPLE SNAIL AT LAKE WOODRUFF NATIONAL WILDLIFE REFUGE

Matthew C. Perry
Lake Woodruff National Wildlife Refuge, DeLeon Springs, Florida 32028
(Presently Migratory Bird and Habitat Research Laboratory,
Patuxent Wildlife Research Center, Laurel, Maryland 20810)

Abstract: *The habitat requirements of apple snails at Lake Woodruff National Wildlife Refuge were studied during the summer of 1971. Snails were observed throughout the 19,000 acre refuge, but were most abundant in Spring Garden Creek. Three transects were established to sample snail egg clusters as an index of snail abundance. Transects were located at the head, middle, and mouth of the creek to best represent the diversity of water and vegetational conditions. Quadrats along the transects were studied in August and October. Fewer snail egg clusters were found at the mouth than at the head of the creek. Eggs in 70 clusters were counted and the following parameters recorded: range 3-50, mean 28.3, and median 27. Height of 67 egg clusters were: range 0-38", mean 9.1", and median 6". It appeared that snails had no preference for egg laying substrate and used whatever plant species were most available. Seven chemical and physical water characteristics were analyzed. Apparent color and turbidity increased from the head to the mouth of the Creek, while hydrogen ion concentration (pH) decreased. Several snails were observed laying eggs beginning 2 to 3 hr after sunset. Eggs were laid at the approximate rate of 1 every 4 minutes, and total time to lay an average cluster was 1 to 2 hr.*

INTRODUCTION—The apple snail (*Pomacea paludosa*) [formerly *Ampullaria depressa*] is considered the sole food of the everglade kite (*Rostrhamus sociabilis plumbeus*) (Cottam and Knappen, 1939). The kite feeds in shallow water where snails can be snatched from the vegetation. The evolution of such a specialized feeding habit combined with habitat modification, have resulted in the everglade kite becoming an endangered species. There were approximately 120 birds of this subspecies alive in 1970 (Harris, 1972), and these birds were concentrated in south Florida. Extensive drainage of marshlands for agricultural, navigational, and other reasons has progressively destroyed kite feeding habitat. The spread of water hyacinth (*Eichhornia crassipes*) has also reduced good habitat. This aquatic pest covers large, shallow water areas making feeding difficult or impossible for the kite.

In the United States the apple snail is restricted to Florida and southern Georgia (Clench and Turner, 1956). Throughout its limited range, however, it is an important food for wildlife. The apple snail comprised 65.8 percent by volume of the stomach contents of 36 immature alligators (*Alligator mississippensis*) collected in the Everglades (Fogarty and Albury, 1967). The comparative feeding behavior upon snails of three avian predators, the everglade kite, the limpkin (*Aramus guarauna*) and the boat-tailed grackle (*Cassidix mexicanus*), has been described by Snyder and Snyder (1969). Other predators of the snail include many fishes, turtles, crayfishes, and aquatic insects (Snyder and Snyder, 1971).

Few ecological studies of *Pomacea paludosa* have been published. Clench and Turner (1956) stated that it was widely distributed in central and southern Florida and found in rivers, lakes, ponds, and even roadside ditches. In northern Florida and southern Georgia it is found only in large springs and spring-fed creeks. Clench and Turner attribute this to the spring-fed creeks remaining warmer during the winter months than do the creeks carrying surface run-off. Pennak (1953) discussed the importance of calcium carbonate ($CaCO_3$) to snails for shell construction and correlated snail abundance with water hardness. Talbot (1970) found with the aid of radioisotopes, that apple snails in aquaria preferred eating the leafy portions of hyacinths to the roots or detritus.

The historic breeding range of the everglade kite included freshwater marshes from southern Florida north to Pannasoffkee and Crescent Lakes and west to Wakulla Springs (Howell, 1932). This area includes the wetlands that presently comprise Lake Woodruff National Wildlife Refuge. Because of the everglade kite's present status, an increase in population and breeding range is desirable. If possible, the birds should be reestablished at the Lake Woodruff Refuge and other wetland areas within its original range. Habitat improvement by management of the marshes with impoundments might be necessary. A prerequisite for such management is information about the habitat requirements of the apple snail. When the requirements of the snails are known, they can be duplicated as closely as possible in fresh-water impoundments. This paper reports on some of the initial findings of a long-range study at Lake Woodruff National Wildlife Refuge to determine the habitat requirements of the apple snail.

METHODS—Several observations of snail egg clusters were made throughout the refuge by boat. Detailed observations and counts of egg clusters were made along Spring Garden Creek. Transects were located at the head, middle, and mouth of the creek to best represent the diversity of water and vegetational conditions. Each of the three transects was 100 m long and extended along the emergent vegetation most distant from the shore. Ten sample areas, 1 sq. m each, were randomly selected along each transect. A frame made of 4 narrow wood strips was placed along the transect at the selected stations. All unhatched apple snail egg clusters within the square meter were tallied. Data were collected on the frequency of plant species in each sample and the plants on which egg clusters were laid. The selected quadrats in each transect were sampled on 31 August and 1 October 1971. In October the height of egg cluster above water and the number of eggs per cluster were recorded.

Surface water samples were collected near each transect and at several other locations within the refuge. All samples were collected in late morning between 15 July 1971 and 8 September 1971. Chemical analyses of water quality were conducted at Stetson University, Deland, Florida, with a Hach water analysis test kit. Water temperature was recorded at each station.

RESULTS AND DISCUSSION—Apple snails were found in wetlands throughout the refuge, but the greatest abundance of snails and egg clusters occurred in Spring Garden Creek. There also appeared to be more snails in the headwaters of the creek than at the mouth. Data from the three transects indicate a progressive decrease in snail egg clusters from head to mouth of creek for both sample periods. Although there were fewer snail egg clusters in transect 2 than in transect 1, the fewest clusters by far were in transect 3 (Table 1).

TABLE 1. Results of egg cluster sampling, Spring Garden Creek, Lake Woodruff National Wildlife Refuge, Florida, 1971.

Transect	Date	Number Unhatched Egg Clusters	Number Eggs per Cluster		
			Range	Mean	Median
1	31 Aug.	36			
	1 Oct.	34	3–50	28.5	30
		70			
2	31 Aug.	23			
	1 Oct.	33	9–49	26.8	25
		56			
3	31 Aug	2			
	1 Oct.	3	36–46	41.7	45
		5			

Fig. 1. Three transects were established along Spring Garden Creek to sample snail egg clusters as an index of snail abundance. Each transect was 100 meters long and extended along the emergent vegetation most distant from the shore. Photo by: Bureau of Sport Fisheries and Wildlife. Fig. 2. Ten one-square meter quadrants were selected along each transect and all unhatched apple snail egg clusters within the sample were tallied. Photo by: Bureau of Sport Fisheries and Wildlife.

1

2


3
4
5

In October, the number of eggs in all unhatched clusters within quadrats were counted. This was done to determine if the number of eggs per cluster decreased as well as the number of clusters. If this were so, then it might be possible to correlate the effect of water characteristics (*e.g.*, $CaCO_3$) with the population density of snails and with the number of snail eggs per cluster. The range of eggs per cluster for all 70 clusters observed in October in the three transects was 3 to 50 with a median of 27 and a mean of 28.3 eggs per cluster. As many as 80 eggs have been reported in a single cluster (Anon., 1971).

The height of the egg cluster above the water was measured for all hatched and unhatched egg clusters in the quadrats of transect 1 during the second sampling. Clusters in transects 2 and 3 were not measured because most of them were on hyacinths which significantly limit the height a snail can travel. Hatched and unhatched clusters were measured giving a total sample of 67. Range of cluster height was 0 to 38 in., and mean and median were 9.1 in. and 6 in. respectively. These figures are minimal as measurements were made when water level was higher than it had been at any time during the previous 3 months. The greatest distance measured (not in a transect) was 60 in. on a cattail (*Typha domingensis*) leaf blade. The snail had traveled so far on the leaf that its weight probably caused the leaf to arc considerably.

Egg clusters were found in the refuge on practically any available substrate (Perry, 1971). Many egg clusters were on cattail because this plant was dominant in transect 1 where snails were particularly abundant. In transect 2 hyacinth was the most commonly used substrate because of its availability. Snails apparently used submersed vegetation such as *Elodea densa* to reach the floating hyacinth. In areas where hyacinths were floating free of submersed plants or the bottom, no egg clusters were found. The greatest vertical distance traveled by a snail to deposit its eggs was 7 ft. on a piling in Spring Garden Lake.

Water analysis was conducted at Stetson University, Deland, Florida, by the author and results are summarized in Table 2. Readings for dissolved oxygen were excessively high, apparently due to poor technique and were therefore discarded. Hydrogen ion concentration (*p*H) was lower at transect 3 than at transect 1 or 2. Apparent color and turbidity increased from transect 1 to 3. Water hardness was similar at all transects. The lower *p*H and higher apparent color and turbidity at the mouth (transect 3) was due to drainage from the marshes surrounding the spring-fed creek that causes an increase in organic acids. These acids cause *p*H to decrease and color and turbidity to increase. More water analyses are necessary before a significant correlation can be made concerning water quality and snail abundance.

Fig. 3. Egg clusters were found in the refuge on practically any substrate including woody vegetation. Photo by: Bureau of Sport Fisheries and Wildlife. Fig. 4: Eggs are pink in color when laid but turn white with age. Remains of a hatched cluster are on right and two unhatched clusters are on left. Photo by: Bureau of Sport Fisheries and Wildlife. Fig. 5. Apple snails observed were inactive for about 15 minutes before laying eggs. Photo by: Bureau of Sport Fisheries and Wildlife.

TABLE 2. Results of water analyses of Spring Garden Creek, Lake Woodruff National Wildlife Refuge, 15 July—8 September 1971.

Transect		CO_2 (ppm)	pH Value	Apparent[1] Color	Turbidity[2]	Ca Hard. (ppm)	Tot. Hard. (ppm)	Temp. (°C)
1	Range	20–24	8.5	20	0	110–150	200–210	29
	Mean	22	8.5	20	0	130	205	29
	No. of Analyses	2	2	2	2	2	2	1
2	Range	20–48	8.1–8.4	20–80	0–20	130–170	210–220	30
	Mean	39	8.3	57	7	150	215	30
	No. of Analyses	3	4	3	3	2	2	1
3	Range	40–56	7.2–8.5	80–100	0–30	140–160	250–260	29.5
	Mean	48	7.7	103	13	150	255	29.5
	No. of Analyses	3	4	3	3	2	2	1

[1] American Public Health Association Platinum-Cobalt Standard
[2] Jackson Turbidity Units—Formazin Standard

The author observed snails laying eggs on several occasions. The snails ascended emergent vegetation approximately 2 to 3 hr. after sunset. They climbed to a height of about 12 in. above water, and after about 15 min. of inactivity, began laying eggs. Eggs were laid at an approximate rate of 1 every 4 min., with the cluster being completed in 1 to 2 hr. Eggs are soft when first laid and adhere to the substrate with a gelatinous material which later dries and hardens. The eggs are usually laid in a single layer in several rows adjacent to each other, but sometimes there are several layers in the cluster. Eggs are pink when laid but turn white with age. Time until hatching is 15 to 20 days, and hatching young snails have basic morphology similar to adults. The number of clusters each snail lays is unknown. Egg clusters appear much more abundant than snails so it would appear that each snail lays many clusters during a year.

Apple snails drop from vegetation as a defense response to mechanical disturbance (Snyder and Snyder, 1971). I observed this on many occasions during the study. At night, however, snails were less likely to drop from vegetation while laying eggs than when moving up vegetation or during the inactive period prior to egg laying. Once a snail laying eggs was observed to move to the other side of vegetation after a short exposure to outboard motor fumes and then continue to lay eggs. It appeared that the snail was attempting to avoid the fumes by getting into the lee created by the vegetation.

The apple snail is found in wetlands throughout Lake Woodruff National Wildlife Refuge, and is most abundant in the first half of Spring Garden Creek. Several vegetational and water characteristics differ among the three selected study areas in the Creek. More research on the apple snail should include a long-range investigation to learn more about the habitat requirements. When more is known about this snail, management can be conducted to make it more abundant and available to the everglade kite and other wildlife species that prey on it.

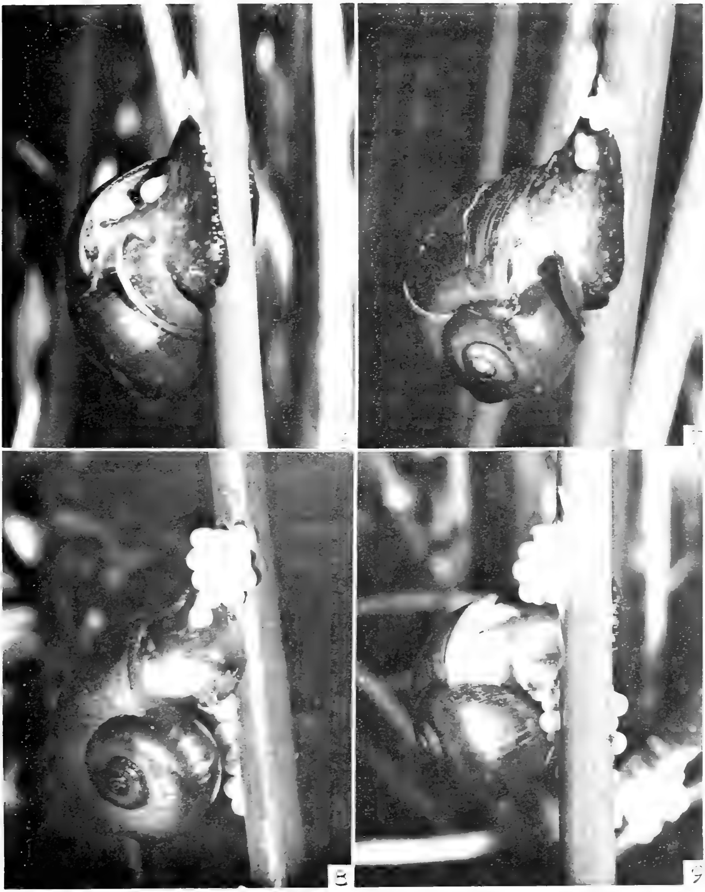

Fig. 6. Eggs are laid at the rate of approximately one every four minutes. Fig. 7. Eggs are soft when first laid and adhere to the substrate with a gelatinous material which later dries and hardens. Fig. 8. The eggs are usually laid in a single layer in several rows adjacent to each other, but sometimes there are several layers in the cluster. Fig. 9. Total egg cluster is completely laid in one to two hours.

LITERATURE CITED

ANON. 1971. Apple snails—escargots for the rare everglade kite. Audubon 73: 24-25.

CLENCH, W. J., AND R. D. TURNER. 1956. Fresh-water mollusks of Alabama, Georgia and Florida from the Escambia to the Suwannee River. Bull. Fla. State Mus. 1: 120-122.

COTTAM, C., AND P. KNAPPEN. 1939. Food of some uncommon North American birds. Auk 56: 138-169.

FOGARTY, M. J., AND J. D. ALBURY. 1967. Late summer foods of young alligators in Florida. Proc. of 21st Ann. Conf. S. E. Assoc. Game & Fish Comm. pp. 220-222.

HARRIS, V. T. [Ed.]. 1972. Wildlife Research-Problems, Programs, Progress—1970. Bur. Sport Fish. & Wildl. Res. Publ. 104. 98 p. Washington, D. C.

HOWELL, A. H. 1932. Florida Bird Life. Florida Dept. Game and Fresh-water Fish & U. S. Bur. Biol. Surv. 579 p. Coward-McCann, New York.

PENNAK, R. W. 1953. Fresh-water Invertebrates of the United States. 769 p. Ronald Press Co., New York.

PERRY, M. C. 1971. Habitat requirements of the apple snail (*Pomacea paludosa*) at Lake Woodruff National Wildlife Refuge. Prog. Rpt. No. 1. Lake Woodruff NWR, DeLeon Springs, Fla. 12 p. Mimeo.

SNYDER, N. F. R., AND H. A. SNYDER. 1969. A comparative study of mollusc predation by limpkins, everglade kites and boat-tailed grackles. The Living Bird 8: 177-223.

———, AND ———. 1971. Defenses of the Florida Apple Snail (*Pomacea paludosa*). Behaviour 40: 175-215.

TALBOT, S. 1970. A study of *Pomacea paludosa* and *Lepomis macrochirus* as a possible strand of the food web of the *Eichhornia crassipes* community. Unpubl. Mimeo. Stetson Univ., Deland, Florida.

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CAVE DWELLING YELLOW BULLHEADS IN FLORIDA

Kenneth Relyea and Bruce Sutton
Department of Biology, Jacksonville University, Jacksonville, Florida and
Department of Biology, Tulane University, New Orleans, Louisiana

Abstract: *The occurrence of yellow bullheads,* Ictalurus natalis, *in two caves is recorded. The bullheads are associated with another troglophilic fish,* Hybopsis harperi, *in both caves. Analysis of stomach contents of the bullheads indicates that mud, leaf detritus, pieces of limestone rock, and springtails (Collembola) are commonly ingested. One specimen had ingested a troglobitic crayfish,* Procambarus lucifugus. *The presence of juvenile bullheads in the caves suggests possible spawning in the subterranean system. Developmental abnormalities (lack of pelvic fins, lack of adipose fin, deformed caudal fin) were noted for several specimens, indicating that inbreeding in a small, isolated population may be occurring.*

Although no troglobitic cave fishes are known from Florida, several cave adapted epigean species of fishes are. These include: *Anguilla rostrata,* the American Eel, which has been observed in caves around Marianna, Jackson County, Florida (pers. obs.; Pylka and Warren, 1958); *Hybopsis harperi,* the redeye chub, which has been found in central Florida caves (pers. obs.; Hubbs, 1956:5, described this form as *H. h. subterranea*), and in the caves around Marianna (pers. obs.); and *Ictalurus natalis.* We report here on observations of the yellow bullhead, *Ictalurus natalis,* as this species, to our knowledge, has not been recorded in the literature as occurring in Florida caves.

We have captured and observed the yellow bullhead in two central Florida caves in Alachua County, 5 miles north of Newberry. These two caves (locally known as Bat and Martin's Caves) are approximately 10 air miles from the nearest above ground drainage (Santa Fe River, Suwannee River drainage). We gained entrance to the caves via sinkhole shafts opening into subterranean chambers. The entrances to the two caves are about 200 yards apart. Pools of water in the caves are connected to large underground water systems. There is minimal light penetration into the caves from sinkhole shafts, and most pools are probably always in total, or nearly total, darkness.

Hobbs (1942:138), in his classic study of Florida crayfishes, described several of the sinks and caves of this Alachua County area. The area is characterized by sinks and caves in Ocala Limestone, opening into exposed areas of water connecting to a vast subterranean water system. Hobbs (*op. cit.*) noted the occurrence of *Erimystax* (= *Hybopsis*) in these caves and stated that he had seen another light colored fish on several occasions. Hobbs has also observed catfish in Martin's Cave (personal communication).

We have observed *Ictalurus natalis* swimming sluggishly in these pools. They can be seen emerging from deep water in the cavern system, coming up into water only a few inches in depth. We have captured three juveniles, one from Bat and two from Martin's Cave, and have observed others. We have captured eight adults from Martin's Cave, and observed another in Bat Cave. These fish are seemingly healthy, not emaciated, and show varying reactions to light (some quickly swam off when a flashlight was directed on them; others seemed unconcerned). The three captured juveniles, measuring 28, 41 and 21 mm standard length, are in the Jacksonville University Biology Museum Collection (JU 1003 and JU 1303). Adults ranged from 138 to 204 mm standard length (JU 1144).

Juveniles are strongly negatively phototropic, and are found along pool margins. When disturbed, juveniles seek cover in limestone crevices. It is worth noting that juveniles are not aggregated along pool margins, but rather are dispersed. Clumping or clustering of juveniles in epigean populations of bullheads is common. The scattering of juveniles in the caves may indicate that energy supply is critical.

Although the *Ictalurus natalis* from central Florida caves are unquestionably that species, they appear somewhat depigmented. This is probably the result of their darkened environment, rather than a genetic factor. Epigean populations of *I. natalis* are known to be very variable in terms of degree of pigmentation. The yellow bullhead is, of all North American bullheads, perhaps the most suited for subterranean life, since it has reduced eyes and an elaborate chemosensory system (Todd, 1971).

The extent of these subterranean populations, and those of *H. harperi*, is unknown. They may well be concentrated only near sink hole openings, and not generally distributed in the underground system, since the sink holes act as "energy funnels". The full ecological relationships of the bullhead, the chub, and troglobitic forms in the caves are unknown.

We have examined the digestive tract contents of seven of the adults, which were easily captured on a handline using worms for bait. One fish contained a significant food item, a large *Procambarus lucifugus*, the troglobitic crayfish. This may represent the first documentation of predation on any of the Florida troglobitic crayfishes by a troglophilic fish. Identification of *P. lucifugus* is relatively easy, as this is the only troglobitic crayfish of the three known from Alachua County which retains eye pigment. Hobbs (1942:136-139) referred this population to *P. l. alachua*. Other fishes collected contained mud, leaf detritus, small pieces of limestone rock and springtails (Collembola), indicating that these fish browse on the substrate. Hobbs (1942:136) observed springtails in the caves to the south of Alachua County, in association with *Procambarus lucifugus lucifugus*.

Reproductive cycles are unknown, but we captured and observed juveniles during winter (February and November). Juveniles may be recruits from epigean populations, but due to the great distance of the caves we have studied from such populations, we feel that *I. natalis* may be spawning in subterranean waters in Florida (we suspect the same for *Hybopsis harperi*). Three of the adult *I. natalis* captured were females showing ovarian development, but the ovaries were far from maturity.

These specimens were captured on 6 June 1971. No juveniles were present in the caves in June, only during the winter. Fall spawning may be suggested, but much more data are necessary. In fact, reproductive activities of *I. natalis*, are, in general, not well known. Data accumulated by Mansueti and Hardy (1967:165-166) indicate a mid-May to June spawning period. The May to June spawning period probably does not apply to Florida populations. We have juveniles from central and north Florida in the JU collections in June, August, October and December, in addition to the February and November cave individuals.

That the *Ictalurus natalis* are an isolated subterranean population is suggested by another set of surprising observations. Of the eight adults captured, two completely lacked pelvic fins, and another had only one pelvic fin. The other five adults and three juveniles had normal pelvics. Also, one of the specimens lacking pelvics had no adipose fin, and the specimen with one pelvic fin had a distinctly reduced adipose. This is not attributable to damage or tagging. No scars or rudiments of pelvic fins are apparent. We have observed no such abnormalities on *Hybopsis*, but absence of pelvic fins has been observed by Relyea in *Ictalurus catus* in the St. Johns River (but not for *I. natalis*). Other fins appear normal, with ray counts typical of *I. natalis*, except for the caudal fins of two adults and one juvenile which contain notches and coalesced fin rays. This latter feature may represent mechanical damage (we initially suspected that they were old tags). Another specimen had a ragged caudal. This may result from intraspecific aggression. Table I summarizes the condition of the adult and juvenile specimens.

It is intriguing to speculate that the pelvic fin and adipose fin abnormalities may have a genetic basis, suggesting inbreeding within a restricted population. Developmental environmental conditions may be an equally plausible explanation, however. One must ask if there are other aberrant physiological or morphological features that we have not observed for these fishes. Pleiotropy is a generally favored explanation for the apparent rapid evolution of cavernicoles (Barr, 1968), but the lack of pelvic fins on some specimens may indicate

TABLE 1. Summary of features of 8 adult (JU 1144) and 3 juvenile (JU 1003 and JU 1303 specimens of *Ictalurus natalis* from subterranean waters in Alachua County, Florida

Sex	Standard Length (Millimeters)	Pelvic Fins	Caudal Fin	Adipose Fin
Male	204	Normal	Normal	Normal
Undetermined	145	Normal	Normal	Normal
Female	168	Normal	Deformed	Normal
Female	164	Normal	Normal	Normal
Female	147	Absent	Deformed	Absent
Male	170	Absent	Normal	Normal
Male	138	Left normal, Right absent	Normal	Reduced, deformed
Male	151	Normal	Normal	Normal
Juvenile	28	Normal	Normal	Normal
Juvenile	41	Normal	Normal	Normal
Juvenile	21	Normal	Deformed	Normal

developmental energy economy (also see Barr, 1968:79). Of note, is that the amblyopsid fishes lack pelvic fins, except for *Amblyopsis spelaea* which has rudimentary pelvics (Woods and Inger, 1958).

This subterranean situation for catfishes in North America is not without parallel. Two troglobitic species, *Satan eurystomus* and *Trogloglanis pattersoni,* are known from Texas (Hubbs and Bailey, 1947; Suttkus, 1961). Another form, *Prietella phreatophila,* occurs in Mexico (Carranza, 1954). The troglophilic situation for *I. natalis* in Florida parallels closely that found for *Rhamdia* populations in Yucatan by Hubbs (1936).

LITERATURE CITED

Barr, T. C. 1968. Cave ecology and the evolution of troglobites. Evol. Biol. 2: 35-102.

Carranza, J. 1954. Descripcion del primer bagre anoftalmo y depigmentado encoutrado en aguas Mexicanus. Ciencia 14(7-8): 129-136.

Hobbs, H. H., Jr. 1942. The crayfishes of Florida. Univ. Florida Publ. 3(2): 1-179.

Hubbs, C. L. 1936. Fishes of the Yucatan Peninsula. Carnegie Inst. Wash. Publ. 457: 157-287.

_____. 1956. Preliminary analysis of the American cyprinid fishes, seven new, referred to the genus *Hybopsis,* subgenus *Erimystax.* Occ. Pap. Mus. Zool. Univ. Mich. 578: 1-8.

_____ and R. M. Bailey. 1947. Blind catfishes from artesian waters of Texas. Occ. Pap. Mus. Zool. Univ. Mich. 499: 1-15.

Mansueti, A. J., and J. D. Hardy, Jr. 1967. Development of the fishes of the Chesapeake Bay region: An atlas of egg, larval, and juvenile stages. Part I. Port City Press. Baltimore, Maryland.

Pylka, V. M., and R. D. Warren. 1958. A population of *Haideotriton* in Florida. Copeia 1958: 334-336.

Suttkus, R. D. 1961. Additional information about blind catfishes from Texas. Southwest. Naturalist 6: 55-64.

Todd, J. H. 1971. The chemical languages of fishes. Sci. Amer. 224: 98-108.

Woods, L. P., and R. F. Inger. 1957. The cave, spring, and swamp fishes of the family Amblyopsidae of central eastern United States. Amer. Midland Nat. 58: 232-258.

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PHYSICAL SCIENCE WITH A NEW DIRECTION[1]

FRANK M. DUDLEY
University of South Florida, Tampa, Florida 33620

ABSTRACT: *The Syllabus-Notebook method of presenting the "Big Ideas" in the physical sciences has resulted in improved performance by students enrolled to meet general education requirements.*

SOME unique innovations have been made in the Physical Science Course PHS (formerly CBS 209) 209 offered to meet the general education requirement at the freshman and sophomore levels at the University of South Florida. A major change in emphasis has been implemented from conventional Chemistry and Geology content and methods to a Geo-Chemistry Environment-Ecology content and non-textbook method approach.

OBJECTIVES—The objectives not only include those common to most courses involved with science content, but also those objectives peculiar to science as taught to non-science majors and/or with a general education point of view. The three most important ones falling into the latter category are: to promote interest; to change attitudes; and to teach for science literacy. General education connotes education for improvement of the "whole person", i.e. toward producing a better person, and is aimed at all students regardless of career goals or background of preparation. To achieve this end, no particular body of content is sacred. The method through which an understanding is achieved is of vital importance.

THE "BIG IDEAS"—The concepts and principles which will have the greatest impact upon the individual as a whole individual in society will be selected for content emphasis. For PHS 209 this means principles and concepts that are vitally involved with daily living.

TOOLS AND SKILLS IN USING THEM—In order to understand the quantitative relationships that exist among the concepts and principles of a Physical Science, certain tools must be utilized. Obviously, the use of the tools requires the mastery of certain skills. For example, the mathematics is held to a minimum while such quantitative tools as graphic relationships, indirect measurement by narrow limits-comparison, and expression of quantitative values in terms of "ball-park values" in exponential form are exploited to the maximum.

WHY NO TEXT?—The boredom of wading through a text chapter-by-chapter, and having to sift out the important ideas from a myriad of pages of unfamiliar material are two of the primary reasons given by the non-science major for avoiding science as a major. The Syllabus-Notebook method is very effective in preventing the loss of students who avoid science for the above reasons.

THE SYLLABUS-NOTEBOOK—The Syllabus-Notebook contains tools for

[1]Presented at the Florida Academy of Science meeting, April 7, 1972.

handling scientific data in a quantitative manner; laboratory activities that will aid in a better understanding of the concepts and principles involved in the content presented; outlines containing the important topics and sub-topics under which information is supplied by the student from the lectures and discussions; and exercises that can be done by the student both in and outside of the class. The exercises serve to help the student become more competent in knowledge of the content material, and develop the skill in the use of the tools needed to analyze the material in a quantitative manner.

Content Emphasis—Two basic units are utilized in an integrated coverage of Geo-Chemistry and one unit emphasizing the tie-in of the Geo-Chemistry with ecological and environmental factors peculiar to the local geographic area. These are the three units: 1) *The Structure and Behavior of Matter* is a study of structure through the development of such sub-unit topics as "The Chemical Nature of Matter"; "The Electrical Nature of Matter"; "The Particle Nature of Matter"; and "Radioactivity". 2) *The Geo-Chemical Processes of the Earth's Changes* involves such sub-unit topics as "The Chemical Approach to Minerals via Crystallization from Magma"; "Land Forms from Ground Water, Glaciers, Oceans and Wind"; "Faults, Folds, Earthquakes, X-raying the Earth"; and "Chemistry of the Carbonates and the Geological Processes Involved". 3) *Geo-Chemical Processes and Ecological Problems* involves the geological history and geochemistry of the carbonates, phosphates and geodes found in the Tampa Bay area, and the geographic area immediately surrounding the bay area. This tie-in with the environmental surroundings of the local area enhances the interest of the student and allows the course to have a direct meaning to the student's daily life.

Advantages and Disadvantages of the Syllabus-Notebook Method—Several advantages are apparent from the experience of operating PHS 209 utilizing the Syllabus-Notebook method. The following constitute the major advantages found after operating the course as described for four quarters: (1) The student is forced to keep pace with the course content and complete work related to the content as the course is presented. This is advantageous to the student because he does not have to "cram" near the end of the course in order to pass the final, and to the instructor because make-up work is greatly reduced. (2) Self-discipline is produced in the student through the careful note-taking in the lectures and discussions. The note-taking replaces the reading normally done from a text, in the conventional textbook method. The note-taking experience increases the student's ability in writing. (3) The complete coverage of the concepts and principles within the content is demanded in order for continuity and meaning to emerge. The advantage of this type of coverage is the prevention of gaps in the student's association of concepts involved in the content. (4) Only the "big ideas" emerge from the content. This is extremely advantageous for the student, and circumvents the problem of his wading through several hundred pages of content searching for the important concepts and principles. In addition, the time saved by the student can be directed toward another part of the course that he finds more interesting or a part he might want to examine at a slower pace because of the complexity of the material.

Perhaps the major disadvantage of the Syllabus-Notebook method is the result produced as a consequence of poor note taking. Inadequate understandings and misconceptions sometimes are the outcome of poor note taking. Every opportunity should be seized by both the student and instructor to improve note taking skills at the earliest signs of this deficiency exhibited by a student. Frequent contacts between student and instructor should be planned in order to alleviate this problem.

An Analysis of the Course by Students—The response from 109 students taking the course during the Winter Quarter 1972-3 indicated the following rather interesting results: Sixty-five percent said the Syllabus-Notebook method was less boring than the conventional textbook method. Seventy-one percent thought the principles and concepts were more easily learned with the Syllabus-Notebook method than from the textbook (to which they had access in the library) coverage of the same concepts and principles. Eighty-five percent said they spent less time in preparation with the Syllabus-Notebook than with the conventional textbook method. Forty-nine percent indicated that the Discussion-Laboratory sessions were the most helpful in mastering the material as compared to five percent who believed the reference reading from the reference text was the greatest help. The latter evidence was reinforced by the fact that forty-four percent indicated that the reference text was the least helpful in the preparation and mastery of the material.

Conclusions—Certain inferences might be made and conclusions drawn from the experience of four quarters teaching through the Syllabus-Notebook method. First, from the student evaluation the conclusion can be made that students prefer this method to the conventional textbook method. Second, students believe that the discussion-laboratory contributed most to their productivity. Third, students find the Syllabus-Notebook method more interesting than the conventional textbook method. Several inferences might be drawn: the course was much more popular with students when the Syllabus-Notebook was used as compared with the use of a textbook; the enrollment increased markedly during the four quarters when the Syllabus-Notebook was used when compared with the four quarters prior to the adoption of the Syllabus-Notebook; the understanding of content material, based upon a comparison of students who remain in the course with those who fail and/or drop (failure was the most frequent reason given for dropping) was much greater when the Syllabus-Notebook is used. Although no faculty analysis was made, the general expressed opinion of the faculty indicated a slight preference (3 for, 2 against) for the Syllabus-Notebook method over the conventional textbook approach. The two primary reasons for the preference of the Syllabus-Notebook was a better attitude of the students toward the course (less apathy toward outside assignments and completion of in-class assignments) and greater over-all quality of productivity from the students. This evidence was based upon higher class average on test scores, less failures and better quiz and laboratory exercise scores relevant to the course requirements. The future of the course will depend largely on the selection of the course by the student among other alternatives (seven alternative courses) to meet the general education requirements.

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THE UNIVERSITY OF FLORIDA IN WORLD WAR II

George Osborn
Department of Social Sciences, University of Florida, Gainesville, Florida 32611

The immediate future of the University of Florida in 1942 would demand many changes, but President John James Tigert thought there would not be the serious disruption of college and university campuses that had occurred throughout the country during World War I. There would not be another nightmare of the Student Army Training Corps (S.A.T.C.) in which "the institutions were neither adequate training grounds for the armed forces or for peaceful pursuits." In his roles as President of the National Association of State Universities and as Chairman of the Joint Committee with the Land-Grant College Association, Tigert worked with government officials to secure a commitment that the government would cooperate with educators in carrying forward its war-time manpower program with as little disruption of civilian campus activities as possible.

During the war, plans were worked out to permit a student to graduate in three years or less, or to permit a student to enter the university prior to his high school graduation. Early graduation was made possible by streamlining the academic program, by careful guidance, by curtailing of vacations, and by expanding summer session course offerings. Over 3,000 students took advantage of this program. Early admission required placement tests by which a high school student could demonstrate that he was capable of doing university work.

The University placed additional emphasis upon mass physical education so as to stress general health, physical fitness and individual corrective exercises. Adjustments of specific offerings were made to meet the immediate requirements of war; specific topics were introduced into existing courses and the institution added new courses in aeronautics and engineering to meet the needs of industry and of the armed forces. Indeed, the University, through its President, pledged to President Roosevelt the University's complete facilities and resources, both human and material. This all-out effort was made with a deep and abiding sense of putting first things first; without impairing quality or curtailing the quality of work being done.

The student body changed in appearance in February, 1942, when 750 enlisted men in their neatly pressed uniforms arrived from military camps to take their places in the classrooms beside civilian students. Preceding these soldiers who were beginning the new army training program were some 600 uniformed men in administrative officer's candidate school, in trainee groups in pre-radar, radio, and ground flight school. Since the civilian students numbered 1637, the student body was almost balanced between civilian and military students. Tigert announced that all students would have the same social status. The trainees were not permitted to participate in intercollegiate athletics, but intramurals were available to them. They were assigned 24 class hours per week, heavier schedules than most of the civilian students carried.

A presidential announcement placed the University on a twelve months basis. It had a double responsibility during the summer session of offering courses essential to training teachers for the public schools of Florida and to meeting the needs of those students who were speeding up their educational programs. Tigert assured the public that no effort would be spared in meeting every war-time need of the state and the nation.

The Pensacola NEWS-JOURNAL commended Tigert's streamlining of the University to a war pattern. It would have two great effects: young men would be better prepared for service in the Army, Navy and Air Corps and many college youths would be attracted by the possibility of preparing themselves for commissions and would remain in college instead of plunging immediately into volunteer military service. The St. Petersburg TIMES told parents who were worrying about whether or not their sons should enter military service or should continue in their education, to heed Dr. Tigert's announcement that "in the fields of engineering, pharmacy, chemistry, pre-medicine and a few others, the government has to date not only allowed, but insisted, that students be urged to complete their training." This was also true in some branches of agriculture, he added. The TIMES noted that the University had attuned its energies and facilities to the objective of winning the war; it was performing a proud and important part toward attaining the nation's goal. The Jacksonville TIMES-UNION added that Tigert's program had the approval of the Selective Service Board in Washington and should receive the cooperation of all Floridians (1).[1]

President Tigert explained to the campus the demands of the accelerated program. Some University holidays would be eliminated, including spring vacations. For the duration of the national crisis no fraternity would be permitted a spring house party. Spring commencement would be held one week early and the ceremonies would be condensed. When a student was drafted into military service before the semester ended, a committee would consider the merits of the case, and wherever feasible his examinations would be given early. The President advised every boy, however, to remain in school as long as possible. Courses were being added to help all interested students meet the requirements of the United States Naval reserves. Although no ROTC program was planned for summer, advanced ROTC would be retained. A campus-wide blackout was imminent and the students were urged to remain calm. Token attacks would, in all probability, be made against the site where 1500 students were studying military science.

President Tigert issued an eight page "special war bulletin" which he addressed to "The Present and Prospective Students; Their Parents and Friends."

[1]Editor's Note: The nature of sources cited in this contribution are such that a numeral system of citations is used instead of the author, date method employed in our usual editorial format.

This message contained several suggestions to Florida high school senior boys and to their parents. He suggested that each boy graduating that spring begin his higher education in the University's summer school if he could meet the entrance requirements. If the boy attended the University on a twelve months basis he could graduate in three years or less if he worked hard enough. In critical times, he stated, "everyone must do more with less." He emphasized that "the enormous task which a peaceful, unmilitarized people face in meeting the modern total war, demands that each individual or organization must direct every effort toward achieving the objectives of victory and a lasting peace."

Tigert reviewed the University's record of cooperation with the government's war program, citing as an example the cooperative training program which the University had worked out with the Civil Aeronautics Authority (CAA). For over a year the College of Engineering, in cooperation with the United States Office of Education, had been directing engineering science and management training courses throughout the State to train workers for defense industries. The University radio station (WRUF), the General Extension Division, the Agricultural Experiment Stations and Extension Service conducted many defense projects. Many members of the faculty left the campus to instruct men at Camp Blanding, the Jacksonville Naval Air Station, and the Orlando Air Force Base. Several faculty members were serving on committees of the State Defense Council. President Tigert promised that the University's policies would be flexible enough to meet any situations "ranging from the adjustments of students programs to the use of the staff and the physical equipment" (2).

He received many acknowledgments of the University's participation in the nation's war effort. General O. W. Griswald, of the United States Army Headquarters, IV Army Corps, Jacksonville, thanked him for his generous cooperation in supplying instructors and material for the training school at Camp Blanding, without which it would have been impossible to get the training classes started promptly. In addition, the University assisted in conducting a school for the interrogation of prisoners of war. The success of the school, wrote General Griswald, was due largely to the help the University gave it. Lieutenant T. J. Needham appreciated the generous cooperation received by the Navy Reserves in its recruiting program. "The spirit of patriotism and the will to help, so evident at the University of Florida, is very heart warming," concluded Lieutenant Needham (3).

Although Tigert's energies were almost wholly absorbed in the process of continuing adjustments of the University of the requirements of the national crisis, he occasionally obtained a reprieve from the pressures of his job. One such brief interlude occurred in June, 1942, when he delivered the commencement address to the Michigan State College graduating class. Speaking on the topic "Where the Light Dwelleth," he discussed the hopes of the post war world. He thought that with the restoration of peace the United States would have three possible alternatives to pursue: (1) "We can undertake to police the world with our Allies and attempt to destroy or crush under our heels the German and the Japanese. (2) We can adopt again a position of complete isolationism and attempt to develop a self-contained America without regard to other nations. (3) We can collaborate in setting up an association of free nations willing to submit their differences to the arbitration of a court rather than to the sword, and restrained by an international police power." He left no doubt in the minds of his youthful listeners and their parents and friends about his personal choice when he predicted that the first and second courses would inevitably lead to another war of world-wide dimensions. A concert of nations was the only foundation upon which any lasting peace could be laid. The association, or league, or society of nations, he emphasized, must have as its objectives "righteousness, justice and goodwill rather than might, selfish aggrandizement and intolerance" (4).

Upon returning to his office, he welcomed Sir Josiah Stamp, a correspondent for the London TIMES. In an article, "America at the Moment" the English journalist wrote of the vigor which he saw on the university campus and of the enormous part that would be played in the future of America by university trainees. More specifically, he wrote that President Tigert of Florida was building a great university center adapted to the particular needs of that area. The New York TIMES told its readers that "Florida Sets the Mark" and explained that upward of 4,000 of the University of Florida former students were with the armed forces in every area of the global conflict. In addition, 68 members of the administrative and teaching staff were actively engaged in the war. The faculty and students who remained on campus had bigger and harder tasks to do during the national crisis, but they were performing these tasks cheerfully (5).

When the fall semester began, Tigert explained to the students that the Army-Navy-Marine Corps procurement committee had prepared a plan through which students could enlist in the Reserve Corps of the various Services and could complete their essential pre-induction training while they were in college. The government, said Tigert, was trying to avoid the mistake it made in personnel during the World War I by recognizing that men were as vital in war industry as they were in the fighting forces. There was need for intensive research, he added, to keep abreast of the enemy's advances in technological fields. University training "both in the classroom and on the drill field would fit the students to take their places in the ranks of the battle for democracy."

He made it clear that the military status of every faculty member and of every student was determined entirely by the draft board or by a governmental agency, and was in no way influenced by the University. In short, the University was not, nor could it ever be, a shelter for anyone seeking to avoid military service. In cooperation with all governmental agencies, the University made available the official records of every student, including his courses and his grades. Moreover, each student made an individual decision concerning his immediate enlistment. The foremost concern of the University was to help win the war. All branches of the armed services needed men trained to think, to make the right decisions, and to exercise good judgment. They asked the colleges and universities to help prepare men for leadership responsibilities. Consequently, the University was taking those who enrolled as students, enlisting them in one of the reserve branches, and moving them along as rapidly as possible on a college program which had been selected by the student and which was acceptable to the armed services.

Tigert arranged for the Army, Navy, Marine Corps and Coast Guard Procurement Boards to send representatives to the campus to explain in detail the various reserve programs of the armed services and to give information which would enable each student to determine how he could best fit into the nation's war program. William Corry, President of the Student Body, supported Tigert's admonition to work hard by telling his fellow students that they were in school because the government felt that they could contribute most to immediate victory and to the future well-being of the country by completing their college training. Because the government wanted them to finish school and yet needed them so critically, there was great pressure to get through as quickly as possible (6).

The University began its first full wartime academic year with a total campus-wide participating group of 3,332 of which 3,052 were students. Seventy-six faculty members had left campus for military service. Three special war programs—the Officers Candidate School, an aviation training course, and a radio training course were already installed on the campus. Tigert welcomed to the University the second of four Army Administrative Officers Candidates' Schools in the country. It opened with 180 candidates and was supervised by a staff of 40 members. In the new military school approximately 180 new candidates would be enrolled every four weeks and by December over 500 men would be training on the campus preparatory to receiving bars as commissioned officers. Tigert was elated that the University of Florida was one of four universities in the United States selected to train men as administrative officers. The cooperation between the civilian students and the military trainees showed a united campus.

The COLLEGIATE DIGEST noted that the University of Florida was first in the nation to embark upon a campus-wide program of "reclamation, conservation and economy." Florida boys collected over 20,000 pounds of scrap metal, which was melted into ingots in the University's engineering laboratories, and 1,500 pounds of paper weekly. These reclaimed products were sold, the money obtained was converted into defense bonds and turned over to the Tolbert Memorial Loan Fund, the University's largest student aid fund (7).

While the students under President Bill Corry's supervision were energetically collecting materials to sell to build the student loan fund, Tigert was in Chicago attending meetings of land grant colleges and state universities. The colleges were trying to coordinate their efforts in coping with the nation's critical situation.

President Tigert was kept busy every day and frequently far into the night with administering a university in wartime. His associations with state, regional, and national organizations also made heavy demands on his time. Issues growing out of the war situation were the most crucial of all. In making a radio address over WRUF he predicted that the university would "become khaki" sometime in 1943 if the plans of the Army and Navy were carried out. The entire program would necessarily be arranged to meet military needs. "The pinch of necessity requires us to direct our instruction more and more to utilitarian things of wartime," he declared.

President Tigert opposed having the Army and the Navy dictate the curriculum for the University because it would mean minimizing liberal arts courses; it would be the death knell for humanities courses. University courses would be confined largely to chemistry and engineering. He indicated, however, that military regimentation would soon prevail. This he did not like at all; it reminded him painfully of the World War I period. Consequently, he announced that in spite of the demands of the military, and of the University's determination to meet these requirements, regular courses would be preserved even though the war program required a steadily increasing share of the University's manpower and plant facilities. The University would continue to serve the state, while it assumed the additional responsibility of serving the nation.

He announced further that the Law College would, be "War-ized," and went on to explain. Beginning with the second semester, and for the duration of the national crisis, students who had completed two years at an accredited college could enter the Law College. Those who had completed two years in the General College on the campus and were recommended for the upper division could enter the Law College directly. This combined curriculum would allow students to qualify for degrees in the College of Law and in the College of Arts and Sciences or in the College of Business Administration if they wished to qualify for both degrees (8).

Only 1,637 civilian students enrolled for the second semester, 1943, and the rate of decline accelerated as the war continued. Military groups on the campus replaced the decreasing civilian enrollment and further utilization of the university facilities by the government was expected. An Office of War Information release stated that the University of Florida had been selected as a training base for Army engineers and aviation cadets. The Army Administrative Officers Candidate School (OCS) which was already on the campus would remain.

As the campus courses continued to shift from civilian to military, Tigert conferred with his administrative assistants and announced that beginning in September, 1943, the University would abandon the semester system for the quarter system. The teaching facilities and staff of the University would be reorganized to cope with the change. He named a faculty committee, with Dean James Norman of the College of Education as chairman, to work out the details for the campus-wide reorganization. With this shift the year round operation of the institution would be at full speed with four terms of 12 weeks each. Each student would have fewer courses a term but classes would meet more frequently each week. When course requirements permitted, civilian students and soldiers attended the same classes. A group of 750 aviation cadets were expected on the campus on March 1 to begin five months of training in ground courses.

Upon the arrival of the 750 aviation cadets, Tigert appointed Kenneth R. Williams, Professor of School Administration in the College of Education, as Director of Training Courses. In order to provide adequate housing facilities, Tigert commandeered the fraternity houses near the campus and announced that they were a part of "the residence system of the University."

To teach the Air Corps cadets some 90 faculty members were selected. Although most of them remained in their fields of specialization, some found it necessary to brush up on additional areas of study in order to teach the new courses (9).

In March, Tigert publicized his biennial report which had been prepared for the Board of Control. Basically, he pictured a state university doubling up to help a nation at war, yet retaining the essential features of its peace time activities. Reduced by more than one-third by the men entering military service, the staff with few additions had assumed added teaching and counseling responsibilities in order to meet the wartime demands of the University. The President indicated that more than $1,000,000 had been saved the state through avoiding replacement of the personnel entering the military. These economies, he emphasized, were made at an immense sacrifice. In fact, the state was merely postponing the financing of the real needs of the University. Such action could be justified only on the grounds that it was necessary to meet the demands of winning the war. The savings were actually unfilled obligations to Florida's youth (10).

Students taking advanced R.O.T.C. became members of the University unit of the Army Enlisted Reserve Corp (A.E.R.C.). From this campus group the Army made periodic demands for needed personnel. The initial call from the Florida unit was for twelve men to report for active duty. Those left were urged to stay in school, to continue their studies and to secure transcripts of both their college and their R.O.T.C. records. Upon completion of their basic army training the inductees had an opportunity to qualify for the Army Specialized Training Program (A.S.T.P.), which many of the Florida students did. Tigert explained that the purpose of the A.S.T.P. was to train college men in technical and professional skills required by the Army. The success of the A.S.T.P. unit on the campus was recognized when Tigert was named a member of the War Department Army Specialized Training Division Advisory Committee. The function of this committee was to set up standards for and to organize A.S.T.P. units on the campuses of more than 300 colleges and universities. Tigert was the only committee member from the lower South (11).

By mid-summer, 1943, the campus was becoming increasingly dominated by the military. Among the units connected with the University at that time were the Officer Candidate School (O.C.S.), the Army Specialized Training Program (A.S.T.P.), the Chemical Warfare School (C.W.S.), the Army Aviation Cadets (A.A.C.), the Army Enlisted Reserve Corps (A.E.R.C.). In addition, the Regular Officer Training Corps (R.O.T.C.) was continued. The University of Florida Extension Department had charge of a multiple city program for the training of the technical personnel needed in war industries and in the armed services. By July, 1943, approximately 7,000 Florida citizens had been enrolled in University administered courses in engineering, management, and science. Because of its massive offerings of 145 college courses in 27 fields the Extension Division had enrolled several thousand enlistees. With Tigert's recommendation the Board of

Control approved a schedule of reduced fees for all military personnel enrolled in any of the University's Extension Courses. As a result, wrote Dean B. C. Riley, all posts and commands of the Army, the Coast Guard, the Marines and the Navy located in Florida had shown considerable interest in extension work. This was especially true after the United States Armed Forces Institute began subsidizing the cost to all military personnel. The Extension Division also made successful efforts to enroll WACS, WAVES, WMC, and SPARS (12).

By September, 1943, 111 faculty members had been given leave of absence and four had resigned, all to go directly into military service. In addition, 95% of the women employed on the campus had entered some kind of armed auxiliary services. They were enrolled in training programs which were regarded as highly important toward the success of the war. Of the remaining faculty, approximately 125 were engaged in teaching various groups of military trainees on and off the campus. A majority of the faculty taught civilian courses in addition to the military trainee programs. Finally, President Tigert announced, almost a score of faculty members were conducting research projects seeking solutions of war problems (13).

Tigert and Governor Spessard Holland initiated a plan to locate a veteran's rehabilitation hospital in Gainesville near the University so that as wounded servicemen were rehabilitated physically they could be trained intellectually for civilian life. The project had the full support of Senator Claude Pepper and the entire Florida Congressional delegation. R. A. Gray, Secretary of State, representing Governor Holland, and Tigert headed a group of 20 Floridians to Washington, where they remained for several days holding conferences with political leaders. The Florida Committee for the Rehabilitation of Servicemen sponsored a luncheon at which Senator Pepper presided. Tigert, as spokesman for the Florida group, told of the fortunate location of the University of Florida climatically and culturally: "It seemed like the Lord ordained the University of Florida to be the logical place to carry out this program." General Frank T. Hines, Director of the Veterans Administration, said "I must agree with you that Florida deserves another Veterans hospital." Although the group returned to Florida pleased with their trip, the V.A. hospital would not be built for another twenty-five years, long after President Tigert's retirement. In one sense, it was a long delayed but significant contribution of his planning for the University and for the community (14).

Tigert appreciated the accolades he received in recognition of the University's war efforts. Paul V. McNutt, Director of the War Manpower Commission, wrote: "Let me congratulate you upon the splendid record of your institution during these most difficult times." From Major General Joe N. Dalton, Director of Personnel in the Headquarters Army Service Forces, came a note of thanks for the A.S.T.P. unit at the University. J. W. Harrelson wanted him and the University to know what fine performances they made in the A.S.T.P. It was a noble success. When Tigert was asked to train U.S. Air Force Cadets, he and his faculty took on the burden and accomplished it remarkably well. The award of a certificate of service from the Air Force was important to Tigert for it gave proof that the

University was doing outstanding work. He stated that the University took deep satisfaction in the feeling that it had been able to have a small part in forwarding the war effort. "The morale among the officers and men has been consistently high; the staff and civilian students at the University of Florida have received numerous compliments from the personnel of the Air Corps."

A recognition of Tigert's personal leadership in the campus activities of the military units came from President Roosevelt himself when he appointed Tigert as the only Southern member of the Board of Visitors to the Naval Academy at Annapolis. Tigert considered this a very high honor and looked forward to the responsibilities with keen anticipation. He had rendered excellent service as a member of a group of university administrative advisors to the War and Navy Departments on college training programs.

The summer of 1944 found Tigert working too strenuously. At 62 years of age, over-fatigue, nervous strain and near exhaustion caused youthful allergies to re-appear; he had a very bad case of shingles. The painful skin eruptions, which covered his body, fortunately did not appear on his face or hands. For almost two weeks he slept scarcely at all. He took shots of thiamine-chloride and gradually improved. He rejected the invitation from his brother to come for an extensive visit and rest because he "was engaged in some very difficult and important problems at the University." He was negotiating with the Veterans Administration for the education of discharged veterans. In addition, he and his administrators were doing a lot of postwar planning as the end of the war, in his judgment, was not far off. He realized that the postwar years would involve the University much more than the war period.

This conclusion he discussed at length with J. A. Murray of the Tampa TRIBUNE. The books studied in the good old days, he told his host, would not be good enough to prepare our sons and daughters for the world of tomorrow. Some students, he predicted, would switch from Latin to Chinese or substitute Russian for Greek. Some would want to study the cultures and ideologies of people, practically unknown before the war because we were witnessing a world revolution and when it was over there would be a "new world with new alignments socially, politically and economically." Educators would see the dawn of a new era with changes perhaps as great as came with the dawn of the Christian Era or with the downfall of Rome. The United States had always taken its lessons from Europe and studies European ideologies . . . "Now schools must develop a scheme of education that is world-wide. . . . Russia is going to be one of the greatest nations, probably a strong rival of the United States. We've got to deal with Russia and we ought to know the customs and habits of the Russian people. We must understand them which we have not done in the past. . . . We have got to have a wider and a more liberal educational program. . . . I believe there will be a revival in liberal education for the reason that if we go on developing technology and fail to bring about a better understanding of its social and political implications we are lost (15).

Approximately 700 freshmen entered the University in September, 1944, which was about 100 more than enrolled in the preceding year. The number of military trainees, however, were beginning to decline, particularly those in the A.S.T.P., which was phased out completely in January, 1945. Other units called into active combat were not replaced. According to the FLORIDA ALLIGATOR it was about 90% veterans and 10% civilians. During the 1943-1944 session the institution provided training for 4493 students in the A.S.T.P. and the Air Force College Training Program (A.F.C.T.P.). In addition there were 693 civilian students enrolled on the college level and 466 on the sub-college level for a grand total of 5,652 (16).

In a speech before the Florida Public Health Association in December, 1944, Tigert gave statistical evidence of the great and increasing need for the building of a medical college. In the middle of the Twentieth Century, he declared, Florida had no medical colleges. Less than 1% of the graduates of the 82 American medical schools came to Florida to practice. People living in small towns and rural areas depended largely upon "family remedies" and the patent medicines they found in drug stores to "doctor" themselves. Heretofore, he told his audience, he had opposed the establishment of a medical school at the University because "a state must have a lot of resources to defray the expenses of a really good medical school that is fully equipped and offers a four-year course." He now contended that the State was able to take the step forward for the health of its citizens and urged the 1945 legislature to act. A medical college at the University could, he maintained, provide greatly expanded health services throughout the State. In Tampa he told a group of civic minded businessmen that the rural sections of Florida had become a "medical desert." He explained that the University sponsored a two-year pre-med course but that many Florida boys who completed this course were unable to gain entrance to medical schools because of over crowded conditions in medical schools throughout the country. When they were admitted to out-of-state medical colleges, they were charged exorbitant out-of-state fees. The time had come for building a state medical college in Florida, he urged (17).

By the spring of 1945 Florida had over 200,000 of its citizens in the armed forces, more than 10,000 of whom were alumni of the University. One hundred seventy-eight University alumni were known to have been killed; many others were listed as missing or as prisoners of war. Two hundred thirty-five alumni had earned 553 decorations. During the closing months of the war, President Tigert had frequent occasions for mourning the loss of former students (18).

But in war a university prepares for peace! At its March meeting the Board of Control instructed President Tigert to "develop and approve courses for veterans in all colleges, departments and subject matter so far as our resources will permit." The University needed also to plan vocational, technical and functional training for which no college credit would be given. All programs would be cleared through the President's office. For months faculty committees had been meeting to consider proposals for peacetime alterations. One committee was studying agriculture, another studying religious education, a third was devoting its attention to the humanities, a fourth was seeking ways of making more comprehensive the teaching of social studies and a fifth committee was working in the biological sciences. The direction from the Board of Control simply gave official approval of the actions already begun by Tigert and his co-workers.

General George C. Marshall wrote President Tigert the welcome news that Florida would be offered the opportunity to continue its affiliation with the War Department in the Army R.O.T.C. program. "We are pleased that the University of Florida has a proposal of continuing its affiliation with the War Department in the important matter of military preparedness," Tigert replied and continued, "of the 125,000 Reserve Officers available at the beginning of the war, 2,000 were trained on our campus" (19).

Major General H. C. Ingles, Chief Signals Officer of the Army Service Forces, thanked Tigert for the service which the University had rendered in its research in Static Direction Finding (sferics). The University had "trained military personnel in its operation and maintenance. It had provided facilities and equipment for putting into operation the first Static Direction Finding (sferics) network in use by the United States Army. These contributions have been the foundations of the establishment of a working system of Static Direction Finding which is now in tactical use by the armed services." Major General Ingles said that "although equipped only with facilities intended for research and development, the University of Florida met the demand for required equipment until regular production could be arranged" (20).

As Tigert received certificates of merit and letters of commendation from ranking military officials for the war efforts of the University of Florida, he continued to plan for the strenuous years ahead which he knew would follow the restoration of peace.

LITERATURE AND RESOURCES CITED

(1) Jacksonville Times-Union, January 8, February 2, 17, 1942; Florida Alligator, January 10, 14, 1942; Pensacola News-Journal, January 11, 1942; Saint Petersburg Times, January 11, 1942.

(2) Florida Alligator, February 27, March 6, 1942; Jacksonville Times-Union, March 4, 1942; Saint Augustine Record, March 8, 1942; Pensacola Journal, March 8, 1942; Ocala Star, March 10, 1942; Tampa Morning Tribune, March 9, 1942.

(3) General O. W. Griswold to Tigert, February 2, 14, 1942; T. J. Needham, Jr. to *id.*, March 7, 1942; all in John J. Tigert's Papers in the library of the University of Florida; hereinafter Tigert Papers will refer to this source.

(4) Tigert, "Where the Light Dwelleth," ms. in Tigert's Papers; Jacksonville Times-Union, June 14, 1942.

(5) Sir Josiah Stamp, "America at the Moment," London Times, June 23, 1942; New York Times, September 6, 1942.

(6) Jacksonville Times-Union, August 19, September 24, 1942; Tampa Tribune, September 4, 18, 1942; Miami Herald, September 11, 1942; Florida Alligator, September 25, 1942.

(7) *Ibid.*, October 2, 1942; Jacksonville Times-Union, October 10, 22, 1942; Collegiate Digest, October 20, 1942.

(8) Tigert, "The Place of a University in Wartime," ms. in Tigert Papers; Florida Alligator, November 20, December 11, 1942.

(9) Florida Alligator, February 12, 19, March 5, 1943; Gainesville Sun, February 19, 28, 1943; Tigert to Sir Francis Wiley, March 3, 1943; *id.* to Fredrick Shannon, March 20, 1943; Major Linton E. Allen to Tigert, March 16, 1943; all in Tigert Papers; press clipping N.P. dated April 17, 1943, *ibid.*

(10) Jacksonville Times-Union, March 21, 1943; Florida Alligator, March 26, 1943.

(11) FLORIDA ALLIGATOR, March 23, 1943; Jacksonville TIMES-UNION, March 28, 1943. In addition to Tigert as chairman, the committee consisted of President Isaiah Bowman, Johns Hopkins University; President Robert E. Doherty, Carnegie Institute of Technology; President Clarence A. Dykstra of University of Wisconsin; Guy Stanton Ford, American Historical Association; the Reverend Robert T. Gannon, President, Fordham University; President Ralph D. Hetzel, Pennsylvania State College; President Felix Morley, Haverford College; Chancellor Ray Lyman Wilbur, Stanford University.

(12) Jacksonville TIMES-UNION, June 28, July 5, 1943; FLORIDA ALLIGATOR, July 2, 1943; Gainesville SUN, June 29, 1943; Tigert to Sir Francis Wylie, July 2, 1943, in Tigert Papers.

(13) Jacksonville TIMES-UNION, July 5, 1943.

(14) Gainesville SUN, November 7, 10, 11, 23, 28, 1943; FLORIDA ALLIGATOR, November 12, 1943.

(15) Paul V. McNutt to Tigert, November 22, 1943. Joe M. Dalton to *id.* November 6, 1943; FLORIDA ALLIGATOR, February 25, September 22, 1944; J. W. Harrelson to Tigert, July 21, 1944; Tigert to Sir Francis Wylie, March 15, 1944; *id.* to Reverend Hoyt M. Dobbs, April 26, 1944: all letters in Tigert Papers; Jacksonville TIMES-UNION, April 10, 1944. In 1944 the Board of Visitors was composed of 7 members appointed by President Roosevelt, 5 U.S. Senators appointed by Vice President Henry A. Wallace and 6 Congressmen named by Speaker Sam Rayburn; Orlando MORNING SENTINEL, July 24, 1944. Holland M. Tigert to Tigert, August 8, 1944; Tigert to Holland Tigert, August 14, 1944; both in Tigert Papers; J. A. Murray, "University President Sees Great Change in Education," Tampa TRIBUNE, August 6, 1944.

(16) FLORIDA-ALLIGATOR, September 29, 1944; Jacksonville TIMES-UNION, September 13, 1944.

(17) Gainesville SUN, December 14, 1944; Jacksonville TIMES-UNION, December 17, 1944; Tampa TIMES, January 30, 1945.

(18) FLORIDA ALLIGATOR, March 2, 9, 1945.

(19) Tigert to Deans, Directors and Administrative Heads of Departments, March 28, 1945; J. A. Murray, "University President Sees Great Changes in Education," Tampa TRIBUNE, August 6, 1944; George Marshall to Tigert, April 2, 25, 1945; Tigert to Marshall, April 10, 1945; all in Tigert Papers.

(20) Major General H. C. Ingles to Tigert, April 4, 1945; *ibid.*

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MEAN HIGH WATER MARK AND USE OF TIDELANDS IN FLORIDA[1]

MAURICE W. PROVOST

Florida Medical Entomology Laboratory (formerly Entomological Research Center),
Department of Health and Rehabilitative Services,
P. O. Box 520, Vero Beach, Florida 32960

ABSTRACT: *An analysis of ocean tide patterns is used to explain the difficulties in determining the mean high water mark in Florida. Seasonal oscillations of the sea are so related to tide intervals that a submergence periodicity on the tidelands is created which is unique to the state. The high marsh remains dry during one part of the year and is almost continuously tide-flooded during the other. Important differences between Atlantic and Gulf coasts are demonstrated. The high marsh, located between mean neap high and mean spring high tide levels, occupies more of the tidelands in Florida than the low marsh. For the protection of tidelands it is recommended that they be delineated by their vegetation until more tidal bench marks are available.*

PRODUCTIVITY OF TIDELANDS—It is only in the past decade or two that the extraordinary productivity of estuaries has been demonstrated and measured. Dr. Eugene P. Odum of the University of Georgia, a pioneer in this type of research, gives (Odum, 1961) the following comparisons in terms of magnitude of gross primary productivity by dry weight of organic matter fixed annually.

Ecosystem	*lbs/acre/year*
Land deserts, deep oceans	Hundreds
Grasslands, forests, eutrophic lakes, ordinary agriculture	Thousands
Estuaries, deltas, coral reefs, intensive agriculture (sugar cane, rice)	Ten-thousands

He further states that the net production of Georgia's estuaries is about 32 million calories per acre per year, far more than is produced by the best wheat and corn fields of the world. Obviously, estuaries must be well fertilized, which they are naturally with nutrients brought in by rivers or flowing off tidal marshlands (Odum, Smalley, 1959; Schelske, Odum, 1961; Shuster, 1966). Shutting off this flow of nutrients has been shown to dramatically reduce estuarine production, whether they arrive by river, such as the blockage of the Nile by the Aswan Dam (Carlander, 1966), or whether they arrive from the mangrove swamps of south Florida (Robas, 1970). The Sapelo Island estuaries studied by Dr. Odum were

[1]Presented before the Florida Society of Geographers, February 12, 1971, Cocoa Beach, Florida.

described as "detritus ecosystems" nourished primarily by cordgrass (*Spartina alterniflora*) and black rush (*Juncus roemerianus*) marshes, identical with the coastal marshes of Florida north of Cedar Keys or Daytona Beach. Within the past three years it has been shown by University of Miami researchers that estuaries in Everglades National Park are also detritus ecosystems and equally productive (Heald, Odum, 1969), but their nutrients originate primarily in the fallen leaves and other debris from red mangrove (*Rhizophora mangle*) swamps.

Role of Tidelands in Fisheries Production—These studies in Georgia and Florida involved measurements of total life productivity or biomass and produced strong evidence that even marine or open sea fisheries were dependent on nutrients furnished by the estuaries. Other studies (Anderson, 1958; Darnell, 1959; Gunter, Christmas, Killebrew, 1964; Harrington, 1966; Kilby, 1948; Lindner, Anderson, 1956; Marshall, 1958; Tabb, 1958, 1966; Van Engel, 1958) have singled out individual species of fish, crab, shrimp, etc. and proved that they could not maintain their populations without vast tidal marshlands and mangroves to protect and nourish their juvenile stages. The most important commercial and sport fisheries were among those shown to be critically dependent on marshlands and mangroves. Marine and estuarine research, truly escalating these days, is demonstrating ever more and more the complete absurdity of sacrificing tidelands except in those limited areas where other public interests are paramount. The estuaries of Florida, from the mouth of the St. Mary's River to Florida Bay and out to Escambia Bay, comprise about three million acres. Of these three million acres a little over two million are open water and a little under a million are in salt marshes and mangrove swamps (computed from appendix to ref. U. S. Fish and Wildlife Service, 1954), i. e. are tidelands. There is thus involved a tremendous amount of land, until only recently considered wasteland and much of it practically given away by the original owner, the State of Florida, for real estate development.

By legally accepted definition, tidelands are that land lying between mean low water and mean high water, as defined by the U. S. Coast and Geodetic Survey (1962). Estuarine tidelands in Florida are almost everywhere vegetated. It is extremely important to realize that Florida's vast estuarine tidelands usually contain two mean high water marks (Fig. 1). The outer one separates the low marsh, flooded by tides almost daily, from the high marsh, flooded only by the higher tides. Between these two mean high water marks is a paludal basin which can be very extensive in Florida. Even though frequently occupied by black mangrove (*Avicennia nitida*), saltwort (*Batis maritima*) or saltgrass (*Distichlis spicata*), rather than red mangrove or cordgrass, much of it is still below mean high water. At the outer mean high water mark there is usually a natural levee a few inches high. This was reported and ably discussed (Davis, 1940) by one of the world's outstanding authorities on mangrove ecology, and we ourselves in 25 years of studying tidelands have repeatedly observed it. The trapping and evaporating of salt water in the basin results in high concentrations of salt in the soil. During the dry season, which corresponds with the low-tide season (cf. below), this paludal basin goes months without flooding and its ground waters become saltier than the ocean. Only the most salt-tolerant plants (Taylor, 1939), such as black mangrove, salt grass, saltwort, glassworts (*Salicornia* spp.), sea-blite (*Dondia linearis*), and key grass (*Monanthochloe littoralis*) can therefore occupy the high marsh.

Unfortunately, nearly all the research mentioned as proving the necessity of the estuarine tidelands to fisheries maintenance has been done on the low marsh or in red mangrove swamps. However, studies (Harrington, 1958, 1966; Harrington and Harrington, 1961, 1971, 1972) by Dr. Robert W. Harrington, Jr. of our staff give strong evidence that high marsh and black mangrove swamp are also very productive, although their delivery of nutrients to the estuary may be in seasonal bursts (like river deltas) rather than daily pulses. Certainly young tarpon (Harrington, 1966), mullet (Kilby, 1948), shrimp (Gunter, Christmas, Killebrew, 1964) and many other marine life forms as well as waterfowl (Provost, 1959, 1967, (1969) feed and grow fast on the flooded high marsh. It may be added, parenthetically here, that mosquito breeding on the low marsh is rare. It can be very heavy on the high marsh, but is effectively stopped in Florida by canalling or impounding (Philen, Carmichael, 1956; Provost, *ibid*).

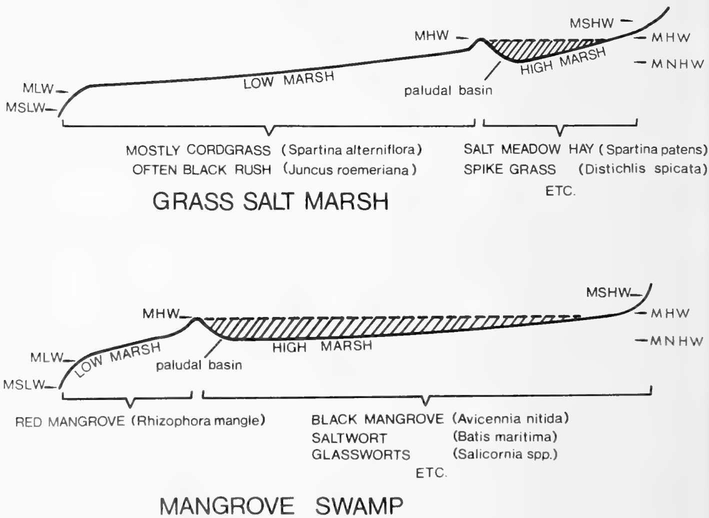

Fig. 1. Intertidal profiles in Florida, with plants characterizing low and high marsh. MSHW, mean spring high water; MHW, mean high water; MNHW, mean neap high water; MLW, mean low water; MSLW, mean spring low water.

Protecting Tidelands on Atlantic Seaboard—Estuaries and their tidelands form ecosystems which can easily be damaged or destroyed by improper treatment (Arnold, 1967; Hutton et al., 1956; Woodburn, 1965). It is the growing realization of the importance of estuaries to marine fisheries, and of salt marshes and mangrove swamps, in turn, to the estuaries, which has brought about so much concern for coastal area management (Heath, 1968; Maine State Planning Office, 1970; Maney, Marland, West, 1968; North Carolina Estuarine Study Committee, 1968; Odum, 1966; Plager, Maloney, 1968; Provost, 1968). Several New England, Middle Atlantic and Southeastern states have adopted stringent regulations to protect their tidal marshlands (e. g., Georgia, State of, 1970; Massachusetts, Commonwealth of, 1965; New Jersey, State of, 1970; Rhode Island, State of, 1965).

Florida, in addition to being one of the most important fishery states, is also and importantly a tourist and retirement state. This latter situation has placed a high value on waterfront development for residential purposes, with a corresponding strain on maintaining the ecological integrity of its salt marshes and mangrove swamps (Woodburn, 1963). The State already has laws dealing with submerged lands and with bulkhead lines, along with a long and complicated history of judicial interpretations and litigations (Brunn, DeGrove, 1959; Florida, State of, 1970a). Lately it has been advanced that the bulkhead line should be at the mean high water mark, but little has been done to define this line. On December 15, 1970, the Trustees of the Internal Improvement Trust Fund (= Governor and Cabinet) adopted an engineering method of locating what they refer to as "a continuous line of mean high water"—the latter presumably to be the legal boundary between State-owned submerged lands and privately owned upland property. Since the method calls for the leveling to start on upland and end where mean high water is first intercepted it has the merit of potentially protecting both high and low marsh. It is important to point out that there are astronomical problems, in every sense of the adjective, in trying to establish a mean high water meander by engineering survey. We can appreciate this best by reviewing first the nature of ocean tides and their special features in Florida.

Tides and Tidemarks in Florida—Ocean tides are caused and governed by a multitude of factors but by far the most important are phase of the moon, distance of the moon from the earth, and declination of the moon with respect to the earth's equator. These three lunar influences can be summarized as follows: (1) The moon when in full or new phase, its gravitational pull being reinforced by that of the sun, exerts a maximum pull on the ocean and creates *spring* tides, meaning large tide intervals, whereas the opposite or *neap* tides occur on either of the quarter moons. (2) As might be expected, when the moon is closest to the earth, i. e. at perigee, it exerts maximum pull and creates extra large or *perigean* tides, while at its farthest from the earth it generates extra small or *apogean* tides. (3) When the moon's axis is at its greatest declination from the earth's equator, 23 1/2° north or south, it exerts its maximum pull creating large tide intervals called *tropic* tides, whereas when it is in line with the earth's equator the minimal or *equatorial* tides result. Each of these three moon factors has its own period or cycle, thus:

		Large Interval	Small Interval
I	Phase (29 1/2 days)		
	Full moon; new moon:	spring tides	neap tides
	Quarter moons:		
II	Distance cycle (27 1/2 days)		
	Nearest earth or perigee:	perigean tides	apogean tides
	Farthest or apogee:		
III	Declination cycle (27 1/3 days)		
	Max. declination N or S:	tropic tides	equatorial tides
	Moon on equator:		

Whenever any of these periods coincide, extra large tide intervals result. Phase and distance of the moon come into mathematical phase or coincide on

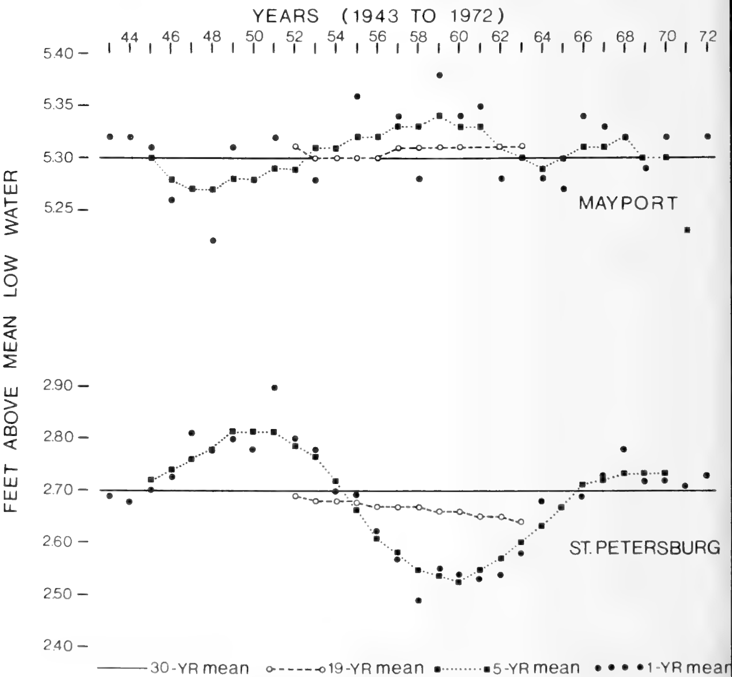

Fig. 2. Thirty-year record of mean spring high waters at Mayport and St. Petersburg, Florida.

approximately the same date every four years. Since these are the two most important tide factors on the Atlantic coast of Florida, with phase foremost, we have prominent spring tides on that coast at 14 3/4-day intervals (full and new moons) and a 4-year cycle of extra large perigean-spring tide intervals. Around Cape Sable and coming up the Gulf coast of Florida, there is a discontinuous but generally progressive shift toward moon declination becoming the most important tide factor, followed by phase. On that coast therefore, especially north of Tampa Bay and westward through the panhandle, there are prominent tropic tides at 13 3/4-day intervals and an 18 1/2-year cycle of extra large tropic-spring tides. The long-term tide cycles are shown in Fig. 2 for Mayport and St. Petersburg which are the U. S. Coast and Geodetic Survey's reference stations for tide

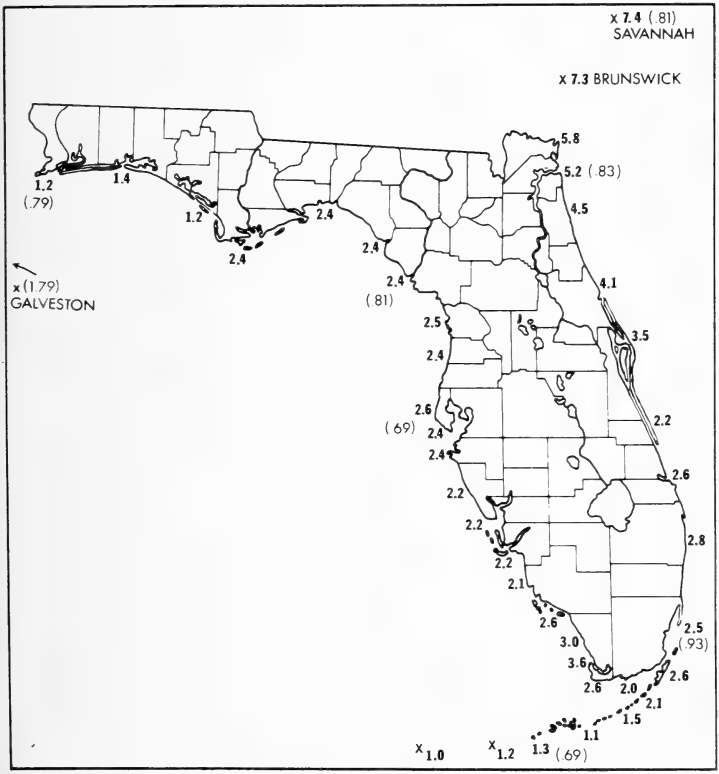

Fig. 3. Mean tide intervals in Florida and 100-year sea-level rise, in parentheses, calculated from U.S.C.G.S. data. Both in feet and tenths.

predictions on most of the east and west coasts, respectively, of the Florida peninsula. The 30-year mean spring high water is 5.304 feet above mean low water at Mayport and 2.688 feet above mean low water at St. Petersburg. A 19-year running average approximates these data at both stations. A 5-year running average, by eliminating the 4-year cycle, brings out the 19-year cycle. This cycle, as stated earlier, is pronounced enough on the Gulf coast to be readily discernible in a plotting of yearly means. What is unexplainable to this author is that the 19-year cycle on the east coast should be, apparently, perfectly staggered with that on the west coast.

The tide intervals, i. e. amplitude or vertical distance from low to high tide of any one cycle, vary in dimension geographically (Fig. 3). In the bight to the north, Savannah and Brunswick have mean tide intervals of a little over seven feet. Florida has much smaller tide intervals, varying as annual means from roughly 6 feet at the Georgia line to a little over one foot in the lower Florida Keys and west of the Apalachicola River. The peninsula has mean tide ranges between 2 1/2 and 4 1/2 feet on the east coast and between 2 and 3 feet on the west coast. It must be borne in mind that these tide intervals are for the ocean front. Within bays, lagoons or other estuaries, tide intervals rapidly diminish with distance from

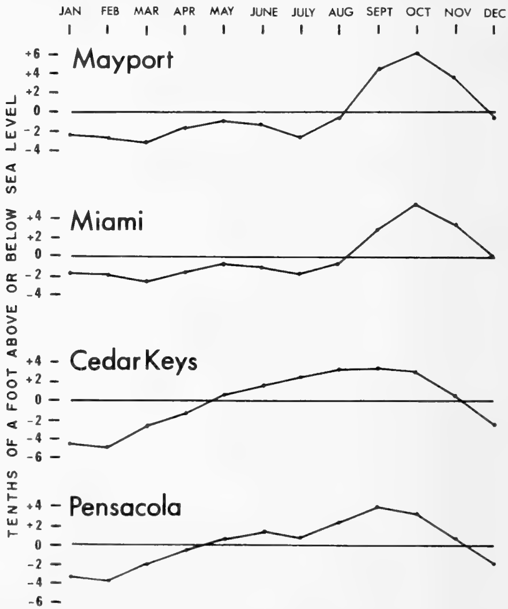

Fig. 4. Annual sea-level patterns in Florida contrasting Atlantic coast (two upper curves) with Gulf of Mexico coast (two lower curves). Adapted from drawings in Marmer (1951).

the nearest inlet and may play out altogether as a lunar phenomenon. In the latter case, exemplified in the middle reaches of the IndiaRiver, wind-generated tides may far outdistance lunar tides in significance.

Now we come to an all-important consideration for Florida, *viz.* mean sea level. Theoretically the above-described changes in tide intervals could go through their cycles, long and short, and never change their midpoints of amplitude. This would mean a constant sea level, something which actually occurs nowhere. On the Atlantic seaboard north of Florida, mean sea level doesn't change much through the year, particularly when compared to tide intervals. But on all coasts of Florida there are very pronounced annual sea-level patterns and these are far more significant when related to tide intervals. A closer examination (Fig. 4) shows these patterns differing between coasts in an important aspect. On the Atlantic coast, the monthly mean sea level climbs rapidly above the mean annual between August and September. On the Gulf coast the monthly sea level rises above the mean annual much more slowly and considerably earlier in the year, usually in May, and it stays above mean annual half the year compared to only three months on the Atlantic coast. An analysis of 1972 predicted tides rising above mean neap high water, usual low point on the high marsh, was made for Boston, Massachusetts (= Atlantic coast north of Florida) and for Mayport (= east coast of Florida) and St. Petersburg (= Gulf coast of Florida). For all three sites (Table 1) the number of high tides reaching between mean neap and mean spring high water marks varies but little from month to month. At Boston this is true as well for tides reaching or exceeding mean spring high water, whereas in Florida such tides occur seasonally only. At Mayport tides exceeding mean spring high water will not occur in January and February and will be very common from

Table 1. Comparison of elevations reached by 1972 (predicted) high tides at Boston, Mass., Mayport, Fla., and St. Petersburg, Fla. by months. MNHW and MSHW are, respectively, mean neap high water and mean spring high water.

		Number of daily tides reaching indicated tide levels												
		J	F	M	A	M	J	J	A	S	O	N	D	YR
> MSHW	Boston	1	2	6	6	7	7	5	3	5	6	6	6	60
	Mayport			2	5	5	4	2	3	9	13	11	5	59
	St. Petersburg					3	8	10	4	1	3	3		32
> MSHW	Boston	2	4	6	6	7	7	6	7	6	6	6	6	69
	Mayport	1		3	5	6	5	3	8	13	16	13	6	79
	St. Petersburg					6	11	13	11	3	4	5	3	56
MNHW to MSHW	Boston	23	20	19	17	20	19	22	23	20	19	17	19	237
	Mayport	23	19	19	15	18	16	21	24	21	18	19	20	233
	St. Petersburg	24	22	22	23	24	20	21	27	29	28	22	24	286

September to November; at St. Petersburg they will occur only from May to November and attain high numbers in June and July.

The high marsh, described earlier, usually develops at elevations between mean neap and mean spring high waters. The peculiar annual sea-level patterns in Florida thus create a unique flooding pattern for the high marsh (Fig. 5). It can remain for months unflooded even by most spring tides, since these must reach

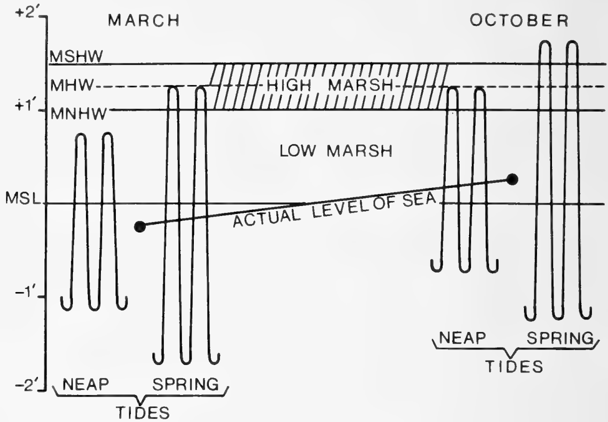

Fig. 5. Schematic drawing illustrating how, in Florida, the same tide intervals can flood the high marsh continuously at one time of the year and not at all at another. MSHW, mean spring high water; MHW, mean high water; MNHW, mean neap high water; MSL, mean sea level.

above mean high water to top the natural levee separating high from low marsh. At another time of the year, with identical tide intervals, the high marsh remains almost continually flooded because even neap tides reach the mean high water level. This is a situation peculiar to Florida and one of utmost importance in understanding the so-called "mean high-water mark" in this State. The laws of the State and their court interpretations (Brunn, DeGrove, 1959; Florida, State of, 1970a; Plager, Maloney, 1968) make frequent use of such expressions as "submerged" lands and "navigable" versus "non-navigable" waters, but nowhere does there seem to be the least intimation or recognition that vast acreages of tideland in Florida—most of the earlier-described high marsh—are dry as dust during a goodly part of the year and almost continuously "submerged" and "navigable" during the other part. And in this respect it is again worthwhile considering the contrast between Atlantic and Gulf coasts. On the Atlantic side (Fig. 6), tides rise above the mean spring level and therefore flood most of the high marsh almost half the days in September, October and November. The 4-year cycle of exaggerated tides is seen not only in these fall months but in the far less frequent spring floodings. On the Gulf side (Fig. 7), we find high-marsh floodings starting in June and persisting through November for about nine years in a row and then lessening dramatically and lasting only through the summer for about nine years. The 18 1/2-year cycle mentioned earlier as characterizing the Gulf of Mexico is very noticeable in such a chart.

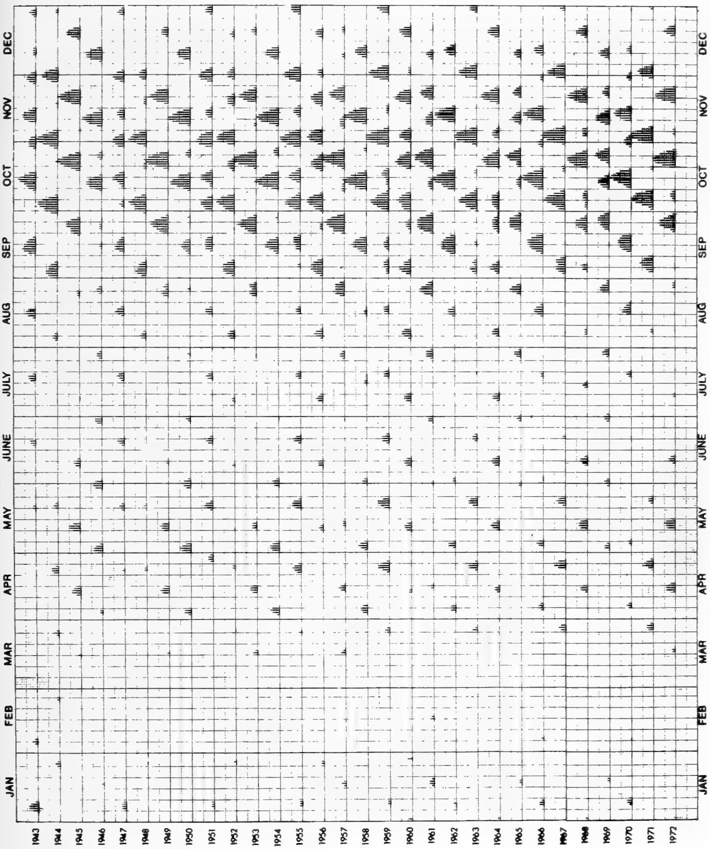

Fig. 6. Predicted daily tides exceeding 5.3-foot mean spring high water at Mayport, Florida, 1943 to 1972. Fine lines above 5.3-foot base line are tenths of a foot.

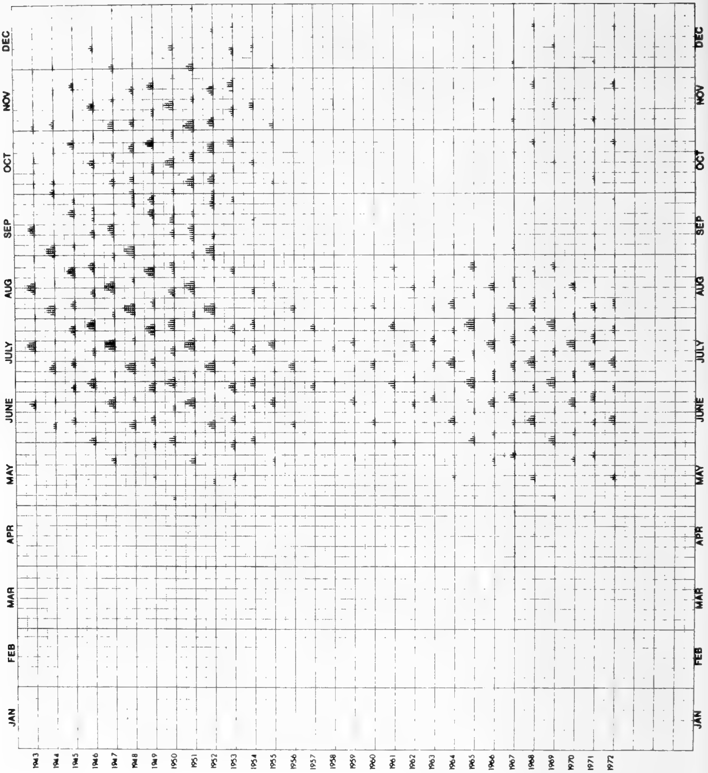

Fig. 7. Predicted daily tides exceeding 2.7-foot mean spring high water at St. Petersburg, Florida, 1943 to 1972. Fine lines above 2.7-foot base line are tenths of a foot.

As though the tide picture in Florida were not enough complicated by the facts so far presented, we must interject a final factor—the historical rise in sea level (Fig. 8). For apparently a century, at least, sea level with respect to land has been rising along Atlantic and Gulf coasts of North America (Marmer, 1951). In the thirties and forties of this century, the rise was so precipitous as to be alarming (Marmer, 1948), but it subsequently dropped and with two decades added to tide records which were not long in the first place (cf. Marmer, 1951), it is now possible to compute the long-range trends with more accuracy and the rate of sea-level rise proves not to be so alarming. Along the Atlantic coast of the United States, sea level is rising one foot every 72 to 125 years, depending on locality, and averaging about a foot per century. In the Gulf of Mexico the picture is not clear for lack of records from Mexico and Central America, but it does appear that the sea-level rise is slower than in the Atlantic on eastern Gulf shores and considerably faster on western Gulf shores. For Florida, specifically, the 100-year sea-level rise so far calculable varies from .69 feet to .93 feet, averaging .79 feet—a figure not great enough to complicate the life of several generations of Floridians.

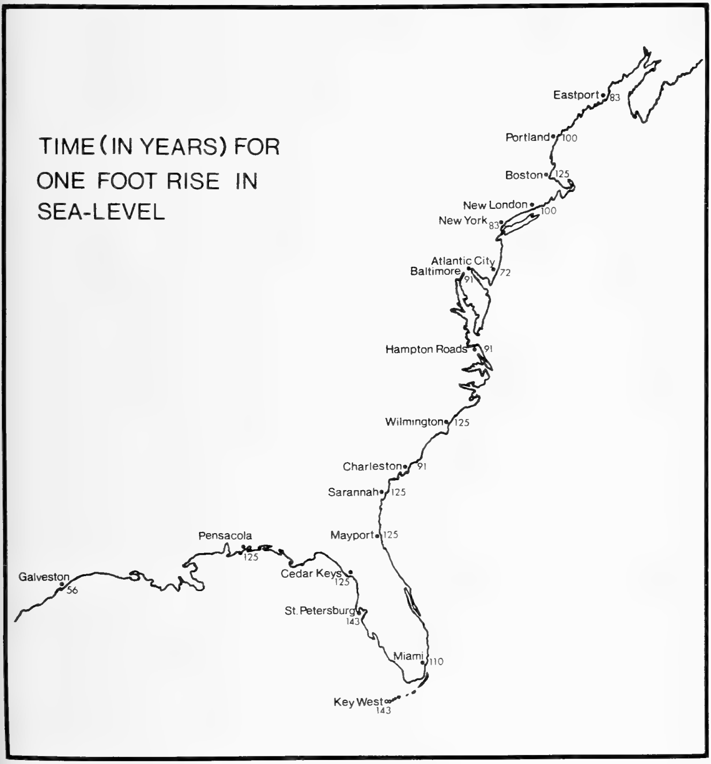

Fig. 8. Coastline of eastern United States indicating, for 18 reference tide stations, the rate of rise in sea level. Calculated from U.S.C.G.S. data.

A recording tide gauge operated continuously since 1959 by this laboratory in the Indian River close to our marshes reveals (Fig. 9) a local sea level 0.39 feet above the 1929 mean sea level datum used for all land elevations in this country. Since our record centers on 1965, or 36 years after 1929, sea level at this station is rising about a foot per century. This gauge also reveals dramatically the significance of the annual sea-level pattern in Florida, for here monthly mean high waters stayed between .4 and .7 above mean sea level from December to August

(9 months) but were 1.2 to 1.4 feet above mean sea level from September to November (3 months). The seasonal movement, therefore, averaged .75 feet—actually more than the mean tide interval for the 12 years, which was .69 feet.

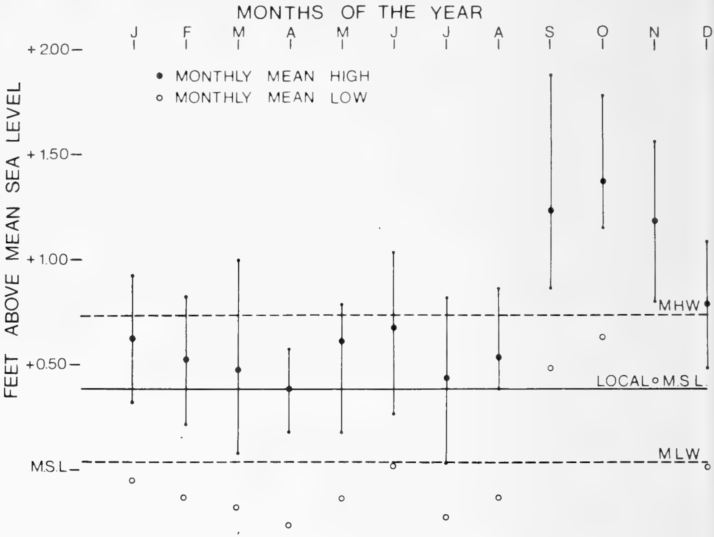

Fig. 9. Twelve-year (1959-1970) record of tides in the Indian River at the foot of Oslo Dock Road. Gauge operated by Entomological Research Center. MHW, mean high water; MLW, mean low water; MSL, mean sea level. Total range of monthly mean high waters shown as vertical bar through means.

Tideland Problems—What an engineer faces, then, in establishing the mean high water mark anywhere in Florida is virtually chaos. Tide intervals vary daily, monthly, seasonally, in cycles of years, and, in addition, they vary geographically. All tide data and tidal benchmarks set by the U. S. Coast and Geodetic Survey are in terms of local mean low water. All land elevations and bench-marks set by the U. S. Geological Survey are in terms of the 1929 mean sea-level datum which is uniform for the United States, having been established as the result of a nation-wide geodesic network of leveling. Where recording tide gauges have been operating at least 19 years, the U. S. Coast and Geodetic Survey has computed the relationship of local mean low water to mean sea level, 1929 datum. As might be expected, the variation from place to place is considerable. For example, for points within sight of one another, the mean low water is 1.78 feet below mean sea level at Ft. Pierce Breakwater, 1.37 feet below at Binney Dock on the inlet, and 0.58 feet below at the Ft. Pierce Municipal Dock. There is no denying that with the help of tidal bench marks engineers could establish a mean high water mark anywhere—but there were until recently only 41 tidal bench marks, for instance, between Fernandina and Miami. The leveling must start with a U. S. Coast and Geodetic tidal bench mark, and this will usually be miles from the point where the mean high water mark is to be set. If it starts with a U. S. Geological Survey mark, the great majority (Gunter and staff, 1948), a year's tide-gauge recording at the end of the line may be necessary in addition to the surveying. And how account for the long-term tide cycles and the rising sea level, which in many places has risen four to seven inches since the reference year of 1929? It is all clearly an engineering quagmire, not to mention a tax-payer's nightmare. It is not surprising that even in tight little Rhode Island (Rhode Island, State of, 1965), where tide marks are immensely more easily established than in Florida, the tidal marshlands are not delineated legally by engineering methods.

Fortunately there is a stop-gap means out of this quagmire. Intertidal plants are adapted both to salinities and to the tidal submergence rhythms they encounter. Plant ecologists can readily establish elevations within tidal marshlands by the vegetation (Adams, 1963; Chapman, 1960; Davis, 1940; Hinde, 1954; Johnson, York, 1915; Kurz, Wagner, 1957; Penfound, Hathaway, 1938), whether grass, shrub, or mangrove. This is because the plants become perfect integrators of all the variables bedevilling the engineer. And to make matters even more satisfying, salt marshes and mangrove swamps are normally dominated by only a few species of easily recognizable plants. Having recognized and mapped the distribution of these few plants, therefore, it is usually a simple matter to characterize the tidelands vegetatively. It is not mere coincidence, therefore, that those states which have passed the most commendable legislation to zone, manage and develop their coastal marshlands (Georgia, State of, 1970; Massachusetts, Commonwealth of, 1965; New Jersey, State of, 1970; Rhode Island, State of, 1965) have spelled out in both common and scientific names those few dominant plants which characterize their salt marshes. Florida should do likewise for its intertidal marshlands and swamplands.

Conclusion—In conclusion then, Florida has almost a million acres of estuarine tidelands in marsh or mangrove. Much of this terrain, regardless of present ownership, must remain inviolate if the State's commercial and sport fisheries are to be maintained, not to mention the retention of integrity and aesthetic values of landscapes and seascapes. This can be done without an unconscionable sacrifice of real-estate waterfront development with the proper use of knowledge and imagination, as the Rookery Bay Area Project (Conservation Foundation, The, 1968) beautifully exemplifies. It is not enough for Florida to implement a wise program of coastal development (Florida, State of, 1970b), it must protect and provide for proper utilization of its tidelands with legislation more realistic and enforcible than the 1957 Bulkhead Act (Florida, State of, 1970a; Woodburn, 1965). A good model is Georgia's "Coastal Marshlands Protection Act of 1970" (Georgia, State of, 1970) which not only creates a Coastal Marshlands Protection Agency but provides for both protection and utilization in the public interest.

ACKNOWLEDGMENTS—Although many of the data used in the analysis of tides and sea levels were from reports of the U. S. Coast and Geodetic Survey (U. S. Dept. of Commerce, 1943-1972, especially), the computations and interpretations thereof are solely the author's. In both computations and drawings, the author was greatly assisted by artists of the Entomological Research Center, James Clark and the late Willem Janse.

LITERATURE CITED

ADAMS, D. A. 1963. Factors influencing vascular plant zonation in North Carolina salt marshes. Ecology 44: 445-456.

ANDERSON, W. W. 1958. Larval development, growth and spawning of striped mullet (*Mugil cephalus*), along the south Atlantic coast of the United States. Fishery Bull. U. S. F. W. S. 58:501-519.

ARNOLD, E. L., JR. 1967. Man's alternation of estuaries by dredging and filling a grave threat to marine resources. Proc. 18th Ann. Conf. Southeast. Assoc. Game and Fish Comm. pp. 269-273.

BRUNN, P., AND J. D. DEGROVE. 1959. Bayfill and bulkhead line problems; Engineering and management problems; Engineering and management considerations. Pub. Adm. Clearing Service Univ. Florida: Studies in Public Administration No. 18. 36 pp.

CARLANDER, K. D. 1966. Observations on fishery management in Africa. Iowa State J. Sci. 73: 145-151.

CHAPMAN, V. J. 1960. Salt marshes and salt deserts of the world. Leonard Hill (Books) Ltd. London. 392 pp.

CONSERVATION FOUNDATION, THE. 1968. Rookery Bay Area Project: A demonstration study in conservation and development, Naples, Florida. Washington, D. C. 61 pp.

DARNELL, R. M. 1959. Studies on the life history of the blue crab (*Callinectes sapidus* Rathbun), in Louisiana waters. Trans. Amer. Fish. Soc. 89: 294-304.

DAVIS, J. H. 1940. The ecology and geologic role of mangroves in Florida. Pap. Carnegie Inst. Washington. Tortugas Lab. 32: 305-412.

FLORIDA, STATE OF. 1970a. Title XVII: Public lands and property. Florida Statutes, Chapter 253 (Bulkhead Act of 1957, amended): Internal Improvement Trust Fund. 21 pp.

————. 1970b. Florida Laws, Chapter 70-259. An Act creating the coastal coordinating council, etc. Filed in Office of Secretary of State, July 1, 1970.

GEORGIA, STATE OF. 1970. Coastal Marshlands Protection Act of 1970. No. 1332 (House Bill No. 212). Georgia Laws, 1970 Session, pp. 939-949.

GUNTER, G., J. Y. CHRISTMAS, AND R. KILLEBREW. 1964. Some relations of salinity to populations of motile estuarine organisms, with special reference to Penaeid shrimp. Ecology 45: 181-185.

GUNTER, H., AND STAFF. 1948. Elevations in Florida. Florida Geol. Surv. Bull. 32. 1158 pp.

HARRINGTON, R. W., JR. 1958. Morphometry and ecology of small tarpon, *Megalops atlantica* Valenciennes, from transitional stage through onset of scale formation. Copeia 1958: 1-10.

————. 1966. Changes through one year in the growth rates of tarpon, *Megalops atlanticus* Valenciennes, reared from mid-metamorphosis. Bull. Marine Sci. 16: 863-883.

————, AND E. S. HARRINGTON. 1961. Food selection among fishes invading a high subtropical salt marsh: from onset of flooding through the progress of a mosquito brood. Ecology 42: 646-664.

————, AND ————. 1972. Food of female marsh killifish, *Fundulus confluenius* Goode and Bean, in Florida. Amer. Midland Nat. 87:492-502.

————, AND ————. 1972. Effects on fishes and their forage organisms of impounding a Florida salt marsh to prevent breeding of saltmarsh mosquitoes. Mosquito News. (In press.)

HEALD, E. J., AND W. E. ODUM. 1969. The contribution of mangrove swamps to Florida fisheries. Proc. Gulf and Caribb. Fish. Inst., 22nd annual session, pp. 130-135.

HEATH, M. S., JR. 1968. Estuarine study committee. A comprehensive estuarine program for the State of North Carolina. 25 pp. (Mimeographed.)

HINDE, H. P. 1954. The vertical distribution of salt marsh phanerograms in relation to tide levels. Ecol. Monog. 24: 209-225.

HUTTON, R. F., B. ELDRED, K. D. WOODBURN, AND R. M. INGLE. 1956. The ecology of Boca Ciega Bay with special reference to dredging and filling operations. Fla. State Bd. of Conservation. Tech. Ser. No. 17 (pt. 1). 87 pp.

JOHNSON, D. H., AND H. H. YORK. 1915. The relation of plants to tide levels. Carnegie Inst. Wash. Publ. 206. 162 pp.

KILBY, J. D. 1948. A preliminary report on the young striped mullet (*Mugil cephalus* L.), in two Gulf coastal areas of Florida. Quart. J. Fla. Acad. Sci. 11: 7-23.

KURZ, H., AND K. WAGNER. 1957. Tidal marshes of the Gulf and Atlantic coasts of northern Florida and Charlestown, South Carolina. Fla. State Univ. Studies no. 24. 168 pp. Tallahassee.

LINDNER, M. J., AND W. W. ANDERSON. 1956. Growth, migrations, spawning and size distribution of shrimp, *Penaeus setiferus*. Fishery Bull. U. S. F. W. S. 56: 555-645.

MAINE STATE PLANNING OFFICE. 1970. Maine coastal development plan: Phase 1 report. 54 pp.

MANEY, D. S., F. C. MARLAND, AND C. B. WEST, eds. 1968. The future of the marshlands and sea islands of Georgia: A record of a conference convened by the Georgia Natural Areas Council and the Coastal Area Planning and Development Commission. Brunswick, Ga. 128 pp.

MARMER, H. A. 1948. Is the Atlantic coast sinking? The evidence from the tide. Geogr. Rev. 38: 652-657.

———. 1951. Tidal datum planes. U. S. Coast and Geodetic Survey. Special Publ. No. 135. 142 pp.

MARSHALL, A. A. 1958. A survey of the snook fishery of Florida, with studies of the biology of the principal species, *Centropomus undecimalis* (Bloch). Fla. State Bd. of Conservation, Tech. Ser. No. 22. 39 pp.

MASSACHUSETTS, COMMONWEALTH OF. 1965. An act providing for the protection of the coastal wetlands of the Commonwealth. Chapter 768, Massachusetts Statutes.

NEW JERSEY, STATE OF. 1970. The Wetlands Act of 1970. Chapter 272, Public Laws of 1970.

NORTH CAROLINA ESTUARINE STUDY COMMITTEE. 1968. A comprehensive estuarine program for the State of North Carolina. 30 pp.

ODUM, E. P. 1961. The role of tidal marshes in estuarine production. N. Y. State Conservationist. (June-July): 12-15; 35.

———. 1966. The urgent need for landscape zoning of the estuarine region according to ecosystem principles. Symp. of Estuarine Ecology of Coastal Waters of North Carolina. May 12 at Raleigh, N. C.

———, AND A. E. SMALLEY. 1959. Comparison of energy flow of a herbivorous and a deposit-feeding invertebrate in a salt marsh ecosystem. Proc. Nat. Acad. Sci. 45: 617-622.

PENFOUND, W. T., AND E. S. HATHAWAY. 1938. Plant communities in the marshlands of southeastern Louisiana. Ecol. Monog. 8: 1-56.

PHILEN, E. A., AND G. T. CARMICHAEL. 1956. The management of water for mosquito control in the coastal marshes of Florida. Mosquito News. 16: 126-129.

PLAGER, S. J., AND F. E. MALONEY. 1968. Controlling waterfront development. Publ. Adm. Clearing Service of the Univ. of Fla.: Studies in Public Administration No. 80. 39 pp.

PROVOST, M. W. 1959. Impounding salt marshes for mosquito control and its effects on bird life. Fla. Naturalist. 32: 163-170.

———. 1967. Managing impounded salt marsh for mosquito control and estuarine resource conservation. LSU Marsh and Estuary Symposium. pp. 163-171.

———. 1968. Florida's estuaries and their protection. Paper read at Southwest Fla. Conservation Clearinghouse, May 16, 1968, at Ft. Myers, Fla.

———. 1969. Man, mosquitoes and birds. Fla. Naturalist. 42: 63-67.

RHODE ISLAND, STATE OF. 1965. Acts of the General Assembly, January Session. 1965, Chapter 140.

ROBAS, A. K. 1970. South Florida's mangrove-bordered estuaries: Their role in sport and commercial fish production. Sea Grant Information Bull. No. 4. Univ. of Miami Sea Grant Institutional Program. 28 pp.

SCHELSKE, C. L., AND E. P. ODUM. 1961. Mechanisms maintaining high productivity in Georgia estuaries. Proc. Gulf and Caribb. Fish. Inst., 14th annual session. pp. 75-80.

SHUSTER, C. N., JR. 1966. The nature of a tidal marsh. N. Y. State Conservationist. (August-September).

TABB, D. 1958. Differences in the estuarine ecology of Florida waters and their effect on populations of the spotted weakfish, *Cynoscion nebulosus* (Cuvier and Valenciennes). Trans. 23 No. Amer. Wildl. Conf. pp. 392-401.

———. 1966. The estuary as a habitat for Spotted Seatrout, *Cynoscion nebulosus*. Amer. Fisher. Soc. Spec. Publ. 3: 59-67.

TAYLOR, N. 1939. Salt tolerance of Long Island salt marsh plants. N. Y. State Mus. Circ. 23. 42 pp.

U. S. DEPT. OF COMMERCE, COAST AND GEODETIC SURVEY. 1943 to 1972. Tide Tables, east coast of North and South America. U. S. Government Printing Office, Washington, D. C.

———. 1962. Shore and sea boundaries. Vol. 1. Publ. 10-1. xxiv + 420 pp.

U. S. Fish and Wildlife Service. 1954. The wetlands of Florida in relation to their wildlife values. Report (with tabular appendices) compiled by Office of River Basin Studies Staff, Fish and Wildlife Serv. Region 4.

Van Engel, W. A. 1958. The blue crab and its fishery in Chesapeake Bay. I. Reproduction, early development, growth and migration. Com. Fish. Rev. 20: 6-17.

Woodburn, K. D. 1963. A guide to the conservation of shorelines, submerged bottoms and saltwaters with special reference to bulkhead lines, dredging and filling. Fla. State Bd. of Conservation Educ. Bull. 14. 8 pp.

———. 1965. A discussion and selected, annotated references of subjective or controversial marine matters. Fla. State Bd. of Conservation. Tech. Ser. No. 46. iv + 50 pp.

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Biological Sciences

STUDIES ON MANGROVE ALGAL COMMUNITIES IN PUERTO RICO

Paul R. Burkholder and Luis R. Almodóvar

Department of Marine Sciences, University of Puerto Rico
Mayaguez, Puerto Rico 00708

Abstract: *Quantitative data have been presented for the occurrence and primary productivity of marine algae growing on the roots of red mangrove in southern Puerto Rico. The wet weight of algae per root (of nine roots) averaged 274g. The average number of algal species per root (of ten roots) was 5.1 and the greatest number per root was ten. A list of species which were dominant on individual roots includes:* Acanthophora spicifera, Anadyomene stellata, Batophora oerstedii, Caulerpa racemosa, C. verticillata, Dictyota dichotoma, Halimeda incrassata, Valonia ventricosa, Wrangelia bicuspidata, *and occasionally others. In a set of typical physiological observations on 14 kinds of algae chlorophyll a content averaged 2.11 mg g^{-1}, carbon fixed in mg per g dry wt per day averaged 34.1 with the oxygen method and 14.7 with the ^{14}C technique. The flora of an average root was calculated to produce in gross photosynthesis 1.47 g C per day, and in "net" assimilation with the ^{14}C method about 0.64 g C per day. The flora of a mangrove root appears to produce about as much organic matter per day as has been observed in a square meter column of phytoplankton in moderately rich tropical lagoons.*

The development of marine macroalgae, along with invertebrate animals, on the roots of the mangrove *Rhizophora mangle*, is outstanding in the region near La Parguera, Puerto Rico. The large mangrove roots offer an excellent supporting substrate for both plants and animals. Relatively small changes of tide, low rainfall during most of the year, adequate light, suitable salinity, protection from heavy seas, and chemical fertility of the neritic waters in the Guayacan channel and other lagoons of southern Puerto Rico provide favorable conditions for growth of numerous species of algae. To date, a large list of macroalgae has been identified from collections made in these mangrove forests (Almodóvar, 1968). It is obvious that the epiphytic community of sea weeds provides a good supply of food and offers shelter for many kinds of marine invertebrates and vertebrates that live permanently in the mangrove, as well as others that occasionally visit the region to feed or reproduce (see the review by Macnae, 1968).

The purpose of this communication is to report our observations concerning the kinds of algae and their quantitative occurrence on representative samples of mangrove roots. Data will also be presented for the chlorophyll content of the species and their photosynthesis determined by carbon 14 uptake and oxygen production in light and dark bottles.

METHODS AND RESULTS—Samples of roots bearing different kinds of algae were sawed off at water level and transported intact in large containers of sea water to the laboratory on Magueyes Island. Each whole root community was photographed and weighed. Then the plants and animals were removed manually and placed in separate containers for weighing and recording by photography. The organisms were dried in an oven at 100C and the dry weights determined. Representative fresh samples of each species of algae were selected from the roots for determination of chlorophyll *a*, oxygen production and carbon fixation.

Pigments were extracted with acetone by grinding weighed wet samples in a mortar, and chlorophyll *a* was determined spectrophotometrically using the methods of Strickland and Parsons (1968). Oxygen production was observed with small weighed samples placed in light and dark bottles of 1 l vol. and incubated for one-half day. Oxygen was determined by use of an azide modification of the Winkler method recommended by the Standard Methods for the Examination of Water and Waste Water of the American Public Health Association (1965). Carbon assimilation was determined by incubating weighed samples in the presence of labeled $Na_2{}^{14}CO_3$ in 1 l light and dark bottles during one-half day. The time of incubation was usually during the period from 0630-1200. The carbon fixed during periods of incubation was determined by combusting ^{14}C labelled, oven dried samples in oxygen, absorbing the CO_2 in phenethylamine solution, and measuring the beta radiation in a Nuclear Chicago liquid scintillation counting apparatus (Unilux 1), employing standard techniques. Oxidation of oven-dried samples (about 20 mg each) was enhanced by addition of cotton in approximately equal amount enclosed with the alga in a small envelope made of lens paper. A Thomas-Ogg infrared ignition apparatus was used, with 2 l flasks and platinum sample carriers made of perforated platinum sheet. Absorption of the CO_2 was done with a solution composed of 27 ml phenethylamine and 27 ml methanol diluted to 100 ml with toluene. Fifteen ml of this absorption solution was added to each cooled flask and after 1 hr in the refrigerator a 5 ml aliquot was removed and diluted in a scintillation vial with 10 ml of toluene scintillator solution, containing Butyl PBD 8.0 g/1 and PBBO 0.5 g/1. Efficiency of counting was determined by use of a weighed amount of ^{14}C-labeled n-hexadecane added to oxygen-flushed phenethylamine in liquid scintillation fluor toluene identical with the system used for preparation of the unknown samples for counting.

Gross photosynthesis was calculated from the oxygen data by adding O_2 consumed in respiration of the dark bottle to the O_2 gained in the light bottle. Assuming a photosynthetic quotient of 1.25, the mg of carbon assimilated was calculated from the relationship 32000 × 1.25 mg of O_2 equivalent to 12,000 mg of C, or mg C = mg O_2/3.33.

The gross photosynthetic O_2 was calculated from results obtained with samples incubated for one half day as follows:

(1) mg O_2 gram^{-1} dry wt day^{-1} = (mgO_2 per liter gained in the light bottle 41.08 ÷ g dry wt of sample + mg O_2 per liter lost in dark bottle 41.08 ÷ g dry wt of sample) × 2. The factor 1.08 is used to obtain the amount of oxygen in the volume of water actually used which was 1,080 ml. Since the experiments

Fig. 1. Some examples of marine algae growing on roots of mangrove at La Parguera, Puerto Rico. Photographs were made in July, 1971. A. *Acanthophora spicifera*; B. *Codium isthmocladum*; C. *Caulerpa sertularioides*; D. *Caulerpa verticillata*; E. *Caulerpa racemosa* along with sponges and tunicates; F. *Ulva lactuca*; G. *Microcoleus lyngbyaceus*; H. *Dictyota divaricata*.

were performed for one-half day of light it is necessary to multiply the O_2 of gross photosynthesis by 2 in order to obtain the daily value.

Carbon assimilation with the ^{14}C technique was calculated from the general equation as follows:

(2) mg C gram $^{-1}$ dry wt day $^{-1}$ =

$$\frac{\text{dpm light-dpm dark}}{\text{\% efficiency } 42.22410^{6} \times \text{uCi}} \times \frac{12}{44} \cdot 90 \times \frac{2}{\text{g dry wt}}$$

where the efficiency of the counter was determined by use of an internal standard; $\frac{12}{44}$. 90 is the mg total available C in the sea water; and the factor 2 converts to one whole day, dpm are counts made on light and dark samples; 2.22410^{6} are dpm of one uCi of which five were used in 1.08 liter of sea water in these experiments.

Various types of algal communities obtained from mangrove roots during July, 1971, are shown in Fig. 1. Photo E is typical of many mixed associations of algae and animals adhering to a root. Other pictures illustrate various species growing

TABLE 1A. Types of algal communities growing on roots of mangrove (*Rhizophora mangle*) in the Guayacan channel near La Parguera, Puerto Rico, April 8-10, 1968.

	Wet Wt. g	Dry Wt. g
Root A (Algae and animals removed	257.0	92.5
Algae	82.0	8.5
Acanthophora spicifera	54.0	4.7
Laurencia obtusa	12.0	1.4
Polysiphonia ferrulacea	9.7	1.5
Spyridia filamentosa	5.2	0.7
Hypnea spinella	0.8	0.1
Caulerpa verticillata	0.3	0.1
Animals (tunicates, oysters, barnacles, mussel)	21.9	7.8
Root B (Algae and animals removed)	194.5	66.5
Algae	210.8	25.3
Wrangelia bicuspidata	93.0	9.9
Caulerpa verticillata	59.3	9.2
Acanthophora spicifera	55.8	5.8
Hypnea spinella	2.7	0.4
Animals (barnacles, tunicates)	8.9	1.0
Root C (Algae and animals removed)	419.0	236.5
Algae	735.9	57.3
Caulerpa racemosa	678.2	52.7
Valonia aegagropila	37.7	2.6
Dictyota bartayresii	12.7	1.3
Acanthophora spicifera	7.3	0.7
Animals (Sponges, tunicates, mussel, oyster, barnacles)	626.8	200.9

chiefly as unialgal communities. Quantitative data for the abundance of plants and animals are presented in Table 1. A list of the dominant species on each root includes the following: *Acanthophora spicifera, Wrangelia bicuspidata, Caulerpa racemosa, Dictyota dichotoma, Valonia ventricosa, Halimeda incrassata, Caulerpa verticillata, Batophora oerstedii,* and *Anadyomene stellata.* Along with these dominant species, there may occur various co-dominants and others in less amounts. The wet wt of the algae per root (of nine roots) averaged 274 g and the dry wt came to 31 g. The average wet wt of the roots, with plants and animals removed, was 616 g, and the average dry wt was 103 g. Mixed species of algae often grow together on a single root, sometimes showing distinct patterns of vertical zonation. The average number of algal species observed per root (of ten roots) was 5.1, and the greatest number per root was ten.

Various animals are associated with the algae in greater (roots E, G, H, I and J) or lesser (roots A, B, C, D, F) amounts. The mangrove fauna includes sponges, tunicates, mussels, oyster, barnacles, crabs, snapping shrimp and worms. The most conspicuous animals are oyster (*Ostrea rhizophorae*), fire sponge (*Taedania ignis*), and black tunicate (*Ascidia nigra*).

TABLE 1B. Continuation of TABLE 1A.	Wet Wt. g	Dry Wt. g
Root D (Algae and animals removed)	189.0	73.5
Algae	323.5	21.9
Dictyota dichotoma	162.0	20.2
Valonia aegagropila	129.0	0.8
Caulerpa racemosa	23.7	0.1
Acanthophora spicifera	7.1	0.7
Laurencia obtusa	1.7	0.1
Animals (sponges, tunicates, mussel, barnacles, oysters)	157.5	4.9
Root E (Algae and animals removed)	255.5	107.3
Algae	275.4	21.6
Valonia ventricosa	114.2	7.2
Laurencia obtusa	110.6	5.4
Caulerpa verticillata	44.6	7.9
C. racemosa	6.0	1.1
Animals (sponges, tunicates, mussel, oyster, barnacle)	621.3	99.1
Root F (algae and animals removed)	2885.5	1211.7
Algae	518.6	85.4
Halimeda incrassata	211.0	42.5
Caulerpa verticillata	122.4	22.5
C. racemosa	42.8	3.5
Spyridia filamentosa	38.2	4.1
Acanthophora spicifera	33.6	3.6
Avrainvillea longicaulia	32.8	5.1
Hypnea spinella	14.7	2.2
Wrangelia bicuspidata	18.3	1.2
Laurencia obtusa	2.6	0.4
Dictyota divaricata	2.2	0.3
Animals (sponges, oysters, barnacles, tunicates, worms, crabs.)	94.4	26.8

TABLE 1c. Continuation of TABLES 1A and 1B

	Wet Wt. g	Dry Wt. g
Root G (Algae and animals removed)	10,879.0	
Algae	2,720.0	
Caulerpa verticillata	—	—
Cladophoropsis membranacea	—	—
Acanthophora spicifera	—	—
Caulerpa racemosa	—	—
Hypnea spinella	—	—
Avrainvillea longicaulis	—	—
Acetabularia crenulata	—	—
Laurencia obtusa	—	—
Halimeda incrassata	—	—
Dictyota divaricata	—	—
Animals (sponges, tunicates, oysters, barnacle, crabs, snapping shrimp)	6,346.0	
Root H (Algae and animals removed)	879.5	358.5
Algae	265.2	47.7
Caulerpa verticillata	255.6	45.4
Penicillus capitatus	9.2	2.2
Acetabularia crenulata	0.4	0.1
Animals (oysters, sponge, barnacles, crabs, tunicates, mussel).	714.8	236.0
Root I (Algae and animals removed)	135.8	40.5
Algae	18.0	3.3
Batophera cerstedii	14.7	2.5
Acetabularia crenulata	3.3	0.8
Animals (Colonial tunicatea)	42.8	1.9
Root J (Algae and animals removed)	327.0	137.3
Algae	33.7	4.8
Anadyomene stellata	27.9	3.8
Batophora cerstedii	5.4	0.9
Acetabularia crenulata	0.4	0.1
Animals (Colonial tunicates, hydroids)	34.6	3.0

The physiological results obtained for 22 species of algae in April, 1968, are presented in Table 2. Chlorophyll *a* varied widely among these species, in the range from 0.39 to 4.93 mg per g dry wt. The gross oxygen production ranged from 14 to 182 mg per g dry wt per day. Not always were the algae with most chlorophyll the most productive. Species of *Valonia, Acetabularia, Avrainvillea, Bostrychia, Halimeda* and *Penicillus* assimilated less carbon than species of *Acanthophora, Cladophoropsis, Falkenbergia* and others.

Similar determinations on 14 species of mangrove algae were made in April, 1971, and the results are shown in Table 3. The averaged value of Chlorophyll is slightly higher in the 1971 set of determinations, and gross oxygen production and calculated carbon uptake are appreciably higher in 1971. Values for gross carbon assimilation based upon O_2 production appear to be 2.3 times greater than the results determined with the ^{14}C method. Possibly the data obtained with the isotope technique give values approximating net photosynthesis. Estimations of assimilation ratios averaged 9.6 in the carbon—14 method and 20.9 by calculation from oxygen production in the observations made in 1971. By applying appropriate values of production to chlorophyll data or to dry wt data, it may be possible eventually to calculate productivity of the various algal members of the mangrove forests.

TABLE 2. Chlorophyll *a* content, oxygen production, and carbon assimilation in algae growing on roots of mangrove in the Guayacan channel near La Parguera, Puerto Rico, April 8-10, 1968. Assimilated Carbon = 0.3 mgO_2 gm^{-1} dry wt. per day.

Species	Chlorophyll *a* mg gm^{-1}	Gross Oxygen mg gm^{-1} day^{-1}	Assimilated Carbon mg gm^{-1} day^{-1}
Acanthophora spicifera	1.81	148	44.4
Acetabularia crenulata	0.43	40	12.0
Catenella repens	0.45	48	14.4
Avrainvillea longicaulis	4.41	19	5.7
Batophora cerstedii	0.71	73	22.9
Bostrychia tenella	0.39	24	7.2
Caulerpa racemosa	1.65	88	26.4
C. sertularioides	4.93	78	23.4
C. verticillata	2.73	102	30.6
Cladophoropsis membranacea	2.21	182	54.6
Dictyota bartayresii	1.86	52	15.6
D. dichotoma	4.72	63	18.9
D. divaricata	2.97	100	30.0
Falkenbergia hillebrandii	1.85	150	45.0
Halimeda incrassata	2.62	30	12.0
Hypnea spinella	1.29	97	29.1
Laurencia obtusa	1.43	93	27.9
Penicillus capitatus	2.37	37	11.1
Spyridia filamentosa	0.44	90	27.0
Valonia aegagropila	0.77	34	10.2
V. ventricosa	0.71	14	4.2
Wrangelia bicuspidata	2.19	—	—
Average values	1.95	744	22.3

As an example of the comparative estimates which are possible, we have compared the productivity of the algae of an average mangrove root with that of phytoplankton in the Phosphorescent Bay located near La Parguera, Puerto Rico. The average dry wt of mixed communities of algae on six roots came to 43.2 g. If we multiply the average gross productivity rate of 34.1 mg per g dry wt (oxygen method in Table 3) by the weight, an average productivity rate of 1.47 g per root per day is found. Taking the average "net" carbon—14 value of 14.7 mg per g dry wt (Table 3) and multiplying by the average weight of a single root algal flora (43.2 g) we find a value of 0.64 g per root per day. Our published value of plankton productivity in Phosphorescent Bay (Burkholder et al., 1967) was 0.8 g C m^{-2} day^{-1}, and values for rich plankton blooms varied from 1.3 to 8.3 g C m^{-2} day^{-1} in the different mangrove lagoons. The flora of a mangrove root appears to be roughly equivalent in productivity to a square meter column of phytoplankton in a moderately rich tropical bay.

TABLE 3. Chlorophyll *a*, oxygen production and carbon assimilation of algae growing on the roots of mangrove in the Guayacan channel near La Parguera, Puerto Rica, April 6-12, 1971. All values are the average of duplicate determinations.

Species	Chlorophyll *a* mg g^{-1} dry wt	Oxygen mg g^{-1} day^{-1}	Carbon-mg g^{-1} day^{-1}		Assimilation ratios mg C g^{-1} day per mg chlorophyll *a*	
			From 0_2	From ^{14}C	Calculated from ^{14}C data	Calculated from O_2 data
Caulerpa racemosa	1.09	30.5	9.2	2.9	2.7	8.4
Halimeda incrassata	2.33	32.9	9.9	7.2	3.1	4.2
Spyridia filamentosa	1.23	95.5	28.7	10.0	8.1	23.3
Caulerpa verticillata	4.18	109.2	32.8	13.5	3.2	7.8
Dictyota dichotoma	3.02	53.6	16.1	6.2	2.5	5.3
Hypnea spinella	0.47	76.7	23.0	16.8	33.6	48.9
Laurencia obtusa	0.93	105.2	31.6	11.6	12.4	34.0
Bostrychia tenella	0.85	35.1	10.5	3.8	4.5	12.3
Wrangelia bicuspidata	1.54	128.0	38.4	9.6	6.2	24.9
Caulerpa sertularioides	4.33	149.8	44.9	21.2	4.8	10.3
Acanthophora spicifera	0.97	85.2	25.6	14.8	15.2	26.4
Bryopsis pennata (Enrique)	3.06	287.3	86.2	21.8	7.1	28.1
Microcoleus lyngbyaceus (Enrique)	4.63	265.1	79.5	46.0	9.9	17.1
Acanthophora spicifera (Enrique)	0.97	137.4	41.1	20.4	21.0	42.4
Averaged values	2.11	113.6	34.1	14.7	9.6	20.9

SUMMARY—Quantitative data have been presented for the occurrence and primary productivity of marine algae growing on the roots of red mangrove in southern Puerto Rico. The wet weight of algae per root (of nine roots) averaged 274 g. The average number of algal species per root (of ten roots) was 5.1 and the greatest number per root was ten. A list of species which were dominant on individual roots includes: *Acanthophora spicifera, Anadyomene stellata, Batophora oerstedii, Caulerpa racemosa, C. verticillata, Dictyota dichotoma, Halimeda incrassata, Valonia ventricosa, Wrangelia bicuspidata*, and occasionally others. In a set of typical physiological observations on 14 kinds of algae chlorophyll *a* content averaged 2.11 mg g^{-1}, carbon fixed in mg per g dry wt per day averaged 34.1 with the oxygen method and 14.7 with the ^{14}C technique. The flora of an average root was calculated to produce in gross photosynthesis 1.47 g C per day, and in "net" assimilation with the ^{14}C method about 0.64 g C per day. The flora of a mangrove root appears to produce about as much organic matter per day as has been observed in a square meter column of phytoplankton in moderately rich tropical lagoons.

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LITERATURE CITED

ALMODOVAR, L. R., AND F. A. PAGÁN. 1971. Notes on a mangrove lagoon and mangrove channels at La Parguera, Puerto Rico. Nova Hedwigia 21: 231-254.

AMERICAN PUBLIC HEALTH ASSOCIATION. 1965. Standard methods for the examination of water and wastewater. Amer. Publ. Health Assoc., New York. 769 pp.

BURKHOLDER, P. R., L. M. BURKHOLDER, AND L. R. ALMODÓVAR. 1967. Carbon assimilation of marine algal flagellate blooms in neritic waters of southern Puerto Rico. Bull. Mar. Sci. 17: 1-15.

MACNAE, W. 1968. A general account of the fauna and flora of mangrove swamps and forests in the Indo-Western Pacific region. Advances Mar. Biol. 6: 74-270.

STRICKLAND, J. D. H., AND T. R. PARSONS. 1965. A manual of sea water analysis. Fisheries Res. Board Canada, Bull. 125. 203 pp.

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ACIDITIES OF SOME CYCLOPENTANEPOLYONES

J. E. Fernandez,[1] R. D. Whitaker,
Miguel Fernández Braña and Jon Simon

Department of Chemistry, University of South Florida, Tampa, Florida 33620
and Departamento de Química Orgánica, Facultad de Ciencias,
Ciudad Universitaria, Madrid, Spain

Abstract: *The pKa's determined for ethyl 4-methyl-2,3,5-triketocyclopentylglyoxalate, 3-methylcyclopentane-1,2,4-trione, and 2-methylcyclopentane-1,3-dione indicate unusually high acidities. Nuclear magnetic resonance spectra were obtained.*

Although the acidities of cyclohexanediones and triones are well known (Meek, *et al.*, 1953, Schwarzenback, *et al.*, 1944, 1947), those of the corresponding cyclopentanediones and triones have not been previously studied.

We have determined the pKa's of ethyl 4-methyl-2,3,5-triketocyclopentylglyoxalate (I), 3-methylcyclopentane-1,2,4 -trione (II), and 2-methylcyclopentane-1,3-dione (III). These values are shown in Fig. I. The nuclear magnetic resonance (nmr) spectra of these compounds have also been obtained.

The salient features of our findings are as follows:

(1) These compounds exhibit unusually high acidities when compared with the analogous cyclohexane derivatives. For example, 2-methylcyclopentane-1,3-dione, III, has a pK_a of 4.6 compared with a pK_a of 6.7 for 3-methylcyclohexane-1,3-dione (Meek, 1953). We attribute this greater acidity of the cyclopentane derivatives to the more nearly planar geometry of the cyclopentane ring compared to the cyclohexane ring. Thus more complete delocalization of π-electrons is possible in the former anions.

(2) Analysis of the nmr spectra shows that in the dissociation of II in chloroform or water solutions only the enolic proton is lost. The CH_2 at position 5 remains intact both in chloroform and in water solutions. In aqueous NaOH solution, however, a second proton becomes labile as evidenced by the reduction to one half of the relative area of the resonance corresponding to the ring methylene protons.

(3) Spectra of I were difficult to obtain, especially in basic solution, because of rapid decomposition. Clean spectra could be obtained only immediately after preparing the solutions. In all cases studied, the ring proton was found to be labile in all solvents tried as evidenced by the absence of a resonance in the nmr spectra. Alternatively, its presence may be masked either by the water protons or by the chloroform.

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[1]Fulbright Lecturer, University of Madrid, 1966-67; to whom inquiries concerning this paper should be addressed.

(4) The nmr spectra of III were the same in water as in aqueous NaOH solution, indicating that the second ionization is virtually nonexistent in aqueous solution.

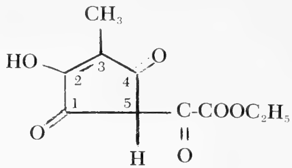
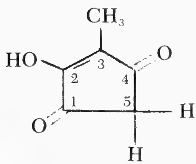
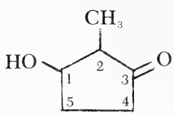
		pK_{a1}	pK_{a2}
I		2.96	6.35
II		3.22	—
III		4.58	—

Fig. I. pK_a's of Compounds I, II, III

Experimental Section—*Materials.* The preparations of the three cyclopentanones were carried out as described by Orchin and Butz (1943).

Ethyl 4-methyl-2,3,5-triketocyclopentylglyoxalate (I), m.p. 160-163° (Orchin and Butz: m.p. 160-163°); 3-methylcyclopentane-1,2,4-trione monohydrate (II), m.p. 76° (Orchin and Butz: m.p. 74-79°); 2-methylcyclopentane-1,3-dione (III), m.p. 206° (Orchin and Butz: m.p. 210.5-212.5°, Cornforth and Earl (1940) 208-210°). All melting points are uncorrected.

pK_a Determinations. Titration curves were obtained using a Sargent Model LS pH meter and combination glass electrode standardized against Beckman 3501 pH 7 buffer solution. Titration of compounds II and III with standardized aqueous 0.1 *N* NaOH produced typical titration curves for monoprotic acids. The pK_a's were estimated from the half-neutralization point. The titration curve of I was typical of a diprotic acid. However pK_1 and pK_2 were not separable by inspection. Solution of simultaneous equations at points in the buffer regions of the curve yielded the pK_a values shown in Figure I.

Nmr Spectra. Nmr spectra were determined using a Varian A-60 spectrometer. All δ values refer to TMS as internal standard. The solvents used were D_2O, 0.1 *N* NaOH/D_2O, $CHCl_3$ (fractionated immediately before use).

Compound I. $CHCl_3$ solvent: δ 0.80 (t, 3, J=4.0 Hz, Ethyl-CH_3); 1.31 (s, 3, ring-CH_3); 3.79 (q, 2, J=3.0, Ethyl-CH_2–).

D_2O solvent: δ 0.69 (t, 3, J=7.5 Hz, Ethyl-CH_3); 1.38 (s, 3, ring-CH_3); 3.20 (q, 2, J=7.5, ethyl-CH_2–); 4.81 (s, H_2O).

Compound II. $CHCl_3$ solvent: δ 2.00 (s, 3, ring-CH_3); 3.00 (s, 2, ring-CH_2–); 7.38 (s, slight peak, ring-H).

D_2O solvent: δ 1.80 (s, 3, ring-CH_3); 2.94 (s, 2, ring-CH_2); 4.71 (s, H_2O).

0.1 *N* NaOH/D_2O solution: δ 1.76 (s, 3, ring-CH_3); 2.89 (s, 1, ring-CH_2–); 4.78 (s, H_2O).

Compound III. D_2O solvent: δ 1.56 (s, 3, ring-CH_3); 2.56 (s, 4, ring-CH_2–); 4.72 (s, H_2O).

0.1 *N* NaOH/D_2O solution: δ 1.41 (s, 3, ring-CH_3); 2.26 (s, 4, ring-CH_2–); 4.70 (s, H_2O).

LITERATURE CITED

CORNFORTH, J. W., AND J. C. EARL. 1940. Sarcostin. I. Preliminary study of its behavior with reagents. J. Chem. Soc. London pp. 1443-1447.

MEEK, E. G., J. H. TURNBULL, AND W. WILSON. 1953. Alicyclic compounds. III. Ultraviolet absorption, acidity, and ring fission of 1,3-cyclohexanediones. J. Chem. Soc. London pp. 2891-2896.

ORCHIN, M., AND L. W. BUTZ. 1943. Hydrogenation of 3-methyl-1,2,4-cyclopentanetrione. J. Amer. Chem. Soc. 65:2296-2299.

SCHWARZENBACH, G., AND E. FELDER. 1944. Determination of keto-enol equilibrium in water. Helvetica Chim. Acta 27:1044-1060.

———, AND ———. 1944. Acidity and enolization tendency. Helvetica Chim. Acta 27:1701-1711.

———, AND C. WITMER. 1947. The keto-enol equilibrium of cyclic α-diketones. Helvetica Chim. Acta 30:663-669.

Florida Sci. 36(1):75-77. 1973.

ACADEMIC ACHIEVEMENT OF DYSLEXIC CHILDREN DURING THE FIRST TWELVE MONTHS AFTER INTENSIVE REMEDIATION[1]

Anita N. Griffiths

P. O. Box 230, Lakeland, Florida 33802

The author (Griffiths, 1970) has previously shown significant increases in I.Q. scores and in reading capability for dyslexic children who had undergone remediation for a period of approximately twelve weeks with one hour sessions once per week. The magnitude of the improvement was such as to question whether or not the child's academic capability could be maintained. The data presented below concerns sixteen of these children at six months and twelve months following the completion of the original remedial period.

Both reading and arithmetic abilities have been shown to be below expected achievement levels for children with learning disabilities, and both skills were measured in this study. Reading was checked with three different tests, the WRAT, the Gilmore Oral Reading Test and the Stanford Paragraph Meaning Test which measures silent reading. In addition, the children were checked for arithmetic on the WRAT. All numerical ratings in this report deal with percentile rankings so that data for all children are on a comparable basis. Three of the sixteen children in this study were girls. The group of sixteen was divided according to whether or not additional remedial effort was considered necessary and was undertaken as a result of the six months' testing. Thus, nine children did not receive additional remediation at the end of six months and seven did. The children varied in age from six years and three months to thirteen years and one month with an average age of just slightly more than nine years at the end of the initial intensive remediation period.

The results from each of the four reading tests and the arithmetic tests were handled statistically by an analysis of variance (Snedecor, 1938) and differences between time intervals of testing were rated for significance by Duncan's Multiple Range Test (Duncan, 1955). It is important to note that when a child shows no improvement on his percentile ranking over a period of time, this does not mean that he is not learning. If he is at the 20th percentile to begin with, and six months later is still at the 20th percentile, he has been learning. Like Alice down the rabbit hole, dyslexics must run just to stay in one place.

The initial percentile rating on WISC I.Q. scores varied from a low of the 20th to a high of the 96th percentile at the pre-remediation period, and varied from the 40th to the 99th percentile at the close of the initial remediation time. Those children who did not receive additional remedial treatment after six months had

[1]Presented at the Florida Academy of Science meeting, April 7, 1972.

an average percentile I.Q. rating of 68.7 before remediation and 80.4 after remediation. The group that received additional remediation had I.Q. percentiles at 75.9 initially and 86.1 following remediation. While the differences between the two groups are not significant, the group which required remediation had slightly higher initial I.Q.'s, but the amount of improvement was approximately the same for both groups during the initial period of remediation. These are comparable to the increases in I.Q. as previously reported by the author for larger groups of children.

TABLE 1. Percentile scores on WRAT word pronunciation for children before and after remediation, and six months and twelve months later. Letter designations show no significance between means for the same letter.

	Extra remediation		Combined
	None	at 6 mo.	Total
Pre	41.9	24.6	34.3
Post	54.2 A	37.4 A	46.9 A
6 months	59.1 A	34.1 A	84.2 A
12 months	53.7 A	37.0 A	46.4 A
F value	3.54[1]	4.18[1]	6.63[2]

[1] Significant at 5%
[2] Significant at 1%

WRAT WORD PRONUNCIATION—Results of the reading section of the WRAT are shown in Table 1. This test is basically a test of word pronunciation and in no way measures understanding of reading material by the child. This table shows the percentile rating prior to the initial remediation, at the close of remediation, six months later and at the end of twelve months. It presents the combined total for all sixteen children as well as separating the changes for the two groups—one of which received remediation at the end of six months. F values are shown and significant differences between sub-groups are indicated by difference in letter designations. It will be noted that for both groups and for the combined total, improvement was significant at the post-remedial period and did not differ at the six or the twelve month period in spite of additional remediation for some of the children. It will be noted that those that did not require remediation scored much higher on the pre-remedial test, but improvement was comparable for both groups.

Although no significant difference is shown, it should be noted that the group which received additional remediation showed a slight increase at the end of twelve months, while the other group showed a decrease when compared with the six month testing.

GILMORE ORAL READING TEST—The Gilmore Oral Reading Test measures both accuracy and comprehension. During the oral reading period the examiner is permitted to correct some of the child's errors, so that comprehension by the child is not adversely affected by the errors in accuracy of oral reading.

Table 2 shows the percentile figures for oral reading accuracy. For the nine children to whom no additional remediation was given, there was a significant gain in the initial remedial period, but no significant change thereafter. However, as in the case of the WRAT, the percentile score improved somewhat at the six month period and then showed a slight decrease at the last testing. Contrasted with this, the group which required additional remediation improved significantly at the post-remedial testing, but regressed to a point where at the end of six months they were not significantly different from the pre-remedial period. With additional remediation, the percentile scores improved and were again significantly different from the pre-remedial period, but were not significantly different from the six month period. However, the actual percentile score was approximately the same as for the group that did not receive the additional remediation.

TABLE 2. Percentile scores on Gilmore Oral Reading accuracy for children before and after remediation, and six months and twelve months later. Letter of designations show no significance between means for the same letter.

	Extra Remediation		Combined Total
	None	at 6 mo.	
Pre	25.0	18.1 A	22.0
Post	53.1 A	44.4 B	49.3 A
6 months	57.0 A	34.9 AB	47.3 A
12 months	50.7 A	48.3 B	49.6 A
F value	8.08[2]	5.30[1]	12.01[2]

[1] Significant at 5%
[2] Significant at 1%

Table 3 shows comparable information on percentile scores for comprehension on the Gilmore Oral Reading Test. There was significant improvement at the end of the initial post-remedial period. Neither group changed significantly in the following six months, but both showed a decrease in percentile rating. Those who received remediation improved significantly and attained the highest percentile rating at the end of the twelve month period. Those that did not receive the additional remediation showed a continued reduction and were significantly lower at the end of twelve months than at the post-remedial testing.

STANFORD ACHIEVEMENT TEST—Table 4 records percentile scores for the children on the reading portion of the Stanford Achievement Test. The results here, as contrasted with those presented in Tables 1 through 3, indicate significant differences at the 5 percent level when both groups are combined, but the individual groups fail to show significance between the four testing periods. Since it is recommended that Duncan's Multiple Range Test is not applicable where significance at the 5 percent level does not exist, it was not applied to the sub-groups, but only to the entire group of 16 children.

TABLE 3. Percentile scores on Gilmore Oral Reading Comprehension for children before and after remediation, and six months and twelve months later. Letter designations show no significance between means for the same letter.

	Extra Remediation		Combined Total
	None	at 6 mo.	
Pre	28.7	31.1	29.8
Post	70.2 A	61.3 AB	58.7 A
6 months	64.6 AB	51.1 A	63.6 A
12 months	54.2 B	75.6 B	66.3 A
F value	14.15[2]	9.24[2]	16.02[2]

[2] Significant at 1%

These results, when contrasted with those for the other two reading tests, indicate initial improvement, but even for those children with additional remediation, there was a reduction in percentile scores between the six month and the twelve month period. This test measures the sum of two characteristics and is judged on the basis of the child's comprehension of what he reads. If his accuracy for silent reading is very low, there is no way that he can answer the questions and obtain a satisfactory score. Thus, comprehension is being measured, but for the poor reader, comprehension is impossible if the words are improperly read.

TABLE 4. Percentile scores on Stanford Silent Reading Test for children before and after remediation, and six months and twelve months later. Letter designations show no significance between means for the same letter.

	Extra Remediation		Combined Total
	None	at 6 mo.	
Pre	25.4 A	20.0 A	23.1
Post	34.4 B	34.3 B	34.4 A
6 months	32.9 AB	27.7 AB	30.6 AB
12 months	30.9 AB	24.7 AB	26.3 B
F value	1.87	2.14	4.08[1]

[1] Significant at 5%

WRAT ARITHMETIC TEST—The percentile scores for arithmetic are shown in Table 5. There was significant improvement at the post-remedial period. The group which required remediation at the six month interval showed a significant reduction at that time and then a significant increase after the second remedial period.

DISCUSSION—Although I. Q. percentiles suggested that these children should on the average be scoring above the 75th percentile, such achievement was accomplished only by the group which received additional remediation and then for only one test, the Gilmore Oral Reading Comprehension. Here, since some of the child's oral reading errors could be corrected, comprehension was not markedly impeded by an inability to read accurately. This is in sharp contrast with the results on the SAT Paragraph Meaning Test which measures comprehension on material which the children apparently were unable to read silently. While most of these children showed marked improvement in their school work, they were generally not attaining the potential indicated by their I. Q. on either reading or on arithmetic. However, remediation improved their achievement materially, and a subsequent short period of remediation appeared to be beneficial.

TABLE 5. Percentile scores on WRAT Arithmetic Test for children before and after remediation, and six months and twelve months later. Letter designations show no significance between means for the same letter.

	Extra Remediation		Combined Total
	None	at 6 mo.	
Pre	31.3	38.1 A	34.3 A
Post	42.3 A	48.9 B	45.2 B
6 months	48.3 A	34.1 A	42.1 AB
12 months	40.2 A	49.4 B	44.2 B
F value	3.23[1]	4.74[1]	2.79[1]

[1] Significant at 5%

Only four of the children, three of whom did not receive additional remediation, tended to have comparable percentile ratings on the WRAT and Gilmore tests to those for their I. Q. at the end of the twelve month period. However, their arithmetic was not as high and they did not attain comparable gains for silent reading.

There are indications in this study that the success of initial remediation may be predictable at the time of initial testing, but larger numbers of children will be necessary to corroborate and substantiate this suggestion.

The results of this study clearly indicate that the major reading problem is associated with the child's ability to read silently in a meaningful way. Both on the Gilmore Oral Reading Test and on the WRAT Word Pronunciation, scores were much higher than for the Stanford Paragraph Meaning Test (Table 6). This offers an explanation of the necessity for the dyslexic child to read aloud whenever possible, to be permitted to move his lips silently if oral reading cannot be permitted, and further suggests that the sound of the word itself reinforces the child's ability to understand what he is reading. These children should learn to read silently or orally with a place marker under the line being read. Many teachers discourage this for reasons with dubious validity. If these children *need* a place marker and a finger pointing, they should not be made to feel defensive about it.

Children are tested on grid tests as early as fourth grade, and this testing continues throughout their education. Testing dyslexics with grid tests is like testing a partially deaf child with oral questions. A grid test does not measure what a dyslexic knows about the subject matter; it tests his ability to find his place on the grid.

TABLE 6. Summary of I.Q., reading and arithmetic achievement with and without additional remediation at 6 months. Letter designations show no significance between means for the same letter.

	No Remediation					
		Reading				
			Gilmore			
	I.Q.	WRAT	Acc.	Comp.	SAT	Arit.
Pre	68.7	41.9	25.0	28.7	25.4A	31.3
Post	80.4	54.2A	53.1A	70.2A	34.4 B	42.3A
6 months	—	59.1A	57.0A	64.6AB	32.9AB	48.3A
12 months	—	53.7A	50.7A	54.2 B	30.9AB	40.2A

	Remediation					
		Reading				
			Gilmore			
	I.Q.	WRAT	Acc.	Comp.	SAT	Arit.
Pre	75.9	24.6	18.1A	31.1	20.0A	38.1A
Post	86.1	37.4A	44.4 B	61.3AB	34.3 B	48.9 B
6 months	—	34.1A	34.9AB	51.1A	27.7AB	34.1A
12 months	—	37.0A	48.3 B	75.6 B	24.7AB	49.4 B

In view of the type of errors made in arithmetic, it is relatively obvious that it is often a matter of failing to read the numbers accurately as it is the failure to understand the arithmetic procedure. Thus, the child's ability to read or to work arithmetic are both materially hampered by his inability to adequately comprehend the symbols which are presented to him, whether they be letters or numbers. These data are further suggestive that while major improvement can be made with initial intensive remediation, some children will require additional and perhaps continuous remediation, although this may be much less intensive than in the initial period. In view of the fact that those without remediation were tending to reach a maximum percentile score at six months following initial remediation and then tended to score lower at the end of twelve months is suggestive that almost all would have benefited from additional remedial activity. The degree and intensity of remediation will be a function of the individual child's problems and capability.

SUMMARY AND CONCLUSIONS—1. The results of testing sixteen dyslexic children six months and twelve months after initial intensive remediation for reading and for arithmetic are presented.

2. Seven of the sixteen children received additional remediation at the end of six months and this remediation was found to be effective in increasing their achievement levels.

3. Oral reading ability and comprehension, as compared with silent reading ability and comprehension, showed much greater improvement.

4. Arithmetic improvement tended to follow the same pattern as reading ability.

5. The data strongly suggest that periodic or continual remedial activity is essential for most dyslexic children if they are to achieve their apparent capability as measured by I. Q. for either reading or arithmetic. All of the children had improved materially in their academic achievement at school during the period under study.

6. Dyslexic children can show significant improvement with remediation of one hour per week for twelve weeks and some may maintain this improvement for the following twelve months without additional remediation, but the data presented are suggestive that additional remediation would be beneficial for most children.

LITERATURE CITED

DUNCAN, D. B. 1955. Multiple range and multiple F tests. Biometrics 11: 1-42.

GRIFFITHS, ANITA N. 1970. Dyslexia: Symptoms and remediation results. Quart. J. Florida Acad. Sci. 33: 1-16.

SNEDECOR, G. Q. 1938. Statistical Methods. Collegiate Press. Ames, Iowa.

Florida Sci. 36(1):78-84. 1973.

CHARCOAL MAKING: ITS EFFECT IN CAJOLA, GUATEMALA

John G. Hehr

Department of Geography, University of Miami, Coral Gables, Florida 33124

In the western highlands of Guatemala exist numerous Indian villages which have maintained traditional modes of culture. Among these, the municipio (county) of Cajolá is situated in an isolated pocket on the northwest limits of the Basin of Quezaltenango (Fig. 1). Increased population in this primarily subsistence agricultural economy has forced the predominantly Mam Indian inhabitants to seek alternative sources of income. Supplemental economic pursuits, in addition to subsistence agriculture, are limited in Cajolá. The combination of isolation, traditionalism, land shortage, and lack of education have retarded any economic improvement in the area. The Indians of highland Guatemala have long supplemented their farming activities with community specialization in cottage industries and charcoal production (West and Augelli, 1966). The latter, specialization in the production of charcoal, has become the dominant local source of additional income for the 5,000 inhabitants of Cajolá. It has been estimated that 75 percent of the male population is engaged in the production of charcoal at one time or another during the year (Instituto Indigenista Nacional, 1949). From field reconnaissance it appears that nearly 90 percent of the native forest has been cut over in the tree cutting region (Fig. 1), and that much of the remaining forest is located north of Cajolá. The purpose of this paper is to illustrate how the charcoal industry of Cajolá has led to forest depletion in the region.

Through the years it has been traditional, in the extended family, to divide the landholdings evenly among surviving members of a family when the head of the household dies (Wolf, 1964). This tradition has broken up the landholdings to such an extent that plots became incapable of providing subsistence. A study carried out by Guatemala's National Indian Institute substantiated the shortage of land in the municipio of Cajolá. Their findings indicated that the amount of land needed to feed a family of five in the area for one year amounted to 2.2 acres and that the average landholding was .98 acres or 44 percent of what the individual landowner needs to subsist (Instituto Indigenista Nacional, 1957).

Charcoal production has provided those Indians who produce it a significant increase in income. However, the production of charcoal is not without its problems. Six primary operational difficulties plague the charcoal industry. These are: (1) accessibility of marketable trees, (2) price of the trees, (3) credit for tree purchases, (4) license availability, (5) forest administration and management, and (6) cyclic nature of production.

Purchase of Trees—The natural forest cover that remains in the remote regions of the Department (state) of Quezaltenango is of predominantly pine, fir, cypress, and oak. In these areas the pine, fir, and cypress are usually found intermixed in groves, while the oak tends to grow in pure stands. The cutting for firewood and charcoal production has reduced the pure oak stands and permitted

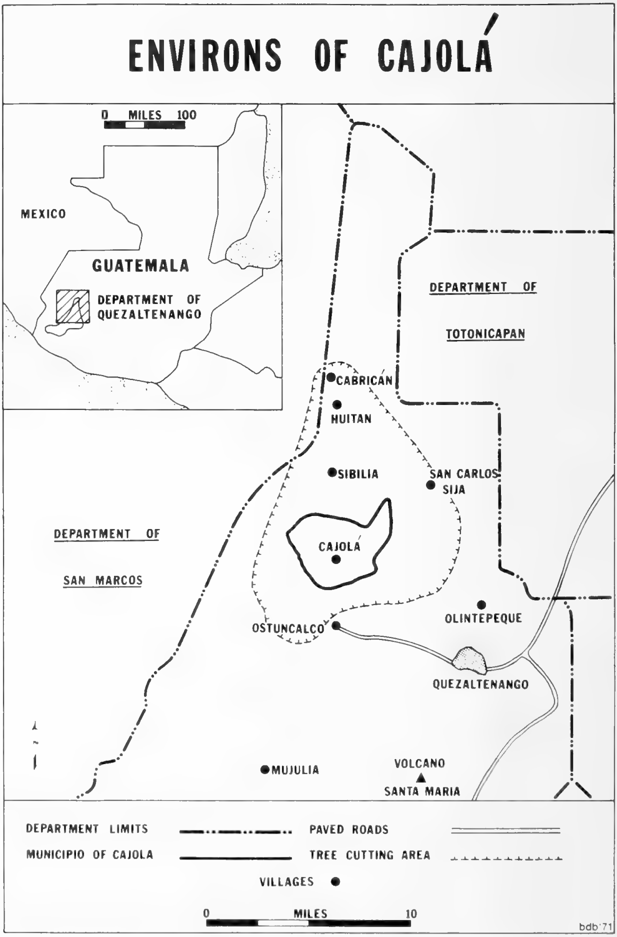


Fig. 1. Map of Cajolá, Department of Quezaltenango, Guatemala.

the encroachment of pine (Standley, 1945). Thus, the pure stands of oak are being reduced and the pine appears to be intruding. Furthermore, the soils, being volcanic in origin, are dissicated easily and the re-establishment of vegetation is slow.

A charcoal maker living in Cajolá, wanting to purchase a number of trees, must first find a landowner willing to sell. Today the shortage of trees has reached the point where the inhabitants of the area are forced to travel to the north and northeast over the mountains to the municipios of San Carlos Sija, Huitán, Cabricán, and Sibilia where much of the remaining forest is found. The charcoal makers usually hear by word of mouth that a landowner in an adjacent municipio has trees to be sold and travels there on foot to negotiate directly with the landowner.

The price of trees is dependent upon a number of factors. The preference in the market place is for charcoal made of oak and other hardwoods which burns longer than charcoal made from softer species such as pine. This demand for hardwood charcoal has created a higher price for it in the market and subsequently increased the price of hardwoods in the field. However, this researcher observed that charcoal makers purchased a variety of suitable species and were forced to put several species simultaneously into the oven, further indicating the problems they have in obtaining the proper raw materials.

Another factor governing the price of trees is their size. Trees with diameters of approximately 40 inches usually sell for $4 while a tree 25 inches in diameter brings the landowner $3. Smaller trees with diameters of 12 inches or less can be purchased for $1 apiece. The charcoal makers naturally prefer the larger trees. However, in areas of critical tree shortages even the smaller trees are being felled to provide additional sources of wood.

The charcoal makers must pay for the trees in cash, for the landowner does not extend credit. Thus, because of a lack of funds the producer is often idle. If the charcoal maker is fortunate enough to have the currency, he will try to bargain for five or six trees so he can produce charcoal in the same area for a considerable length of time.

License and Forest Administration—The procedures a charcoal maker follows in order to obtain the necessary licenses to work within the forests are cumbersome, and the permits are often difficult for an Indian to acquire. Overseeing the sale and use of forest products in the Department of Quezaltenango is the forestry office, which is controlled from Guatemala City through a director in the city of Quezaltenango. The director and a secretary are the sole employees in the forestry office, and are responsible for the maintenance of forest reserves for the entire Department and several isolated areas beyond its border. It is apparent that the existing office is insufficiently staffed to exercise control over the use of natural resources within the Department.

It was observed that the forestry officials carried out the required mechanics of their job but lacked enthusiasm for improving the serious conditions developing in the realm of forest resources. Furthermore, the employees of the forestry office,

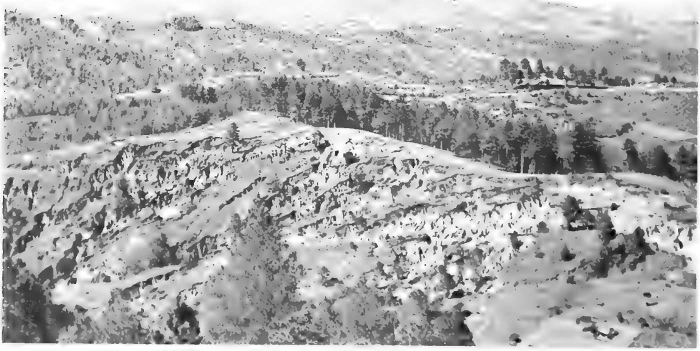


Fig. 2. (upper photo) A dissected slope that was initially cut over for charcoal production near Cabricán, Guatemala.

Fig. 3. (lower photo) Extensive gullying in the vicinity of Huitán, Guatemala. Note the large area denuded of forest much of which went into charcoal.

being Ladinos[1], frequently hampered the Indian's attempt to obtain the necessary permits to work in the forest and often flatly refused to issue licenses. On the other hand, Ladinos wanting to obtain licenses had little difficulty in acquiring them, and if they were influential or wanted to contribute to the funds of the forestry officials, the laws were conveniently overlooked. Thus, the forestry office can be described as a political tool, staffed by men appointed in Guatemala City who have little interest in the efficient operation of an office in charge of forest resources.

In 1965, 409 applications to cut 2,373 trees for the production of charcoal were entered in the records of the forestry office in Quezaltenango. The officials are required by law to field inspect every tree licensed to be cut down for any purpose. This is, of course, impractical with only two men employed in the office. The officials do move into the field when the cutting location is accessible or in close proximity of Quezaltenango, otherwise the cutting areas are seldom checked. The isolation of the remaining forest reserves in the Department of Quezaltenango makes their control a difficult task and it is estimated that 90 percent of all trees used for the production of charcoal are cut illegally.

From a one week survey taken on the outskirts of Quezaltenango it was estimated that 40,000 pounds of charcoal was transported into the city by the charcoal makers of Cajolá. Informants reported that an oak tree 25 inches in diameter would yield approximately 700 pounds of charcoal. Thus, the charcoal makers cut approximately 58 trees with a diameter of 25 inches in order to produce the 40,000 pounds of charcoal.

Charcoal Production—Charcoal is manufactured throughout the year by many of the inhabitants of Cajolá, but during certain periods production increases or decreases substantially. The pattern of charcoal making is very erratic and is predicated upon the cycles of local agriculture and related out-migration to coastal areas to work on farms or grow crops. The cyclic production of charcoal produces periods of surplus and shortage in Quezaltenango, which is reflected in its price. In the course of one year, the price of charcoal varies between $1.50 and $3 per 100 pounds. The highest price obtained for charcoal during the yearly cycle occurs with the highland corn harvest in November and December. The price during this period is near $3 per 100 pounds. In the sowing season—February to May—the price is slightly lower with the bargaining figure near $2.50 per 100 pounds. During periods of major out-migration—August to November—the production of charcoal increases and prices are approximately $2 per 100 pounds. In January, when the majority of the populace is present in the municipio manufacturing charcoal, its price drops to $1.50 per 100 pounds in the city of Quezaltenango.

A charcoal maker selling his product at $2 per 100 pounds in Quezaltenango will make approximately $16 from a tree 40 inches in diameter, while the profit from a tree 25 inches in diameter is approximately $11. Because of the irregularity

[1]Ladinos are loosely defined as those who have taken on westernized modes of culture.

of charcoal production it is virtually meaningless to state an average individual or family income derived from this local industry. It is obvious, however, that this profit is little reward for the time involved in production, transportation, and sale of the final product.

Forest Depletion—The cutting of trees in the Department of Quezaltenango has been continuous for centuries, and the inhabitants are still dependent upon wood for cooking and heating. The absence of a government reforestation program throughout Guatemala's history is beginning to manifest itself in the form of erosion, serious shortages of timber, and the loss of valuable cropland. This has been especially true in and around the Basin of Quezaltenango where the inhabitants of Cajolá have long supplemented their incomes through the sale of charcoal.

The charcoal makers of Cajolá are feeling the effects of deforestation within the municipio and in adjacent cutting areas which are continually receding further from their homes. For many years the forest within the municipio of Cajolá has been cut over and, therefore, the remaining trees are either too small or located on restricted communal land. Extensive areas of slope exist within the region and these have been damaged to such an extent that their reclamation is virtually impossible. Much of this areas has already been eroded into a network of gullies that are 10 to 15 feet deep (see Fig. 2 and 3). The erosion of this area has been enhanced by cultivation and overgrazing of slopes that have been denuded of their forest cover by the charcoal makers. The makers of charcoal are now traveling up to 10 miles from the municipio in order to find suitable trees for raw materials; with the passage of time the distance to cutting sites will prohibit travel by foot or burro resulting in a decrease of charcoal manufacture. As marketable trees become more difficult to find, the cost of purchasing them may rise to the point where a charcoal maker will find it uneconomical to produce charcoal.

Conclusions—With the population density approaching 560 persons per square mile in the municipio of Cajolá, the problem of deforestation and forest depletion is rapidly reaching a critical point. The inhabitants are dependent upon subsistence agriculture, and with approximately half of the total eight square miles of the municipio unfit for cultivation, securing a sufficient supply of food locally is often impossible. The complete absence of conservation practices and modern agricultural methods further increases the plight of the people, and increasing numbers are going to find it necessary to migrate to the coast during harvest periods to pick coffee and cotton in order to subsist.

As the problem of obtaining trees becomes more difficult, the inhabitants of Cajolá will be forced to find new ways of supplementing their incomes. The outlook for alternative forms of employment within the municipio are limited, and, therefore, the populace will have to look to the outside in hopes of obtaining additional income and supplies of food. As the inhabitants become aware of the modern world through increased contact, the entire pattern of life within the municipio will evolve to meet the new ideology. Thus, as the production of charcoal begins to decrease and comes to a halt in the near future, the inhabitants will be forced to find alternative means of supplementing their incomes and this will, in the process, initiate the beginning of a new era in the municipio of Cajolá.

LITERATURE CITED

INSTITUTO INDIGENISTA NACIONAL. 1957. Boletín del instituto indigenista nacional, vol. 1, sequnda epoca. Guatemala City.

———. 1949. Datos sociológicos del municipio de Cajolá, Monografia no. 34. Guatemala City.

STANDLEY, P. C. 1945. Notes on some Guatemalan trees. Tropical Woods 84: 1-17.

WEST, R. C., AND J. P. AUGELLI. 1966. Middle America: its lands and peoples. Prentice-Hall. Englewood, New Jersey.

WOLF, E. 1964. Sons of the shaking earth. University of Chicago Press, Chicago.

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Biological Sciences

AN UNUSUAL DISTRIBUTION OF *TILLANDSIA SIMULATA* SMALL

HAL A. BEECHER AND LUCY DUNCAN

Department of Biology, The University of West Florida, Pensacola, Florida 32504
(Present address: Department of Biological Science, Florida State University, Tallahassee, Florida 32306, and 614 Fairpoint Drive, Gulf Breeze, Florida 32561)

ABSTRACT: *The species was first found in west Florida near Sumatra along Owl Creek.*

SPECIMENS of what we believe to be *Tillandsia simulata* Small were found in a swamp along the lower Apalachicola River in northwest Florida. The distribution of these specimens was noteworthy both as a geographical range extension and because of their very localized distribution within the area in which they were collected.

Identification was made on the basis of leaf form, number of leaves, growth pattern, and flowers. Leaves were about 20-30 cm in length and very narrow except in the first centimeter where they were somewhat broadened. A cross-section of the leaf was somewhat U-shaped except near the leaf tip. The entire lengths of the leaves were scurfy. There were about 30 to 50 leaves per plant. Flower stalks in late March were thicker than the leaves and up to 20 cm in length. The color of the flower stalks was rosy with no indication of a copper color despite their exposure to the sun. Flowering occurred in late May in a greenhouse and the petals were violet. Clusters of 2 to 5 plants were scattered on the host trees.

Tillandsia simulata has been collected from Nassau County in northeastern Florida (Robert K. Godfrey, personal communication), from Dixie County (A. E. Radford, personal communication), and is common in central Florida, but is unknown from west Florida (Daniel B. Ward, personal communication).

On March 24, 1973, the specimens were found in abundance on trees on a submerged island in Owl Creek, a tributary of the Apalachicola River, southwest of Sumatra, Florida. The emergent stand of trees was 500 to 1000 m downstream from the National Forest Service Recreation Area at Wright Lake Landing, at 29 58′20″N, 85 00′50″W, on the boundary between Liberty County and Franklin County, Florida.

Despite careful searching along the creek and the river, no other specimens were found. The partially submerged stand of trees was 30 to 60 m from the nearest trees along the shore, and was oriented about 20° east of north. The stand of trees was only as wide as one or two trees but was several hundred meters in length.

Specimens will be deposited in the herbarium of the Florida State University.

We wish to thank James Burkhalter, Dr. Joe A. Edmisten and Sherlie Gade for their discussion and assistance in identification, and Dr. Edmisten for his critical reading of the manuscript.

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Biological Sciences

PRELIMINARY ELECTRON MICROSCOPE OBSERVATIONS OF CITRUS WITH YOUNG TREE DECLINE

Gail E. VanderMolen
Department of Biological Sciences,
Florida Technological University, Orlando, Florida 32816

Abstract: *Vascular obstructions in xylem vessels of roots taken from trees in late stages of young tree decline were observed with the transmission electron microscope. The vascular obstructions are composed of filaments which vary in diameter, appear to branch, and consist of concentric, alternating electron-dense and electron-transparent layers. Serial longitudinal sections as well as cross sections failed to reveal any biological ultrastructure which correlated with that of known fungal hyphae, actinomycetes, mycoplasma, or bacteria.*

The citrus disease commonly called blight and more recently referred to as young tree decline (YTD) was first described by Underwood in 1891. Trees in late stages of YTD show the following gross symptoms despite adequate irrigation: desiccation of leaves, defoliation beginning at branch terminals, dieback of branches, and the growth of water sprouts from the lower trunk. The symptoms of YTD can be attributed to lack of a normal rate of water and nutrient transport through xylem vessels. Page (1959) has shown that vessel dysfunction is important in water imbalance in banana plants with Panama disease. Similar vascular obstructions have been reported in association with various fungal induced wilt diseases. Saaltink and Dimond (1964) observed individual vessels densely packed with mycelia in *Fusarium*-infected tomatoes. Waggoner and Dimond (1954) concluded from hydrodynamic evidence that mycelia can reduce the efficiency of flow in vessel elements. Childs, Kopp, and Johnson (1965) using cytological techniques reported that vascular obstructions in roots of YTD affected citrus trees were hyphal mats of a chytrid in the *Physoderma-Urophlyctis* group which they named *Physoderma citri*. Observations of spores in vivo were also described but repeated efforts to germinate these spores in vitro were negative.

Methods—Root samples approximately 1 cm in diameter were taken from trees on Rough Lemon rootstock in late stages of YTD. Samples were sectioned on a freezing microtome into 20 μ sections and fixed immediately in 3% v/v glutaraldehyde in 0.1 M cacodylate buffer at pH 7.2. After washing in the same buffer, the sections were post-fixed with 2% w/v osmium tetroxide, washed in distilled water, dehydrated in an ethanol series, and embedded in Spurr's epoxy (1969). Root tissue sections were spread on a mica slide and polymerization was accomplished overnight at 70° C. Mica slides were attached to glass slides and under the light microscope at 400 $\times$ vascular obstructions were chosen and marked. The marked area was cut out of the plastic with a razor blade, lifted from its mica backing with forceps, and glued to a dummy block for trimming and ultramicrotomy. A Dupont diamond knife and a Reichert ultramicrotome were used to obtain sections 60 nm thick. Sections were picked up on 75 mesh, formvar-covered copper grids and observed unstained with a Hitachi HS 8 transmission electron microscope operated at 50 KV.

Observations—Vascular obstructions were found in most vessels. The obstructions are located at the junctions of vessel elements and in heavily plugged samples each junction is the site of a vascular obstruction (Fig. 1). Longitudinal serial sectioning revealed complete occlusion of the vessel lumen. The secondary cell wall which surrounds the obstructing material appears intact in all observed sections. Spherical, ovoid, and longitudinal profiles indicate the filamentous nature of the material comprising the vascular obstructions. The material in all observed obstructions appeared similar to that shown in Figs. 2 and 3. Filaments vary in diameter from 250 nm to 500 nm, appear to branch, and consist of three concentric layers: an inner electron-dense core, a moderately electron-dense outer layer, separated by a narrow electron-transparent middle layer (Fig. 3). Serial sections of several vascular obstructions failed to reveal any biological ultrastructure which correlated with that of known fungal hyphae, actinomycetes, mycoplasma, or bacteria.

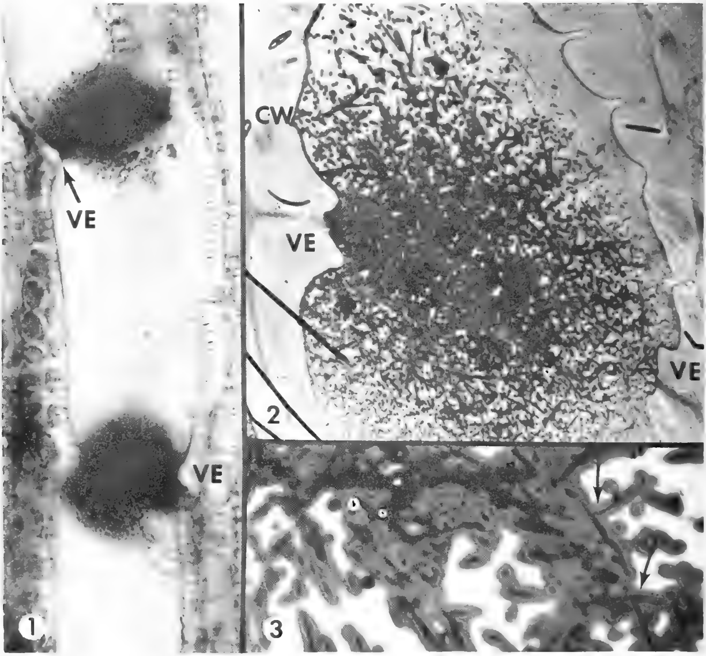

Fig. 1. Brightfield photograph of a vessel with two vascular obstructions located at the junctions of adjacent vessel elements (VE). Section thickness 20 μ. 1200 ×. Fig. 2. Electron micrograph of a vascular obstruction which occludes the vessel lumen at the junction of two vessel elements (VE). The secondary cell wall (CW) surrounding the material appears intact. Section thickness 60 nm. 3500 ×. Fig. 3. Electron micrograph of the material comprising vascular obstructions. Spherical, ovoid, and longitudinal profiles indicate the filamentous nature of the material. Filaments vary in diameter from 250 nm to 500 nm, appear to branch (arrows) and consist of alternating electron-dense and electron-transparent layers. Section thickness 60 nm. 15000 ×.

Discussion—Vascular dysfunction has been reported to result from a number of causes. Struckmeyer *et al.* (1954) noted that extensive plugging of vessels by tyloses and gums was a prelude to the appearance of wilting in leaves of oak. Other high molecular weight substances such as glucosans and other polysaccharides impede water movement in xylem (Tarr, 1972). Chambers and Corden (1963) attributed vascular dysfunction in *Fusarium*-infected tomatoes to the collapse of the vessel walls. The intact secondary cell walls shown here suggest that this is not the case for xylem vessels in YTD affected citrus. It is possible that the vascular obstructions described by Childs *et al.* (1965) cause or contribute to vascular dysfunction in YTD affected citrus. However the vascular obstructions are not the mycelial stage of a fungus. The material comprising the vascular obstructions may originate from a pathogen or from a host response to a pathogen. The elucidation of the origin and the chemical nature of the plugging material will be necessary in order to carry out long term objectives for control or elimination of YTD in citrus.

ACKNOWLEDGEMENTS—Grateful acknowledgement is given Dr. J. F. L. Childs, Plant Pathologist, ARS, USDA, Orlando, Florida, for advice, assistance, and providing root samples and Ann Alexander, ARS, USDA, for technical assistance.

LITERATURE CITED

CHAMBERS, H., AND M. E. CORDEN. 1963. Semeiography of *Fusarium* wilt of tomato. Phytopathology 53:1006-1010.

CHILDS, J. F. L., L. E. KOPP, AND R. E. JOHNSON. 1965. A species of *Physoderma* present in citrus and related species. Phytopathology 55:681-687.

PAGE, O. T. 1959. Observations on the water economy of *Fusarium*-infected banana plants. Phytopathology 49:61-65.

SAALTINK, G. J., AND A. E. DIMOND. 1964. Nature of plugging material in xylem and its relation to rate of water flow in *Fusarium*-infected tomato stems. Phytopathology 54:1137-1140.

SPURR, A. R. 1969. A low-viscosity epoxy resin embedding medium for electron microscopy. J. Ultrastructure Res. 26:31-43.

STRUCKMEYER, B. E., R. H. BECKMAN, J. E. KUNTZ, AND A. J. RIKER. 1954. Plugging of vessels by tyloses and gums in wilting oaks. Phytopathology 44:148-153.

TARR, S. A. J. 1972. The principles of plant pathology. p. 115. Macmillan. London.

UNDERWOOD, L. M. 1891. Diseases of the orange in Florida. J. Mycology 7:27-36.

WAGGONER, P. E., AND A. E. DIMOND. 1954. Reduction in water flow by mycelium in vessels. Amer. J. Bot. 41:637-640.

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Editor: Harvey A. Miller
Department of Biological Sciences
Florida Technological University
Orlando, Florida 32816

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Biological Sciences

TUNNEL SYSTEM STRUCTURE OF THE SOUTHEASTERN POCKET GOPHER

Larry N. Brown and Graham C. Hickman

Department of Biology, University of South Florida, Tampa, Florida 33620

Abstract: *Excavation of 40 tunnel systems of* Geomys pinetis *revealed a high percentage contained a sharply pitched, tightly spiraled, "staircase" tunnel connecting shallow and deep burrow passages. In addition to the previously unknown spiral tunnels, specialized nest and food cache chambers were discovered in the bi-level tunnel system.*

The pocket gopher is an interesting rodent because it is primarily fossorial and behaviorally quite antisocial. Since they spend most of their lives beneath the surface of the ground, pocket gophers tend to construct intricate burrow systems. The characteristics of burrow systems for the southeastern pocket gopher (*Geomys pinetis*) have not been systematically studied and reported. Hubbell and Goff (1940) published a paper on the arthropod inhabitants of *Geomys pinetis* burrows, but made only general observations on tunnel structure itself. Barrington (1940) also commented on the natural history of *Geomys pinetis* and its underground systems.

The organization of the burrows system of other species of pocket gophers are better known, primarily as a result of papers by Scheffer (1940), Smith (1948), and Wilks (1963) on *Geomys bursarius*; by Sagal (1942) and Miller (1957) on *Thomomys bottae*; and by Tryon (1947) and Richens (1966) on *Thomomys tatpoides*, among others.

The purpose of this study was to determine the normal organization and the unique characteristics of the tunnel systems of the southeastern pocket gopher in the west coast region of Florida and to compare these features with those of other species of pocket gophers.

Methods and Materials—A total of 40 tunnel systems of *Geomys pinetis* was fully excavated on and near the campus of the University of South Florida, at the north edge of Tampa, Hillsborough County, Florida, during a three year period from April, 1968 to March, 1971. The study area consists of excessively well-drained sandy soils possessing only a limited amount of organic matter at the surface. The vegetative cover of the lawns and pastures where excavations were made consisted primarily of Bahia grass (*Paspalum notatum*) interrupted only by widely scattered specimens of live oak (*Quercus virginiana*) and an occasional clump of saw palmetto (*Serenoa repens*).

Pocket gophers were always removed by trapping prior to initiating complete tunnel excavation, in order to prevent them from plugging open tunnels which might cause mistakes as mapping of the burrow system progressed. The diameter, location and depth below the ground surface of each tunnel in the system were carefully measured at regular intervals and plotted on grid paper. All chambers, tunnel branches, and surface mounds, were mapped and their contents identified. The pattern of dirt mounds on the surface was mapped and correlated to the subterranean structure of each tunnel. The sex, weight, and age category (juvenile or adult based on pelage coloration) of each resident animal were recorded and related to the characteristics of the burrow system.

Results and Discussion—Of the 40 tunnel systems totally excavated, 20 were occupied by adult females, 15 contained an adult male, and five systems were occupied by juveniles (three females, two males). The sex and age ratio of this sample corresponds rather closely to that reported by Brown (1971) for a much larger sample of pocket gophers collected in the same general area.

The general pattern of all tunnels excavated consisted of one main linear tunnel with short laterals branching off at infrequent intervals (Fig. 1). In no cases did repeatedly anastomosing tunnels occur. A few burrow systems exhibited a long lateral tunnel (maximum 40 ft), but in these systems the main tunnel was also quite long (300-500 ft) and apparently developed over a substantial period of time. Most laterals were short, deadened branches that extended a few in to a few ft in length, or they terminated with some type of special chamber. Laterals leading to surface mounds were usually plugged partially or wholly with dirt down to the point where they intersected the main tunnel. Plugged tunnels supplement mound-building as a means by which a pocket gopher eliminates excavated soil from a new portion of the burrow system.

The total length of the 40 tunnel systems studied ranged from 20 ft to 525 ft, but averaged 145 ft. The longer, more extensive tunnel systems were characteristic of pocket gophers having a large body size. The sex of the animal, however, appeared to have little bearing on the total length or composition of the burrow system. The total tunnel length of a system was probably an indication of the length of time the occupant has resided therein.

The vertical depth of the burrows ranged from two to 60 in, but were seldom deeper than four ft. The bulk of each burrow system occurred between 6 and 18 in below the surface. Such tunnels were referred to as "feeding tunnels" or "shallow tunnels" and made up between 65-80 percent of each system. Deep tunnels (below 18-20 in) and special chambers comprised the remainder of each system. In adult *Geomys pinetis*, no correlation was noted between body weight or sex and burrow depth. Wilks (1963) reported similar results in burrow studies of *Geomys personatus*.

It was noted that during the dry season (winter and spring) in Florida, the sandy soils of the study area were very low in moisture content. During such dry seasons the "shallow tunnels" constructed by *Geomys pinetis*, tended to be somewhat deeper (usually 3 to 6 in deeper) than during periods of saturated soil conditions (summer and fall). Since sandy soils have a tendency to cave in and not hold well when dry, this deepening of "shallow tunnel" construction probably reflects a selection for proper soil moisture conditions by the pocket gopher rather than any great change in feeding

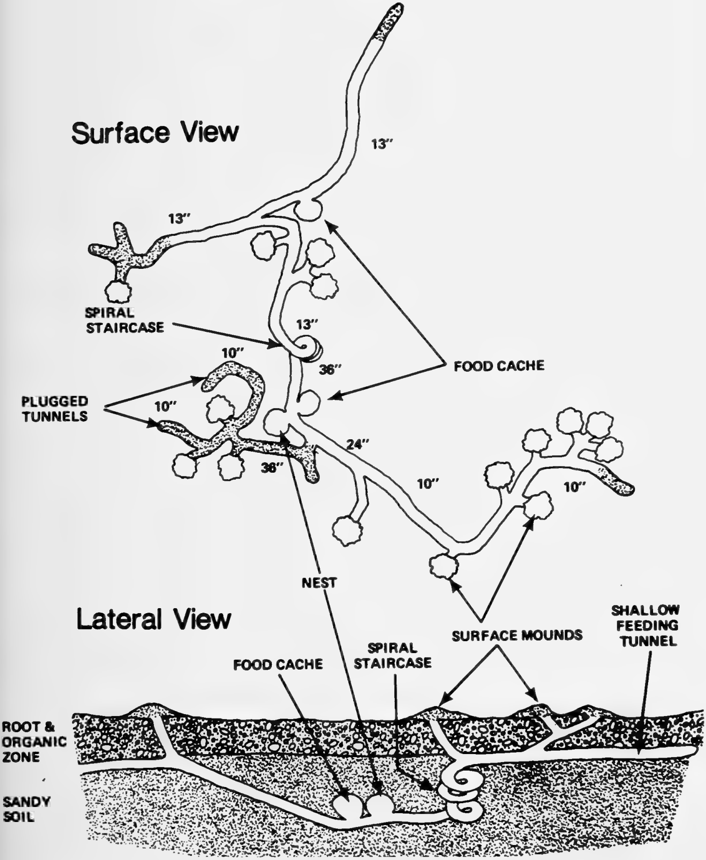

Fig. 1. Diagram of a "typical" tunnel system of *Geomys pinetis* in surface and lateral views.

habits. Likewise, no significant seasonal change was noted in the depth of placement of deep runways and chambers.

In compact soil, the tunnel diameter was found to be a good indication of the approximate body size of the animal. But in some of the burrow systems which were excavated in the loose, dry soils, the tunnels tended to have a significantly larger diameter than the gopher. This suggests that small caveins may occur in the looser and dryer soils during tunnel construction. It might also be possible that a gopher has more difficulty in gauging the diameter of its burrow in loose soil where normal digging efforts would remove more soil than usual.

A unique and hitherto unreported tunnel feature was discovered in approximately 70 percent of the *Geomys pinetis* systems. This was the presence of a sharply-pitched, tightly-spiraling tunnel or "spiral staircase" which often connected deep passages to shallow ones. In all instances, the "spiral staircase" tunnel made three or four sharp, looping turns forming a tight coil with a diameter of 8-14 in. In 75 percent of these cases, the "staircase tunnel" had a clockwise spiral when viewed from above and counterclockwise in the remaining 25 percent of them. The vertical change in tunnel depth produced by traveling up or down the "staircase" ranged from 18 to 36 inches.

Generally there was only one "spiral staircase" present per tunnel system, but in a small percentage (3 of 30), two spiraling tunnels occurred per system. It seems apparent that these spiral tunnels are a regular and somewhat stereotyped feature of most *Geomys pinetis* systems. The feature was equally prevalent in tunnels of either sex and of different body sizes.

The presence of a "spiral staircase" type of tunnel connection between deep and shallow burrows has not been previously reported in the genus *Geomys*. A somewhat analogous structure is produced by gophers in the genus *Thomomys* in the form of a straight vertical shaft which connects deep and shallow tunnels (Seton, 1929; Criddle, 1930; Scheffer, 1931; and Sagal, 1942). There was no report of spiraling construction in any of these species.

The presence of a tightly spiraling tunnel connecting shallow and deep burrows, probably is functional in tending to slow down, confuse, or stop potential predators (such as weasels and snakes) which would pursue the pocket gopher in the total darkness of a tunnel system. Since *Geomys pinetis* has the capability to plug a tunnel with dirt and wall itself off from a predator very quickly, the time gained from the presence of a "spiral staircase" could be very significant from the standpoint of natural selection. Also, from an engineering point of view, a spiral tunnel would be an efficient adaptation in achieving a maximum in vertical movement over a short lateral distance without sacrificing a secure footing for the pocket gopher.

Nearly all *Geomys pinetis* tunnel systems are found to contain two types of special chambers: 1) nest cavities and 2) food caches. Only one nest occurred in each system, and each was constructed at the end of a small, blind chamber located just a few inches off the main deep runway. The compact nest chambers were oval to spherical in shape and ranged in diameter from 4.5 to 7.0 in and roughly corresponded to the body size of the pocket gopher. Each chamber was filled with a hollow, spherical nest composed of shredded grasses and stems, and this was perforated by a single entrance on the side bordering the main deep tunnel. No food items were found within the nests, but occasionally pieces of tubers occurred along side them. As indicated previously, nest chambers were usually situated in the deepest portion of the tunnel system and generally within a short distance of the "spiral staircase" tunnel.

Food-cache chambers were not a constant feature of all systems, but occurred in 45 percent of those excavated. Those systems lacking food chambers often contained piles of plant tubers scattered at irregular intervals along the floor of both deep and shallow runways. Similar piles of tubers were reported by Hubbell and Goff (1940) for *Geomys pinetis* in northern Florida. The food-cache chambers were similar in size, shape, and location to nest chambers and were generally located in the general proximity of the nest chamber. However, in many systems there were food-storage chambers located along shallow tunnels as well as the deep tunnels. Systems having food-cache cavities, averaged 1.8 storage-chambers per tunnel system (range 1-4).

The food stored in the chambers consisted almost entirely of bahia grass tubers and varied in quantity from a few cuttings to large piles of tubers, five to six inches in diameter. Since the ground covering in the study area was almost uniformly bahia, this was about the only acceptable food source available.

About one-fourth of the tunnel systems lacked any type of food stored either in the tunnels or lacked food chambers. This is probably explained by the ready abundance of a constant food source in most areas. Bahia tubers were available throughout the year in quantities that made the storage of food unnecessary.

Tunnel systems located in areas of sparse vegetation showed a greater tendency to contain food caches than those located in well-vegetated areas. This suggests that food-caching behavior was probably partially elicited by a scarcity of suitable food plants. However, a few tunnel systems in areas of abundant vegetative cover also contained well-stocked food chambers. No correlation of the food-storing habit with sex or body size was evident. There likewise appeared to be no seasonal tendency for increased food-caching during the mild winter season that occurs in the Tampa area.

Special chambers for defecation, such as reported for several western species of pocket gophers (Scheffer, 1940; Kennerly, 1954; and Downhower, 1966), are not a characteristic of *Geomys pinetis* systems. However, in several instances chambers were found packed partially or wholly with a mixed refuse consisting of dried grass, dirt, and fecal pellets. Since fresh droppings are normally encountered throughout the tunnel system in the floor of the runways, it seems evident that old chambers become a repository of dirt, droppings, and other debris as a result of tunnel renovations and housekeeping activities.

While no special defecation chambers occurred, sizeable dung masses were present in the floor of the main deep tunnel of several tunnel systems. These were located from two to five ft away from the nest chamber. The main tunnel was not enlarged at the dung site, but the fecal pellets covered the tunnel floor for a linear distance of four to eight in. They were compressed and packed into a compact fecal mass not exceeding one-half in thickness, apparently as a result of the repeated traffic of the gopher through the tunnel.

It was not possible to predict the approximate footage of underground tunnels present by the number and frequency of surface mounds produced by *Geomys pinetis.* Patterns of mound production were entirely irregular, varying from one portion of the same system to another. A great deal of dirt was redistributed underground and packed into older portions of the system or into abandoned laterals. Mounds do tend to occur to one side or the other of the main linear tunnel rather than directly above it since dirt are normally expelled on to the surface from outwardly inclined lateral tunnels. Surface mounds varied tremendously in size, ranging from less than four in to as much as four ft in diameter depending on the situation and the individual peculiarities of the pocket gopher. The heights of freshly produced mounds varied from less than 3 to as much as 12 in. The surface mounds of small gophers tended to be smaller and more tightly clustered than those of larger, older animals. Also, individuals usually constructed larger mounds when their tunnel systems were first established. However, these large initial mounds never contained temporary nests as reported for *Geomys breviceps* by English (1932) in Texas.

The presence of a characteristic central depression in surface mounds which marks the position of the plugged lateral tunnel has been reported in several western species of pocket gophers (Miller, 1948; Storer, 1949; Miller, 1957; Sagal, 1942; and others). No central depressions occur in the mounds of *Geomys pinetis,* but on rare occasions, a peripherally placed plug or depression is sometimes visible which aids in locating the lateral tunnel. Normally however, no clear evidence of the direction of the plugged lateral tunnel is ever visible when the mound is finished.

Summary—The burrow systems of 40 individuals of the southeastern pocket gopher (*Geomys pinetis*) were excavated. Systems varied greatly in length, but were essentially linear with short laterals branching off the main tunnel. Each burrow system was organized into "deep tunnels" (18-60 in deep) and shallower "feeding tunnels", the latter forming 65-80 percent of each system.

A unique and previously undescribed "spiral staircase" type of tunnel was found connecting shallow passages to deep tunnels in 70 percent of the systems studied. The "spiral staircase" tunnels made three or four sharp, looping turns which formed a tight coil with a diameter of 8-14 in. The po-

tential value of the "spiral staircase" as a predator escape mechanism is discussed.

The two types of special chambers found in the *Geomys pinetis* systems were: 1) nest chambers and 2) food cache chambers. Food piles also occurred on the ordinary tunnel floors. No special "defecation chambers" were found, but in a few systems, fecal masses occurred in the floors of certain tunnels.

The distribution of surface mounds was not particularly useful for gauging the distribution and extent of underground tunnels. The surface mounds of small gophers tended to be smaller and more tightly clustered than those of larger animals. Individuals usually constructed larger mounds when their tunnel systems were first established.

ACKNOWLEDGMENTS—Only the skillful assistance of a number of students at the University of South Florida have made the accomplishment of this project possible. Among these, we would especially like to acknowledge the assistance of Richard McGuire, Al Maida, Daniel Durrance, and Richard Bryson.

LITERATURE CITED

BARRINGTON, B. A., JR. 1940. The natural history of the pocket gopher. M.S. Thesis, University of Florida. 49 pp.

BROWN, L. N. 1971. Breeding biology of the pocket gopher (*Geomys pinetis*) in southern Florida. Amer. Midl. Nat. 85:45-53.

CRIDDLE, S. 1930. The prairie pocket gopher, *Thomomys talpoides rufecens*. J. Mammal. 11:265-280.

DOWNHOWER, J. F. AND E. R. HALL. 1966. The pocket gopher in Kansas. State Biol. Surv. Kansas 44:1-32.

ENGLISH, F. 1932. Some habits of the pocket gopher, *Geomys breviceps*. J. Mammal. 13:126-132.

HUBBELL, T. N. AND C. GOFF. 1940. Florida pocket gophers burrows and their arthropod inhabitants. Proc. Fla. Acad. Sci. 4:127-166.

KENNERLY, T. E., JR. 1958. Comparisons of morphology and life history of two species of pocket gophers. Texas J. Sci. 10:133-146.

MILLER, M. A. 1948. Seasonal trends in burrowing of pocket gophers (*Thomomys*). J. Mammal. 29: 39-44.

———. 1957. Burrows of the Sacramento Valley pocket gopher in flood-irrigated alfalfa fields. Hilgardia 26:431-452.

RICHENS, V. B. 1966. Notes on the digging activity of a northern pocket gopher. J. Mammal. 47: 531-533.

SAGAL, B. E. 1942. Natural history of the pocket gopher, *Thomomys bottae*, of Alameda County, California. M.A. Thesis, University of California.

SCHEFFER, T. H. 1931. Habits and economic status of the pocket gophers. U.S.D.A. Tech. Bull. 224:1-26.

———. 1940. Excavation of a runway of the pocket gopher (*Geomys bursarius*). Trans. Kansas Acad. Sci. 43:473-478.

SETON, E. T. 1929. Lives of game animals. Doubleday, Doran and Co., New York, Vol. 4:395-418.

SMITH, C. F. 1948. A burrow of the pocket gopher (*Geomys bursarius*) in eastern Kansas. Trans. Acad. Sci. 51:313-315.

STORER, T. I. 1949. Control of field rodents in California. Univ. California Agr. Ext. Ser. Circ. No. 138:1-50.

TRYON, C. A., JR. 1947. The biology of the pocket gopher, *Thomomys talpoides* in Montana. Montana State Coll. Agr. Exp. Sta. Tech. Bull. No. 448:1-30.

WILKS, B. J. 1963. Some aspects of the ecology and population dynamics of the pocket gopher (*Geomys bursarius*) in southern Texas. Texas J. Sci. 15:241-283.

Florida Sci. 36(2-4):97-103. 1973.

BISCAYNE BAY: BACTERIOLOGICAL DATA INTERPRETATION

CHARLES P. GERBA AND GEORGE E. SCHAIBERGER

Department of Virology and Epidemiology, Baylor College of Medicine,
Texas Medical Center, Houston, Texas 77025,
and Department of Microbiology,
University of Miami School of Medicine, Miami, Florida 33152

ABSTRACT: *Peaks of coliform abundance in Biscayne Bay are correlated with periods of heavy rainfall which flush inland canals holding sludge, nutrients and potential populations of pathogens which could pollute beach areas above acceptable levels for bathing.*

RAPID growth of the greater Miami area resulted in many private utility companies being charged with the responsibility for properly treating and disposing of domestic wastes. These so called package treatment plants were allowed to discharge their "treated wastes" into Dade county's network of canals. The result was gross pollution of almost every canal and waterway in the county and eventually a federal hearing into the matter (Environmental Protection Agency, 1971). This abuse of inland waters raised much concern over the quality of water in Biscayne Bay, into which many of the canals drain. Much of the bay, particularly the area south of the Rickenbacker Causeway, is heavily used for recreational purposes and deterioration of water quality there could pose a public health hazard. Various studies on the northern portion of the bay have been performed (Federal Water Quality Administration, 1970; McNulty, 1970; Johnson et al., 1970), but little has been said about fecal pollution of the southern bay region, where most recreational activity occurs. Bathing, wading, boating, skiing, fishing, and diving are commonly enjoyed here. Matheson Hammock, Homestead Bayfront Park, and the entrance to the Coral Gables Waterway are heavily used. Future planned recreational facilities at Black Point and Chapman Field Parks will undoubtedly increase activity along the bayfront. This report reviews some of the available data on the extent of fecal pollution along the southern bayfront, and discusses how a combination of seasonal and environmental factors can interact to produce unsatisfactory recreational waters.

The principal canals that empty into southern Biscayne Bay are the Coral Gables Waterway, Snapper Creek, C-100, Black Creek, Military Canal, Mowry Canal, and the Florida City Canal. Their location is shown in Fig. 1. These canals were primarily designed to prevent floods, recharge the groundwater, and prevent salt water intrusion into the Biscayne Aquifer. Most originate in Water Conservation Area 3 or in the Everglades west of Miami. Water flow in these canals is controlled by structures in the Everglades operated by the Central and Southern Florida Flood Control Districts, and salinity dams located near their discharge point into the bay. Several of these canals are still receiving sewage from private utility companies in addition to the sub-surface leakage of effluent from septic tanks (Jackivicz, 1969). In 1971, the amount of waste being discharged into the canals was reported as: 2.62 million gallons a day for Snapper Creek, 3.53 MGD for Black Creek, 2.62 MGD for the Coral Gables Waterway, and 3.21 MGD for the remaining south bay canals (Environmental Protection Agency, 1971). These canals also receive surface drainage from streets and agricultural areas.

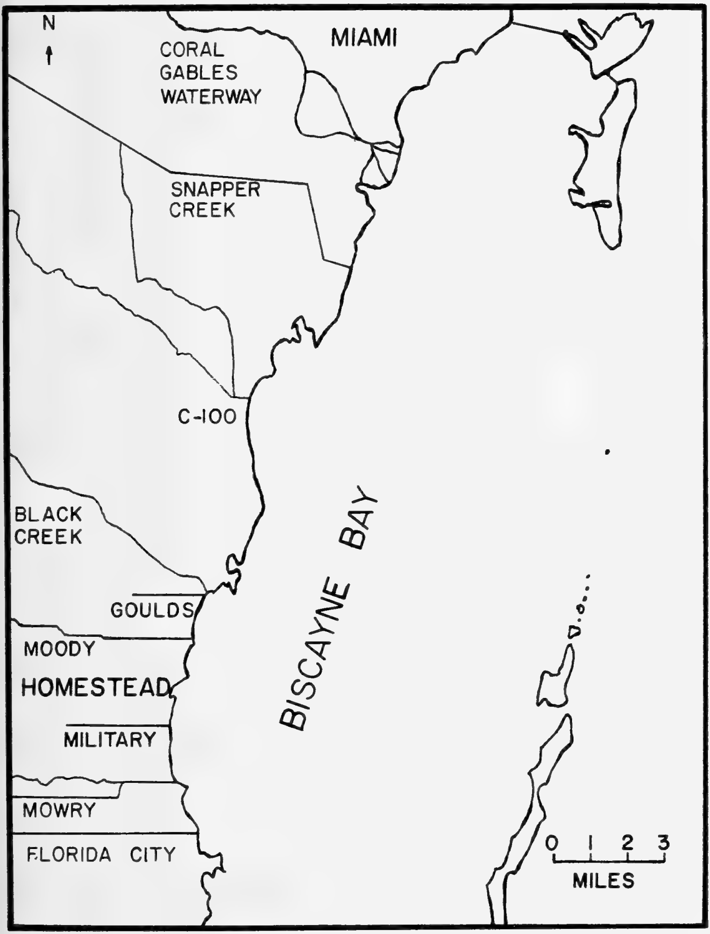

Fig. 1. Major canals that drain into Southern Biscayne Bay, Florida.

High levels of coliform bacteria, which are used to measure the danger from disease causing bacteria, have been detected in most of the canals. For the recreational use of water, involving body contact, the total number of coliforms should not exceed 1,000/100 ml, according to federal, state, and local standards. These standards are exceeded in Black Creek and Mowry Canal, which for 1969 averaged 56,141 and 6,123 coliforms/100 ml respectively (Federal Water Quality Administration, 1970). Between the years 1967 and 1970 values exceeding or approaching 1,000,000 coliforms/100 ml were reported for the Coral Gables Waterway, Snapper Creek, Black Creek, Military Canal, and Mowry Canal (Johnson et al., 1970). A status report by a group of graduate students revealed the effect of discharge on coliform numbers as the water in the canals flows towards the bay (Johnson et al., 1970). For example, the mean coliform values between 1967 and 1969 for Snapper Creek increased from 800/100 ml at its junction with the Tamiami Canal to over 9,000/100 ml near its discharge point into the bay. This represented a greater than ten fold increase in the number of fecal organisms. In addition, these studies revealed that sludge, as a result of sewage discharges, had accumulated to a depth of as much as nine ft in some canals.

Recent efforts by local agencies have improved markedly the quality of discharges (Environmental Protection Agency, 1971). In addition, cessation of waste discharges into the inland canal system is set to be accomplished within the next few years. But, recent studies indicate that long term effects may exist. Hendricks (1971a, 1971b), and Van Dosel and Geldrich (1971) have found that a one hundred to one thousand fold increase in fecal coliforms can occur in the sediments of polluted waters, and that such bacterial pathogens as *Salmonella* and *Shigella* are capable of reproduction in these sediments. In addition, studies in our laboratory (Gerba and Schaiberger, 1972) indicate that viruses become readily adsorbed to particulate matter involved in sediment formation, which acts to prolong their survival time. Given the amount of sludge in the waterways, it seems possible that long term accumulation and regrowth of pathogens has occurred in the canals of Dade County.

While in the adsorbed state on canal bottoms, pathogens pose little danger to public health but the water-mud interface is not a static system. Sediments can easily be resuspended by response to currents, storms, boats, and dredging. Also of concern is the finding that bacterial (Weiss, 1951) and viral (Carlson et al., 1968; Gerba and Schaiberger, 1972) adsorption to sediments is dependent on the salinity, and in the case of viruses the amount of organic matter present (Carlson et al., 1968). Changes in the concentrations of these substances can result in release of adsorbed bacteria or viruses into overlaying water.

Limited water quality data are available extending back several years for certain locations on the bayfront from the state public health office in Miami. Figure 2 illustrates the dramatic increase in coliform numbers between 1960 and 1970 at the north end of the bathing beach at Homestead Bayfront Park. This recreational site is located on the bayfront east of the city of Homestead.

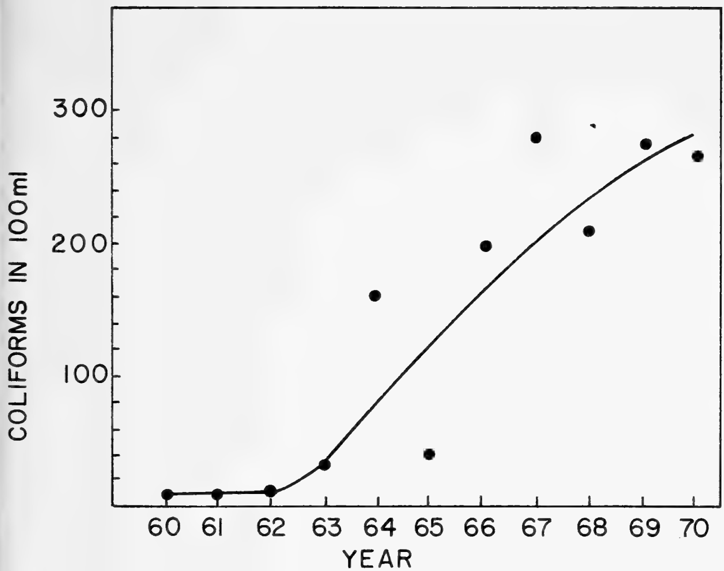

Fig. 2. Average coliform values for bathing beach at Homestead Bayfront Park (north end). 1960-1970.

A man-made bathing beach and a small marina are located due south of where Mowry and Military canal empty into the bay. Examination of data for the years 1969 to early 1970 reveals that during months proceeding dry weather, bathing water quality never exceeded the bacteriological standard of 1,000 coliforms/100 ml. During months of low rainfall, from November through April, none of 61 samples collected exceeded minimum water quality standards for swimming. The highest recorded value was 920/100 ml, and lowest was less than 1.8/100 ml. At this level of fecal contamination the pathogen hazard to swimmers would be expected to be quite low.

Average monthly rainfall data for the years 1968 through 1970 indicate that three noticeable peaks in rainfall occurred (Fig. 3). Sharp rises in rainfall occurred during January, June, and September. Each of these months was followed by a period of increased fecal pollution at Homestead Bayfront Park. Average coliform values exceeded 365/100 ml for the months of March, June, July, and October as compared to a mean of 113 for the other months of the year. This represents a greater than three-fold increase in the number of fecal organisms. While this average is still well below that required for safe body contact, several samples exceeded 1600/100 ml. Thus, a definite deterioration of water quality occurs following those months characterized by high rainfall.

Coliform numbers remain high for only a brief period of time probably due to adsorption, sedimentation, dilution, and natural antagonism by local microflora. This does not necessarily decrease the danger from disease, but makes it more difficult to detect. Sampling by public health personnel has been done on a more or less random basis, but generally every two to four weeks, and short periods of increased danger could easily remain undetected. A comparison of park attendance records for the entire county (Board of County Commissioners, 1968-1970) plotted on a monthly basis with mean coliform values (Fig. 3) indicates that peaks in park attendance occur simultaneously during peaks in coliform numbers in April and July. It thus seems that we have a combination of events necessary to produce an undesirable situation from the public health standpoint.

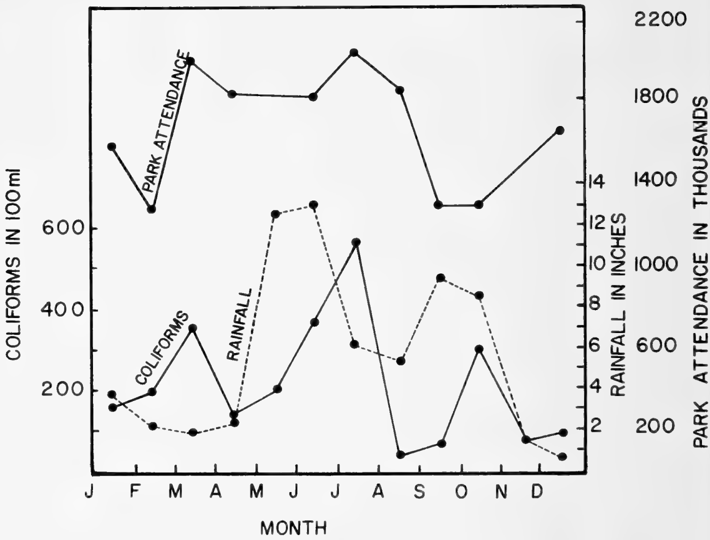

Fig. 3. Comparison of average monthly coliform values at Homestead Bayfront Park (north end), rainfall, and county wide park attendance. 1968-1970.

In summary, we have a situation in which freshwater runoff has a pronounced effect on the quality of water reaching the bay by way of the canals. At those times of the year with little or no rainfall, water is held back from reaching the bay by salinity dams located near the mouths of these canals. Sludge, nutrients, and pathogenic microorganisms accumulate behind these barriers or settle out in the slowly moving or stagnant water. When a fresh surge of water passes through the canal, due to rainfall or release from the conservation areas, accumulated substances are flushed into the bay. The result is a dangerous rise in the levels of coliforms at bathing beaches located in the vicinity of the discharge point of these canals. Thus, we have a combination of factors necessary to produce unsatisfactory bathing water which could continue to be a threat that might erupt in the future.

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LITERATURE CITED

BOARD OF COUNTY COMMISSIONERS. 1968-1970. The Monthly Performance Reports of each Dade County Department as Submitted to the Board of County Commissioners. Metropolitan Dade County, Florida.

CARLSON, G. F., F. E. WOODARD, D. F. WENTWORTH, AND O. J. SPROUL. 1968. Virus inactivation on clay particles in natural waters. J. Water Poll. Control Federation. 40(2,2):R89-R106.

ENVIRONMENTAL DATA SERVICE. 1971. Local climatological data, annual summary with comparative data, Miami, Florida. U.S. Dept. Commerce.

ENVIRONMENTAL PROTECTION AGENCY. 1971. Third session of the conference in the matter of the pollution of the navigable waters of Dade County, Florida, and tributaries, embayments and coastal waters. pp. 1-234.

FEDERAL WATER QUALITY ADMINISTRATION. 1970. Lower Florida estuary study. Pollution of the waters of Dade County, Florida. pp. 1-47.

GERBA, C. P. AND G. E. SCHAIBERGER. 1972. The effect of particulate matter on the survival of viruses in seawater. Abstr. Tech. Pap. Ann. Conf. Water Poll. Control Federation, 1972.

HENDRICKS, C. W. 1971a. Increased recovery rate of *Salmonellae* from stream bottom sediment versus surface waters. Appl. Micro. 21:379-380.

———. 1971b. Enteric bacterial metabolism of stream sediment eluates. Canad. J. Micro. 17:551-556.

JACKIVICZ, T. P. 1969. Pollution of canals by septic tanks. Unpublished Masters Thesis, Univ. of Miami. Coral Gables, Florida.

JOHNSON, G. V., K. JAMES, C. MORRISSEY, AND K. W. SCHANG. 1970. Pollution in Dade County: A status report October 1970. *In* Proceedings of the Conference in the Matter of Pollution of the Navigable Waters of Dade County, Florida, and Tributaries, Embayments and Coastal Waters. pp. 313-365. Federal Water Quality Administration.

MCNULTY, J. K. 1970. Effects of the abatement of domestic sewage pollution on the benthos, volumes of zooplankton, and the fouling organisms of Biscayne Bay, Florida. pp. 1-107. Univ. of Miami Press. Coral Gables, Florida.

VAN DONSEL, D. J. AND E. E. GELDREICH. 1971. Relationships of *Salmonellae* to fecal Coliforms in bottom sediments. Water Research 5:1079-1087.

WEISS, C. M. 1951. Adsorption of *E. coli* on river and estuarine silts. Sew. Indust. Wastes. 23: 227-237.

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MILITARY HERBICIDE DRIFTAGE AND FLORIDA VEGETATION

DANIEL B. WARD AND CARL J. CHAPMAN

The Herbarium, Department of Botany,
209 Rolfs Hall, University of Florida, Gainesville, Florida 32601;
Department of Biology, Concord College, Athens, West Virginia 24712

ABSTRACT: *An Air Force program on the Eglin Air Force Base Reservation, Florida, of testing spray equipment designed to apply herbicides and other biologically active materials by aerial means, has given rise to the possibility that the testing program might affect the biota outside the test area. Observations made as part of the present project show that changes have been induced in the vascular flora, but that they are not extensive in terms of distance from the test area, duration, or magnitude. No species can be demonstrated to be reduced in numbers near the test area, although certain weedy species can be shown to increase in numbers near the area following the temporary defoliation of the forest canopy.*

THE Eglin Air Force Base Reservation in western Florida serves various military uses, one of them being the development and testing of aerial spray equipment for dispensing herbicides and other biologically active materials. Insofar as possible, this equipment must be tested under realistic yet controlled conditions. For this purpose a test facility has been established on the Eglin Reservation, with the place of direct aerial spray application restricted to an instrumented grid approximately one mile square in the south-eastern part of the Reservation and known as Range 52A.

Aerial spray equipment was tested on the Eglin facility between June, 1962 and October, 1970. Whenever possible, inactive mixtures were used in determining the capabilities of the airplane-borne dispensing devices, but realistic evaluation of the equipment required partial use of active military defoliants. The agents used were known by the military names of Purple, Orange, White, and Blue, and consisted of various proportions of 2, 4-dichlorophenoxyacetic acid (2, 4-D), 2, 4, 5-trichlorophenoxyacetic acid (2, 4, 5-T), 4-amino-3,5,6-trichloropicolinic acid (picloram), and dimethylarsinic acid (cacodylic acid). The quantities of these defoliants dispensed above the instrumented test grid have been tabulated by Hunter and Young (1972). Over the series of tests the rate per acre totaled 1,540 pounds of 2, 4-D and 1,487 pounds of 2, 4, 5-T, with much lesser amounts of picloram and cacodylic acid.[1]

There is no means of determining what proportion of the herbicide dis-

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[1]An appreciation of the magnitude of these rates of application may be gained from the statement of Dr. Arthur W. Galston to the Subcommittee on National Security Policy and Scientific Developments, of the Committee on Foreign Affairs of the House of Representatives, December 1969 (Whiteside, 1970). Dr. Galston testified that the use of 2, 4-D and 2, 4, 5-T as a military defoliant in Vietnam had been at the rate of about 27 pounds per acre. This military application rate, in turn, is about ten times the usual rate recommended for domestic control of herbaceous and woody vegetation. The 3,027 pounds of 2, 4-D and 2, 4, 5-T applied to a given acre of the Eglin test grid thus exceeded the usual domestic rate by a factor of approximately 1000.

pensed over the test grid drifted outside of the grid and into the area of the present study. Proportionately it must have been low, for any approach to the massive dosages applied above the test grid would have caused nearly total vegetational destruction. No such destruction has occurred. Yet during the early years of spray application, particularly prior to 1966, changes were manifest in the surrounding forest, presumably a consequence of herbicide driftage outside the area of intended application. Concern over the extent and precise effect of this spray driftage led to the establishment of the present project.

OBSERVATIONS OF THE AREA—The test area known as Range 52A, on which the release of various aerial sprays was centered, is located in a thinly forested stand once dominated by longleaf pine (*Pinus palustris*), but following cutting, by turkey oak (*Quercus laevis*). It is an unusual association in that it contains a large admixture of sand pine (*Pinus clausa*), a species usually restricted to coastal dunes or the peninsular Florida plant association known as scrub. The present tree species, in order of descending importance, are turkey oak, sand pine, and longleaf pine. There is a smaller component of blue-jack oak (*Quercus incana*), sand live oak (*Q. geminata*), persimmon (*Diospyros virginiana*), and other species.

For a distance around the test grid, often extending to one mile or more, there was apparent abnormality to the growth of many of the trees. This abnormality differed among species, and was detectable for varying distances.

Turkey oak near the test area was severely affected, apparently by herbicide driftage, and the large proportion of trees of this species gave the entire forest an abnormal aspect. Upper branches of all trees had apparently been completely defoliated, and many or even most of the twigs were killed. On the lower trunk a proliferation of small branchlets had appeared; in all cases these branchlets began growth in the spring of 1965, as determined by the number of bud-scale scars present.

Blue-jack oak and sand live oak were also heavily damaged near the test clearing, but appeared undamaged as little as 1.1 mile from the clearing in an area where turkey oak still exhibited signs of damage.

Spray damage to the oaks, particularly turkey oak, was noted on all sides of the test area. To the east of the area, along Eglin AFB Road 218, damaged trees were observed for a distance of 1.5 miles. The maximum distance from the grid that spray damage was definitely detected was 5 miles, seen on trees at the upper end of Range 52, north of the test area.

In the fall of 1966, sand pine, even immediately adjacent to the test area clearing, showed no damage attributable to defoliant. Sand pine retains its needles for only a single year, thus only those produced in the spring of 1966 were present on the tree. Internode length varied, but neither the 1964, 1965, nor 1966 internodes showed any consistent pattern of reduced or elongated length.

Longleaf pine adjacent to the test clearing also appeared unaffected. Two years of needle growth were present, as is normal. The 1965 needles were quite uniform in length and color. The 1966 needles varied in length rather more than expected, but after examination of other trees away from the test area it was concluded that this variability is not unusual. Internode length appeared to vary at random.

Effects on the growth of sand pine and longleaf pine of the area adjacent to the test grid were examined further by Hunter and Agerton (1971). They found fluctuations in the width of annual growth rings but were unable to correlate the observed differences with proximity to the test area or with the amounts of defoliants dispensed.

Damage to herbaceous species could not be detected by gross examination. Damage, if present in such groups of plants, may be manifested by the complete disappearance of heavily affected individuals, while less damaged individuals may show complete recovery. A quantitative sampling program, reported below, was designed to reveal such changes in population size of the herbaceous species.

Grasses were observed to form a large part of the ground cover near the test area. The proportion of grass cover along the test transects ranged from a high of 75 percent immediately adjacent to the test area to a low of 1 percent at a distance of 1.1 mile. This is discussed more fully as part of the quantitative sampling program.

Quantitative Sampling—*Experimental Design*: In the fall of 1966 a program was devised to permit the quantitative measurement of changes in density of stand of vascular plants in the area adjacent to the test grid on Range 52A. These changes were to be recorded at points increasingly distant from the test grid, thereby affording a measure of the effects, if any, of the spray program upon the surrounding vegetation.

Five stations were selected in woodland east of the test grid. The stations were selected at places where subjective appraisal of the vegetation indicated a maximum degree of natural uniformity. The stations were spaced at increasing distances to the east of the test grid along Road 218, the first immediately adjacent to the mechanically cleared area of the grid, with the second, third, fourth, and fifth at distances from the first of 0.15, 0.4, 1.1, and 2.0 miles. These five stations were assigned numbers 1, 2, 4, 6 and 7. Other stations were laid out but not used for the present program. The station numbers are therefore not consecutive. In all discussion of these stations and in the accompanying tables and charts they will be referred to by the number originally assigned.

Within each station four linear transects were laid out, each transect being 50 m long, parallel to the others at 10 m intervals, and at right angles to an imaginary radius from the center of the test grid. Thus, within each station 200 m of transect were laid out, with a total of 1000 m for the five stations.

All individuals of vascular plants, as well as many lichens, were counted and listed, if intercepted by the vertical plane of the linear transect. Dead trunks of tree species were also tallied in a separate listing. Species present in the 10 m intervals between the transects were recorded if not intercepted by the transect, but were not included in the transect tally. Species in which one individual tends to spread vegetatively over a considerable area (the habit of certain grasses) would be measured deceptively if the resulting more-or-less continuous cover were tallied as a single transect intercept; these species were recorded in terms of the per cent of the transect covered.

Method of Analysis: The resulting data, i.e., the number of individuals of each species intercepted by each of the four transects in each of the five stations, are interpretable by a conventional statistical analysis, the analysis of variance and associated F-test (Snedecor, 1956; Steele and Torrie, 1960). In this application two estimates of variance are available for each species—the "within-stations" variance and the "among-transects-within-stations" variance. The ratio between these two estimates of variance permits the determination whether the observed fluctuation in number of individuals intercepted at each station does or does not exceed the limits to be expected from chance alone.

Two analyses of variance were prepared for each species. The first was based upon all five stations, while for the second the data for the fifth station, no. 7, the most distant from the test grid, were deleted. For each analysis an F-test was prepared, with the conventional notation of a single asterisk indicative of 95 percent probability and double asterisks indicating 99 percent probability that the different stations were not uniform. These data are included in Table 1.

Those species that showed a probability of 95 percent or above that all stations were not uniform were grouped into similar patterns of frequency distribution, and then charted (Figs. 1-3). The charts were prepared with the horizontal axis representing the different stations, spaced proportionate to their actual distance from the edge of the test grid, and the vertical axis representing the number of individuals of a given species found at each station.

RESULTS—Along the 1000 m of linear transect a total of 2157 individual plants (i.e., colonial-type grasses excluded) was tallied, for an average spacing of 46.3 cm. These individuals belonged to 54 different species, with the most abundant, turkey oak (*Quercus laevis*), being intercepted 715 times, and with ten species being encountered only once. The species, ranked in the order of intercept frequency, are listed in Table 1.

Of the species intercepted by the transects, 34 showed no significant indication that the number of individuals encountered at each station varied other than at random. These species are indicated in Table 1 by a lack of asterisks, both when all five stations were analyzed and when the analysis was limited to the first four stations. These species were not analyzed further.

Nine species of colonial grasses were encountered by the transects. The per cent cover, with data for all species pooled, is given in Table 2.

Few of the species with significant fluctuations in the number of intercepts showed a consistent trend. Among the most striking were the small upright legume *Tephrosia virginiana*, the persimmon, *Diospyros virginiana*,

TABLE 1. Intercept totals.

Species	Stations 1, 2, 4, 6, & 7	Stations 1, 2, 4, & 6
Quercus laevis	715°°	656
Quercus geminata	385	385
Chrysobalanus oblongifolius	244	244
Quercus margaretta	146°°	52°°
Rhynchosia galactioides	90°°	89
Quercus incana	77	52
Galactia microphylla	74°	74
Pinus clausa	63	41
Cladonia sp. "Reindeer Moss"	55	51
Galylussacia dumosa	36	2
Hypericum gentianoides	35°°	31°°
Diodia teres	24°°	3
Serenoa repens	24	24
Tephrosia virginiana	23°	12
Solidago odora	21	16°°
Diospyros virginiana	20°	5°
Cladonia sp. "British Soldiers"	19°	17°
Pinus palustris	19	15
Yucca filamentosa	19	19
Eupatorium capillifolium	18	8
Eriogonum tomentosum	16°°	3
Crataegus lacrimata	15°°	7°°
Smilax auriculata	10	7
Chrysopsis aspera	10	8
Pteridium aquilinum	10°	10°°
Cnidoscolus stimulosus	9	7
Vaccinium arboreum	8	8
Croton argyranthemus	7°°	0
Petalostemon caroliniense	6	2
Liatris gracilis	6	5
Agalinis divaricata	5	2
Polygala polygama	4	3
Schrankia microphylla	4°°	0
Erechtites hieracifolia	4°	3°°
Chrysopsis mixta	4	3
Lechea deckertii	4	4
Centrosema virginianum	3	2°
Stylisma patens	3	3
Rhynchosia reniformis	2	0
Desmodium strictum	2	0
Polygonella polygama	2	0
Eupatorium compositifolium	2	2
Lichens (unidentified)	2	2
Warea sessilifolia	2	2°
Vitis rotundifolia	1	0
Sassafras albidum	1	1
Opuntia compressa	1	1
Commelina erecta	1	1
Ruellia ciliosa	1	0
Helianthus radula	1	0

Asclepias verticillata	1	0
Gaura filipes	1	0
Cassia fasciculata	1	0
Rhus copallinum	1	0

*95% probability of heterogeneous distribution.
**99% probability of heterogeneous distribution.

and the weeping haw, *Crataegus lacrimata* (Fig. 1a). These species were not encountered adjacent to the grid but increased rather consistently to a maximum at station no. 7, the station farthest from the grid.

Two species which increased significantly in number of intercepts away from the spray grid did so because they were encountered only at station no. 7 (Fig. 1b). In the second analysis, when station no. 7 was excluded, the significance naturally disappeared. Both were herbs: *Croton argyranthemus*, and the legume *Schrankia microphylla*.

Four herbs *decreased* significantly away from the spray grid: the legume *Rhynchosia galactioides; Hypericum gentianoides;* goldenrod, *Solidago odora*; and the mustard *Warea sessilifolia* (Fig. 2a).

In a few other species the number of intercepts varied significantly from one station to another, but the trend was not consistent with increasing distance from the spray grid (Fig. 2b). The number was highest at stations no. 4 or no. 6, as in the legume, *Galactia microphylla*; a lichen, *Cladonia* sp.; and bracken fern, *Pteridium aquilinum*.

TABLE 2. Grass cover.

Station no.	Transect	Percent cover
1	1	50
	2	66
	3	75
	4	50
2	1	10
	2	10
	3	5
	4	5
4	1	1
	2	3
	3	1
	4	1
6	1	1
	2	1
	3	1
	4	1
7	1	90
	2	90
	3	75
	4	75

Several other species were present in significant numbers in the stations near the spray grid (no. 1 and sometimes no. 2) and in the station farthest away (no. 7), but were absent at the central stations of the transect (no. 4 and no. 6). These species were all herbs: *Diodia teres;* wild buckwheat,

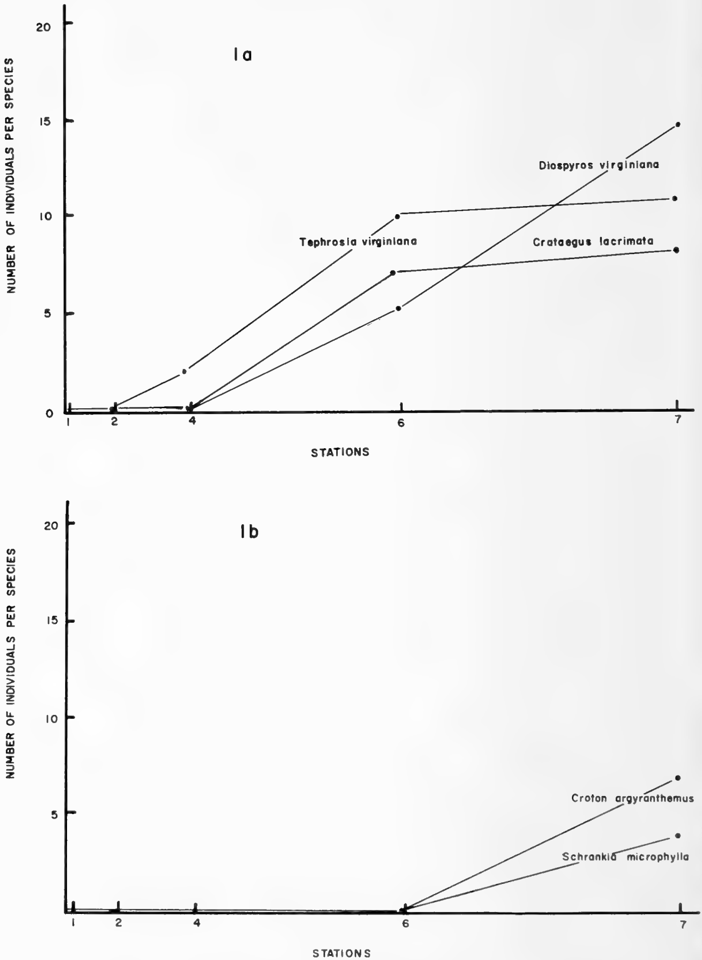

Fig. 1. Change in number of transect intercepts with distance. 1a and 1b: Species occurring with lower frequency near the test area.

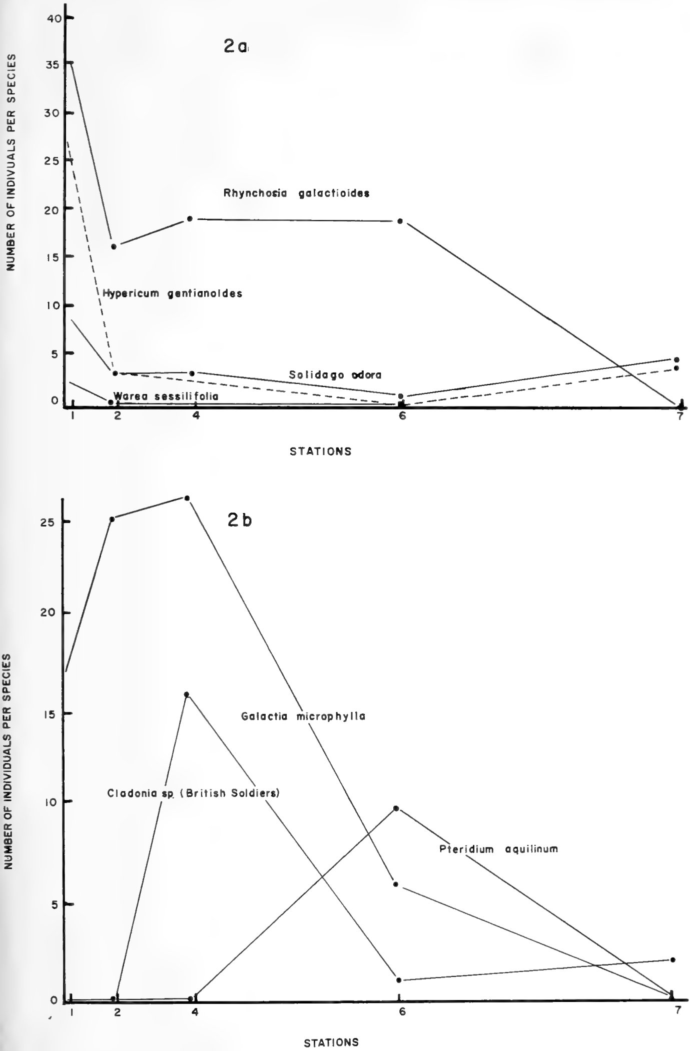

Fig. 2. Change in number of transect intercepts with distance. 2a: Species occurring with higher frequency near the test area. 2b: Species showing varying frequencies.

Eriogonum tomentosum; Erechtites hieracifolia; and the legume *Centrosema virginianum* (Fig. 3a).

Finally, two trees showed rather variable patterns (Fig. 3b). Turkey oak, the most abundant tree of the area, after an initial increase, decreased with greater distance from the grid. Sand post oak, *Q. margaretta,* also relatively common, was found primarily at two stations, no. 2 and no. 7.

The colonial type grasses showed a striking decrease in percent of transect covered from a high of 50 to 75 percent adjacent to the spray grid (station no. 1) to an estimated 1 percent in stations no. 4 and no. 6, then abruptly up to 90 percent in station no. 7. Since the data are in the form of percentages, rather than discrete counts as with the non-colonial species, there is an appreciable possibility that they will not conform to the usual assumptions required for statistical analysis; no mathematical analysis was made, therefore.

Discussion and Conclusions—It was recognized at the time this sampling program was designed that any attempts at quantitative measurement of the effects of the spray program would be handicapped, perhaps seriously, by the fact that a portion of the spray applications was made prior to the present study so that all estimates of changes must be made without examination of the original vegetation. It was therefore necessary to estimate these changes by indirect means.

Careful subjective examination of the area surrounding the test grid (Range 52A), before selection of stations for the present quantitative study, revealed that there was a high apparent uniformity of vegetation type throughout the area. Most of the dominant tree species occurred in rather similar quantities for a distance of several miles to the east and west of the grid and for a somewhat shorter distance to the north and south. Many of the conspicuous herbaceous species were similarly widespread. The two major exceptions to this apparent uniformity were (1) the shallow ravines feeding the steeper valleys draining the area to the south, and (2) the area immediately around the grid where individuals of many tree species were clearly abnormal, surely a residual effect of spray drift. The areas of the shallow ravines were readily recognized, both by topography and by the strikingly different vegetation, and cannot influence the interpretation. The hypothesis was thus proposed that the vegetation of the entire area, excluding the ravines, had once been uniform, and that any measured changes must have been a consequence of the spray program.

As will be noted below, this hypothesis is overly simple, for the data obtained from the sampling and the interpretation of these data indicate that the area was not entirely homogeneous, and that there is thus confounding between natural and spray-caused differences. But on the whole, this hypothesis and its testing do appear to give some definite measures of the changes caused by the spray.

There is no inherent reason why the effects of the spray program may not cause an increase, as well as a decrease, in the number of individuals of different species. The spray is not only differentially effective in its killing

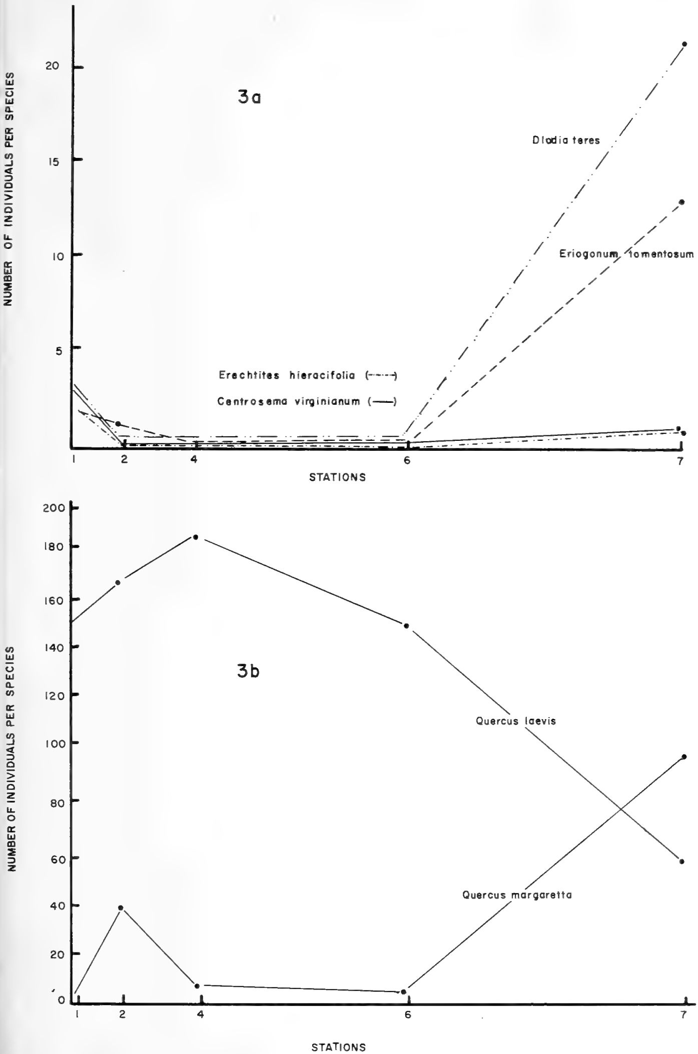

Fig. 3. Change in number of transect intercepts with distance. 3a and 3b: Species showing varying frequencies.

power, but it may well release from competition species otherwise suppressed. This should include the opening up of entirely new habitats to species not previously in the affected area. All of these effects appear to be present.

Tephrosia virginiana, Diospyros virginiana, and *Crataegus lacrimata* increase with distance from the test grid and so would appear to have been reduced in numbers by the effects of the spray. These species would, in fact, appear to have been totally exterminated adjacent to the grid, for no individuals of either were encountered at stations no. 1 or no. 2. Yet knowledge of these particular species suggests otherwise. The *Tephrosia* is a perennial, with a deeply buried, fleshly root, and it is not likely to be killed by a short and dilute application of herbicides. Other legumes with a similar habit did not disappear from the stations adjacent to the grid. The persimmon and the weeping haw, if killed, would have left clear evidence in the form of dead trunks, and none was observed along the transects near the grid. It seems definite, then, that these species are of low frequency near the grid, not because of the spray, but because of a heterogeneous distribution in the undisturbed woodland.

Similarly the species which were encountered only at station no. 7 may be explained, not as the result of destruction of these species at all stations closer to the grid, but merely as native species with a localized distribution. Station no. 7 was transected by an abandoned roadway, not noticed when the station was selected, and these as well as other species were observed there as part of the natural succession back to the climax turkey oak-longleaf pine forest. When this clearly heterogeneous station was removed from the analysis, the significance—in fact, the very existence in the sample—of these species disappeared.

In contrast, the four species that decreased significantly away from the test grid probably were influenced by the spray. All were herbs, and three of them (*Hypericum gentianoides, Solidago odora,* and *Warea sessilifolia*) are notable for their ability rapidly to colonize cleared land. The fourth, *Rhynchosia galactioides,* was common in the first four stations and absent in the fifth (no. 7). The significance of its decrease in frequency disappeared when the analysis was limited to these first four areas and suggests that the changes in this species were caused by heterogeneous distribution in the undisturbed woodland, in this case a mirror image of the *Tephrosia, Diospyros,* and *Crataegus.*

These three weedy herbs, the *Hypericum, Solidago,* and *Warea,* probably are better described as *increasing* in frequency *toward* the test grid, for it appears probable that the observed variation in number of intercepts is best explained by these species colonizing the land newly exposed by the effects of the spray near the grid. Exposure may not have been an actual baring of the soil by the destruction of the vegetation; it was more likely merely an increase in the light intensity at the soil surface when the defoliant temporarily destroyed branchlets of certain of the tree species.

The change in percentage of transect cover by the colonial grasses from a high near the test grid, to a low in stations no. 4 and no. 6, is similarly explained as a response to less canopy cover near the grid. Its abrupt increase to a new high in station no. 7 may be a simple function of the natural heterogeneity of this one station.

The several species that increased at one or more stations in the center of the series, with none or few intercepts at stations no. 1 and no. 7, produced patterns very difficult to explain in terms of the effects of the spray. More reasonably, these local aggregations of individuals may be interpreted as natural fluctuations in the woodland. Similarly, the species may be explained that were present in the end stations but absent in the center, as well as the rise and then fall of *Quercus laevis* and the rise, then fall, then rise of *Quercus margaretta*.

One of the more striking observations was the rather large number of species that did *not* reveal significant fluctuations in number of intercepts among the various stations. Fully 36 of the 54 species encountered showed only differences that could be explained on the basis of random variations within a homogeneous population. It is of course true that ten of these were represented by only a single specimen and were thus too rare to reveal a significant fluctuation in numbers even if such were present, but as low as two individuals could reveal significance if optimally located (that is, one on each of two transects within a single station). This common failure to reveal significance is perhaps the best measure that the original hypothesis of vegetative uniformity was in large part correct.

The hypothesis of uniformity appeared to fail most conspicuously in station no. 7, a location two miles distant from the edge of the spray grid and thus relatively unaffected by herbicide driftage. Of the 54 species, 12 were encountered only at this station, 2 of them in sufficient numbers to be recorded as significant. As noted previously, a number of other species fluctuated abruptly, either upward or downward, at this station.

Yet with station no. 7 excluded there remains little reason to suspect any consistent pattern of induced vegetational heterogeneity for a distance east of the grid of approximately one mile. The fluctuations that are detected are mostly explained as caused by natural factors. No species can be detected to be reduced in frequency near the grid by reasons of the spray program. The few species that can be detected to be increased in frequency near the grid are a probable secondary consequence of this same program.

SUMMARY—There properly has been concern about effects that might accompany the widespread use of herbicides, particularly as a consequence of their employment as military defoliants. An Air Force program on the Eglin Air Force Base Reservation, Florida, has applied very large amounts of military herbicides to a small test area, and driftage has caused changes in the vegetation surrounding the test area. The present study suggests that these effects are not extensive in terms of distance from the test area, nor of duration, nor magnitude. No plant species can be demonstrated to be reduced in

numbers by reason of spray driftage outside the area of intended application, although certain weedy species can be shown to increase in numbers near the test area following the temporary defoliation of the forest canopy.

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LITERATURE CITED

HUNTER, J. H., AND B. M. AGERTON. 1971. Annual diameter growth of conifers adjacent to Eglin Reservation test area C-52A as related to the testing of defoliant spray equipment. Air Force Armament Laboratory Tech. Rep. AFATL-TR-71-52.

———, AND A. L. YOUNG. 1972. Vegetative succession studies on a defoliant-equipment test area, Eglin AFB Reservation, Florida. Air Force Armament Laboratory Tech. Rep. AFATL-TR-72-31.

SNEDECOR, G. W. 1956. Statistical Methods Applied to Experiments in Agriculture and Biology. Iowa State College Press. Ames, Iowa.

STEELE, R. G. D., AND J. H. TORRIE. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Company. New York.

WHITESIDE, T. 1970. Defoliation. Ballantine Books, Inc.

Florida Sci. 36(2-4):110-122. 1973.

EFFECTS OF VARIABLE BRAIN WAVE CONTROL ON DIGITAL RECALL

Michael S. Heffernan

29 E. Sterling St., Fort Myers, Florida 33931

Traditional views of the slow (8-12 Hz), high voltage (above 50 μv.) brain rhythm acknowledge it as an organismic condition of lowered arousal in which cognitive processing is subsidiary to faster (above 12 Hz), lower voltage conditions (Hebb, 1964). Fast, low voltage EEGs have appeared frequently in persons involved in computation (Glanzer et al., 1964; Mundy and Castle, 1951). Elul (1969) indicates the distribution of EEG amplitudes shifts from Gaussian in an idle state to a positively skewed function during arithmetic tasks. Significant correlations between reading and arithmetic scores and fast, low voltage EEG likewise evidence a relationship between cognition and the ability for alpha reduction (Pinney, 1968). Voltage reductions in parieto-occipital regions reveal that fast EEG occurs before the learning of nonsense syllables presented by an auditory serial method (Obrist and Thompson, 1963). The syllables learned in early trials accompanied the initial decrease in amplitude, whereas syllables acquired in later trials, as well as syllables overlearned, paralleled little initial reduction in amplitude. The author interprets these results as maximum desynchronization occurring at the critical stage of the learning process when new associations are formed. The results, however, are equally explainable as the habituation of the cortical components of a declining orienting reaction. Sudden increases in attention or changes in stimulation concomitant with orienting reactions and the assimilation of novel information are well established as periods of fast, low voltage EEG (Sokolov, 1963).

Fast, low voltage EEG, however, may not be a necessary condition for informational incorporation after initial orienting reactions are habituated. Kasamatsu and Hirai (1969) found the cortical slow, high voltage EEG attained in Zen meditation (Zazen) is characterized as a receptive state whereby the individual is aware of external stimulation and does not habituate to sound as do people in fast, low voltage EEG. Rather the Zazen subject shows recurrent short, phasic, desynchronization responses to repetitive clicks. Other persons inferred to be in a slow, high wave EEG have reported being able to repeat back entire conversations heard while meditating (Transcendental Society for Zen Meditation, personal communication, 1970). If the brain wave correlates of sufficient information processors are studied, it is interesting to note that significant relationships occur between performance IQ and the amount of slow, high voltage EEG produced during arithmetical computation (Grannitrapani, 1969; Mundy and Castle, 1958). Similarly, Saunders (1961) reports a high correlation between digit span performance on intelligence tests and percent of slow, high voltage EEG. Some evidence suggests that fast, low voltage EEG before and during mental arithmetic are even correlated significantly with a high probability of error (Glass, 1964).

The present study seeks to test the traditional view of the slow, high voltage EEG as a reduced information processing condition in view of contradictory evidence that suggests just the opposite. The hypothesis as stated is that S*s* who have been operantly conditioned to produce both slow, high voltage and fast, low voltage EEG during auditory digit span tasks will demonstrate differential recall performance dependent on the type of brain wave concurrent with the task. Additionally, the hypothesis that fast, low voltage EEG is a necessary condition for input of information is being put to test.

METHOD—*Subjects.* Ten males, aged 19-22 years, were sampled from a group of college undergraduate students in education and psychology classes at the University of California on the basis of their willingness to participate in an "investigation of human learning." Naive S*s* were picked who had no knowledge of the characteristics of slow, high voltage or fast, low voltage brain waves.

Procedure. Silver disk electrodes were placed with Grass recording paste as follows: occipital, 1 cm above the inion on midline; vertex, on midline at top of the head; frontal, 2 cm above bridge of the nose on midline; and left ear lobe for ground reference. Monopolar traces were recorded from occipital and frontal leads, and a bipolar trace between occipital and vertex leads with a Grass EEG recorder, using 1 cm per 50 μv, and 15 or 30 mm/sec chart speed.

While seated upright in a dark soundproof room, S*s* were asked to "relax for 10 minutes and become accustomed to the surroundings." At this point *E* inspected the record of S'*s* EEG for artifact or improper electrode attachment. One S was discarded when he showed less than 20 sec of alpha rhythm in the period of 10 min on the grounds that an adverse reaction to the experimental situation might be masking natural spontaneous EEG and hence, too long of a period would be needed to produce slow, high voltage brain wave conditioning.

S*s* were instructed to repeat to *E*, 30 sec after presentation, digit sequences delivered each min from a tape. The digits were recorded at a constant rate of two digits/sec. Four digit sequences of variable length were presented in an ascending series beginning with five digits and ending on the number of digits at which S failed. Recall was scored as correct when a sequence with all digits were present in the correct order. S*s* were given scores of one less than the number of digits in the sequence at which they failed. The four scores, one from each digit sequence presentation, were averaged and rounded off to the nearest whole number to determine the number of digits presented to the S*s* later in the experiment.

Brain wave conditioning. S*s* were asked to adjust their mental state in a way that would maintain an "A" verbal signal from *E*. *E* said "A" whenever 10 sec of a 50-100 μv, 8-12 Hz wave occurred on an oscilloscope. S's brain wave was measured by adjusting the oscilloscope sweep frequency to 10 Hz (+2 Hz) and waiting for the appearance of a single 50-100 μv stationary sine wave. Brain wave frequencies other than 8-12 Hz were immediately detectable through rapid wave movement and/or multiple peaks appearing on the oscilloscope. With the successful maintenance of three successive min of 100 percent of 50-100 μv, 8-12 Hz waves, S*s* were asked to alter their mental state in a manner which would eventuate in *E* delivering a verbal signal of "B". "B" verbal signals were administered after each 10 sec in which there were measured oscillations greater than 12 Hz and with amplitudes less than 50μv. Brain rhythms greater than 12 Hz were accurately detected by the disruption of the stationary, single wave which appeared only between 8-12 Hz. Disruption consisted of the appearance of multiple peaks and forward wave movement on an oscilloscope. This procedure continued until three successive min of 100 percent of brain waves greater than 12 Hz with amplitudes less than 50 μv was attained.

One S not achieving three min of alpha and beta elicitation was eliminated. Next, S*s* were required to evoke an alternating sequence of the two conditioned brain rhythms when a click occurred every 20 sec. Ten seconds after the click *E* reported to S "correct" or "incorrect" dependent on S*s* production of 100 percent correct brain wave elicitation. Conditioning was discontinued when 10 correct elicitations were obtained in the sequence A B A B A B A B A B such that: (1) equal latency to onset of the correct brain wave was apparent; and (2) equal levels of subjectively estimated difficulty in elicitation between the two types of brain waves had occurred. A maximum time of 15 min was appropriated for each phase of conditioning. All S*s* except one attained the three conditioning phases within 10-12 min per phase as was found in an earlier investigation (Kamiya and Knowles, 1970).

Experimental Task. Following brain wave conditioning the S*s* were given a number of digits determined as suitable in the preliminary digit span to remember while maintaining either a 50-100 μv, 8-12 Hz brain wave or a less than 50 μv, and greater than 12 Hz brain wave. When possible, ten trials of digits under the two types of brain wave conditions were administered. The two types of brain waves were elicited alternately among trials by "A" or "B" verbal signals delivered by *E* during the 30 sec intertrial interval 20 sec prior to the time when the digits were delivered to the S*s*. Digits were randomly selected and prerecorded to be delivered auditorily from a tape recorder at a rate of 2 digits/sec. S*s* were asked to repeat the digits 30 sec after presentation. Digit recall was scored as correct when the entire sequence of digits was recalled in the order presented. Knowledge of the trial by trial performance on the digit task was withheld from both *E* and S.

Treatment of data. If the vertex—occipital channel evidenced 90-100 percent of either 8-12 Hz, 50-100 μv, or greater than 12 Hz, less than 50 μv brain rhythm the incident was labeled alpha or beta respectively; in the event artifact occluded the vertex occipital channel the other two channels were utilized in scoring. Trials not meeting an alpha or beta definition were labeled as trials attempted, but were not considered as trials completed by the S*s*. Scoring for alpha and beta consisted of counting peaks and measuring the amplitude in each second of EEG record (with a chart speed of 30 mm/sec, this time period corresponds to the distance between two darker red lines on standard chart recording paper). The criteria were as follows: for alpha, 8-12 peaks all greater than 50 μv as measured on a calibrated record; for beta, more than 12 peaks all less than 50 μv as measured on a calibrated record.

Results and Discussion—A correlated t-test for repeated measures design was used to compare S'*s* digit span performances in the two brain wave conditions. Digit recall during alpha resulted in significantly superior, performances by S*s* as contrasted with the beta condition; $t = 6.98$, $P < .001$.

All interpretations of the results of this experiment are confined to the comparison of digit recall performance between induced alpha and induced beta brain rhythms, since no evidence suggests that induced alpha produces facilitation of performance beyond that attained prior to brain wave conditioning.

The present investigation fails to distinguish between the effects on performance of behavioral states evoked by conditioned brain rhythms, and the direct influence of brain rhythms per se. The differences in recall scores might be explainable by a multitude of behavioral states accompanying either alpha or beta. Some examples of influential behavioral states would include: 1) relaxation more typical of alpha, 2) visualization or thinking often associated with beta (Kamiya, personal communication, 1970), and 3) anxiety which may be needed to elicit beta in a relaxed subject.

Performance differences attributable to relaxation during alpha would indicate a lowering of arousal in the induced alpha condition and hence, a decline in recall performance predicted by activation theory (Duffy, 1962). This prediction is opposite to the actual results and may indicate the insufficiency of a relaxation interpretation of the present data. But since the optimal arousal for the digit span task is not defined accurately further experimentation would be necessary before concluding the exact effect of relaxation on recall performance.

An alternate interpretation of reduced recall in beta is explainable as the result of interference with the digit task by visualization or thinking present in the beta condition, and *not* in the alpha condition. This seems possible since S*s* often report evoking visual images or thoughts to maintain a beta brain rhythm (Kasamatsu and Hirai, 1969).

The evocation of anxiety may be needed to maintain beta in relaxed S*s* during the digit task. Such anxiety in beta could retard digit recall. Two varieties of beta different in quality might even be distinguished—one that results from task involvement and another which is self-induced through anxiety and is negatively reinforcing. Combined with the result that *Ss* find alpha pleasantly rewarding such a supposition easily explains the obtained results as differential reinforcement in favor of higher recall scores in alpha.

Since *Ss* in the present experiment were required to do two tasks simultaneously—digit span and brain control—the finding may reflect the phenomenon of divided attention during the beta condition causing performance decrement in digit recall. This would imply that less attention is required by *Ss* in maintaining alpha. Because attempts to control for equal latency to onset, and equal subjectively estimated difficulty in maintaining alpha and beta, this particular interpretation becomes less tenable.

Before considering the implications of the present findings, it is important to note that no conclusions are derivable as to whether the significant differences in recall between the alpha and beta condition are attributed to brain rhythm alterations in the learning process or result from transitory performance changes. Thus, the motivational effect of different induced brain rhythms cannot be excluded in explaining the obtained performance differences.

Implications from the present investigation for future educationally relevant research would include the design of experiments to assess the effects of induced brain rhythms on more meaningful learning material and with different varieties of learning, e.g., paired associate, classical conditioning, problem solving, etc. This is needed to more clearly define the conditions to which the present findings might be generalized. In addition, a more complete appraisal of baseline performance prior to brain wave conditioning would aid in determining the effect of brain wave conditioning on performance. In all these suggested investigations controls should be included to evaluate behavioral and affective states which might appear concomitantly at certain brain wave frequencies and cause alterations in recall. Long-term recall tests might also be used to determine whether the learning process itself rather than just performance is being influenced by certain brain rhythms.

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LITERATURE CITED

DUFFY, E. 1962. Activation and behavior. John Wiley and Sons, Inc., New York, New York.

ELUL, R. 1969. Gaussian behavior of the electroencephalogram: changes during performance of mental task. Science 164 (3877): 328-331.

GLANZER, M., R. CHAPMAN, W. CLARK AND H. BRAGDON. 1964. Changes in two EEG rhythms during mental activity J. Exp. Psychol. 68: 273-283.

GLASS, A. 1964. Mental arithmetic and alpha blocking. Electroenceph. Clin. Neurophysiol. 16: 595.

GRANNITRAPANI, D. 1969. EEG average frequency and IQ, Electroenceph. Clin. Neurophysiol. 27: 480-486.

HEBB, D. 1964. The cognitive processes. *In* Harper, Anderson, Christensen and Hunka (eds.) Prentice Hall, Englewood Cliffs, New Jersey.

KAMIYA, J., AND D. KNOWLES. 1970. Control of EEG alpha rhythms through auditory feedback and the associated mental activity. Psychophysiol. 6: (4).

KASAMATSU, A., AND T. HIRAI. 1969. *In* Altered states of consciousness. Charles T. Tart (ed.). John Wiley and Sons, Inc. New York.

MUNDY, A. C., AND B. A. CASTLE. 1951. Theta and beta rhythm in the EEG of normal adults. Electroenceph. Clin. Neurophysiol., 3:477-486.

________ AND ________. 1958. Electrophysiological correlates of intelligence. J. Personality. 26:184-199.

OBRIST, W. D., AND L. W. THOMPSON. 1963. EEG correlates of verbal learning: amplitude changes electives. Electroenceph. Clin. Neurophysiol. 15: 149.

PINNEY, E. G., JR. 1968. Reading and arithmetic scores and EEG alpha-blocking in disadvantaged children. Dis. Neur. Syst. 29 (6): 388-390.

SAUNDERS, D. R. 1961. Digit span and alpha frequency of the EEG. J. Clin. Psychol. 17: 165-167.

SOKOLOV, E. N. 1963. Higher nervous functions: the orienting reflex Ann. Rev. Physiol. 25: 545-580.

Florida Sci. 36(2-4):123-128. 1974.

Biological Sciences

EPIPHYTISM IN THE MARINE BENTHIC ALGAE OF PUERTO RICO

JULIO N. NAVARRO AND LUIS R. ALMODÓVAR

Department of Biology, Catholic University, Ponce, Puerto Rico; Department of Marine Sciences, University of Puerto Rico, Mayagues, Puerto Rico 00708

ABSTRACT: *Red algae are the most frequently encountered of the epiphytic marine forms in Puerto Rico. In all, 78 algal species were found to be epiphytic on 80 host species.*

MANY marine benthic algae due to their morphology harbor an interesting epiphytic flora which seldom is studied in detail. Researches have shown that some species are associated specifically with a host. Prowse (1959) establishes a relation between the host plants of *Enhydras angustipetala*, *Naias graminea*, and *Utricularia* sp. with the algae *Oedogonium*, and the diatoms *Eunotia* and *Gomphonema* respectively. Ohmi (1960) provides a listing of *Porphyra* species epiphytic on other algae. Tokida (1960) published a list comprising 126 genera and 285 species of Japanese marine algae found on 22 genera of the Order Laminariales which were published in 69 papers from various authors. In Israel, Edelstein and Komarovsky (1961) reported on 51 epiphytes found on *Halimeda tuna* f. *platydisca* growing on Haifa Bay. Abbott (1962) studied the species of *Acrochaetium* found in *Liagora* in Hawaii, Bermuda, and California reporting 23 epiphytes, 5 of which are new species. Humm (1964) on his observations of epiphytism in *Thalassia*, reported 7 algae which were found growing on other algae. The microzonation of the majority of the algae growing on *Digenia simplex* (Wulf.) C. Agardh was observed by Ferreira Correia (1969) in Brazil.

The first report on epiphytism in Puerto Rico is that of Gardner (1932) in which 113 species of blue-green algae were observed growing on other macro algae. Almodóvar (1961) reported 1 species epiphytic at Cabo Rojo, 3 in the reefs off La Parguera (1962), 9 in Guánica (1964) and 24 from the Marshall A. Howe collection (1965). Almodóvar & Blomquist (1965) listed 8 epiphytic species which were new records for Puerto Rico. Díaz (1963) and Díaz and Caballer (1964) reported 22 and 12 epiphytic species respectively.

Since the problem of algal epiphytism in Puerto Rico has received little attention in past years, this study was undertaken.

METHODS AND MATERIALS—Extensive collections of algae were made around the island with concentration along the southern coast. The areas included a diversity of habitats such as coral reefs and mangrove channels at La Parguera, and rocky coasts at Guajataca, Caja de Muertos, Guánica, and Yabucoa to mention a few.

Algae were placed in plastic bags on station and later preserved in 3% seawater formalin. Microscopical examination and final determination was conducted at the laboratory, Department of Marine Sciences at Magueyes Island.

RESULTS AND DISCUSSION—The results obtained indicate that red algae are the most abundant with a large number of epiphytic species followed by the green, brown, and blue-green algae. The order Ceramiales (families Ceramiaceae and Rhodomelaceae) of the red algae, and the Dictyotales (family Dictyotaceae) of the brown algae represent 60% of the total Rhodophyta and 66% of the total Phaeophyta. In the green algae there is no particular family which is represented more abundantly.

The host species found with the greatest number of epiphytes are: *Avrainvillea longicaulis* (Kutz.) Murray & Boodle, *Cymopolia barbata* (L.) Lamouroux, *Halimeda incrassata* (Ellis) Lamouroux, *Udotea flabellum* (E. & S.) Lamouroux, *Padina gymnospora* (Kutz.) Vickers, *Bryothamnion triquetrum* (Gmel.) Howe, *Digenia simplex* (Wulf.) C. Agardh, *Enantiocladia duperreyi* (C. Ag.) Falkenberg, *Gracilaria verrucosa* (Huds.) Papenfuss, and *Laurencia papillosa,* (Forssk.) Greville.

The epiphytes found are: *Acanthophora spicifera* (Vahl) Borgesen, *Acrochaetium* sp., *Amphiroa fragilissima* (L.) Lamouroux, *Antithamnion antillarum,* Borgesen, *Asterocystis ramosa* (Thwaites) Gobi, *Avrainvillea longicaulis* (Kutz.) Murray & Boodle, *Boodlea composita* (Harvey & Hooker) Brand, *Boodleopsis pusilla* (Coll.) Taylor, Joly & Bernatowicz, *Bryopsis hypnoides* Lamouroux, *Bryopsis pennata* Lamouroux, *Bryothamnion triquetrum* (Gmelin) Howe, *Callithamnion byssoides* Arnott *in* Hooker, *Caulerpa verticillata* J. Agardh, *Centroceras clavulatum* (C. Ag.) J. Agardh, *Ceramium* sp., *Ceramium fastigiatum* (Roth.) Harvey, *Ceramium nitens* (C. Ag.) J. Agardh, *Chaetomorpha media* (C. Ag.) Kutzing, *Champia parvula* (C. Ag.) Harvey, *Champia salicornoides* Harvey, *Chrysonephos lewissi* (Taylor) Taylor, *Cladophora* sp., *Cladophora delicatula* Montagne, *Cladophoropsis membranacea* (C. Ag.) Borgesen, *Corallina* sp., *Corallina cubensis* (Mont.) Kutzing, *Crouania attenuata* (Bonnem) J. Agardh, *Crouania pleonospora* Taylor, *Dictyota bartayresii* Lamouroux, *Dictyota dichotoma* (Huds.) Lamouroux, *Dictyota di-*

varicata Lamouroux, *Dictyopteris delicatula* Lamouroux, *Dilophus guineensis* (Kutz.) J. Agardh, *Ectocarpus* sp., *Ectocarpus elachistaeformis* Heydrich, *Ectocarpus rallsiae* Vickers, *Enteromorpha* sp., *Enteromorpha flexuosa* (Wulf.) J. Agardh, *Falkenbergia hillebrandii* (Born.) Falkenberg, *Gelidium* sp., *Griffithsia* sp., *Griffithsia globulifera* Harvey, *Griffithsia tenuis* C. Agardh, *Herposiphonia tenella* (C. Ag.) Ambronn, *Heterosiphonia wurdemanni* (Bailey *ex* Harvey) Falkenberg, *Hormothamnion enteromorphoides* Grunow, *Hypnea cervicornis* J. Agardh, *Hypnea musciformis* (Wulf.) Lamouroux, *Hypnea spinella* (C. Ag.) Kutzing, *Hypoglossum tenuifolium* (Harvey) J. Agardh, *Jania adhaerens* Lamouroux, *Jania capillacea* Harvey, *Jania rubens* (L.) Lamouroux, *Laurencia intricata* Lamouroux, *Laurencia obtusa* (Huds.) Lamouroux, *Laurencia papillosa* (Forssk.) Greville, *Laurencia poitei* (Lamour.) Howe, *Lophocladia trichoclados* (Mert.) Schimber, *Martensia pavonia* (J. Ag.) J. Agardh, *Microcoleus lyngbyaceus* Drouet, *Neomeris* sp., *Oscillatoria* sp., *Padina gymnospora* (Kutz.) Vickers, *Penicillus capitatus* Lamarck, *Pocockiella variegata* (Lamour.) Papenfuss, *Polysiphonia* sp., *Rivularia* sp., *Sphacelaria furcigera* Kutzing, *Spyridia aculeata* (Schimp.) Kutzing, *Spyridia filamentosa* (Wulf.) Harvey, *Struvea anastomosans* (Harv.) *Piccone, Stypopodium zonale* (Lamour.) Papenfuss, *Ulva lactuca* Linnaeus, *Valonia aegagropila* C. Agardh, *Valonia ventricosa* J. Agardh, *Wrangelia argus* Montagne, *Wrangelia bicuspidata* Borgesen, and *Wrangelia penicillata* C. Agardh.

The host species are: *Acanthophora spicifera* (Vahl) Borgesen, *Agardhiella ramosissima* (Harv.) Kylin, *Amphiroa rigida* Lamouroux, *Anadyomene stellata* (Wulf.) C. Agardh, *Avrainvillea longicaulis* (Kutz.) Murray & Boodle, *Avrainvillea rawsonii* (Dickie) Howe, *Botryocladia occidentalis* (Borg.) Kylin, *Botryocladia pyriformis* (Borg.) Kylin, *Bryothamnion triquetrum* (Gmel.) Howe, *Caulerpa mexicana* (Sond.) J. Agardh, *Caulerpa racemosa* (Forssk.) J. Agardh, *Caulerpa sertulariodes* (Gmelin) Howe, *Caulerpa taxifolia* (Vahl.) C. Agardh, *Ceramium nitens* (C. Ag.) J. Agardh, *Chamaedoris peniculum* (Ell. & Sol.) Kuntze, *Champia salicornoides* Harvey, *Chondria littoralis* Harvey, *Cladophoropsis membranacea* (C. Ag.) Borgesen, *Codium taylori* Silva, *Colpomenia sinuosa* (Roth.) Derbes & Solier, *Corallina officinalis* Linnaeus, *Cymopolia barbata* (L.) Lamouroux, *Dasya pedicellata* (C. Ag.) C. Agardh, *Digenia simplex* (Wulf.) C. Agardh, *Dictyopteris delicatula* Lamouroux, *Dictyosphaeria cavernosa* (Forssk.) Borgesen, *Dictyosphaeria vanbosseae* Borgesen, *Dictyota bartayresii* Lamouroux, *Dictyota ciliolata* Kutzing, *Dictyota dentata* Lamouroux, *Dictyota dichotoma* (Huds.) Lamouroux, *Dictyota divaricata* Lamouroux, *Dilophus guineensis* (Kutz.) J. Agardh, *Enantiocladia duperreyi* (C. Ag.) Falkenberg, *Ernodesmis verticillata* (Kutz.) Borgesen, *Eucheuma acanthocladum* (Harv.) J. Agardh, *Galaxaura cylindria* (Ell. & Sol.) Lamouroux, *Galaxaura lapidescens* (Ell. & Sol.) Lamouroux, *Galaxaura marginata* (Ell. & Sol.) Lamouroux, *Gelidiella acerosa* (Forssk.) Feldm & Hamel, *Gracilaria cervicornis* (Turn.) J. Agardh, *Gracilaria compressa* (C. Ag.) Greville, *Gracilaria curtissiae* J. Agardh, *Gracilaria debilis* (Forssk.) Borgesen, *Gracilaria domingensis* Sander, *Gracilaria ferox* J. Agardh, *Gracilaria foliifera*, (Forssk.) Borgesen, *Gracilaria mammillaris* (Mont.) Howe, *Gracilaria sjostedtii* Kylin, *Gracilaria verrucosa* (Kuds.) Papenfuss, *Griffithsia globulifera* Harvey, *Halimeda discoidea* Decaisne, *Halimeda incrassata* (Ellis) Lamouroux, *Halimeda opuntia* (L.) Lamouroux, *Halimeda tuna* (Ell. & Sol.) Lamouroux, *Heterosiphonia wurdemanni* (Bail.) Falkenberg, *Hypnea cervicornis* J. Agardh, *Hypnea musciformis* (Wulf.) Lamouroux, *Hypnea spinella* (C. Ag.) Kutzing, *Laurencia obtusa* (Huds.) Lamouroux, *Laurencia papillosa* (Forssk.) Greville, *Laurencia poitei* (Lamouroux) Howe, *Liagora ceranoides* Lamouroux, *Liagora mucosa* Howe, *Ochtodes secundiramea* (Mont.) Howe, *Padina gymnospora* (Kutz.) Vickers, *Penicillus capitatus* Lamarck, *Pocockiella variegata* Lamouroux, *Polysiphonia* sp. *Pterocladia pinnata* (Huds.) Papenfuss, *Sargassum platycarpum* Montagne, *Sargassum rigidulum* Kutzing, *Sargassum vulgare* C. Agardh, *Spyridia aculeata* (Schimp.) Kutzing, *Spyridia filamentosa* (Wulf.) Harvey, *Stypopodium zonale* (Lamour.) Papenfuss, *Turbinaria turbinata* (L.) Kuntze, *Udotea flabellum* (Ell. & Sol.) Lamouroux, *Valonia aegagropila* C. Agardh and *Valonia ventricosa* J. Agardh.

Different collecting sites around the island provided a degree of variation in respect to habitat. It was found that the major factors affecting distribution are light, the chemical composition of sea-water, the nature of the host's surface area and the size of the host plant. No attempt was made to correlate species specificity. The greatest abundance of epiphytes are in the Rhodophycophyta, especially the families Ceramiaceae and Rhodomelaceae.

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LITERATURE CITED

ABBOTT, I. 1962. Some *Liagora* inhabiting species of *Acrochaetium*. Bernice P. Bishop Mus. Occ. Pap. 23 (6): 77-120.

ALMODÓVAR, L. R. 1961. Notes on the marine algae of Cabo Rojo, Puerto Rico. Quart. J. Florida Acad. Sci. 24: 81-93.

———. 1962. Notes on the algae of the coral reefs off La Parguera, Puerto Rico. Quart. J. Florida Acad. Sci. 25: 275-286.

———. 1964. The marine algae of Guánica, Puerto Rico. Revue Algologique 7: 129-150.

———. 1965. The unnamed Rhodophyta of the Marshall A. Howe collection of marine algae from Puerto Rico. Nova Hedwigia 9: 1-19.

——— AND H. L. BLOMQUIST. 1965. Some marine algae new to Puerto Rico. Nova Hedwigia 9:63-71.

DÍAZ, M. 1963. Adiciones a la flora marina de Puerto Rico. Caribbean J. Sci. 3:215-235.

——— Y C. CABALLER DE PÉREZ. 1964. Taxonomia, ecologia y valor nutrimental de algas marinas de Puerto Rico. Algas productoras de agar. pp. i-x + 1-145. Laboratorio de Investigaciones Industriales de la Administración de Fomento Económico de P. R.

Edestein, T. and B. Komarousky. 1961. Epiphytic algae on *Halimeda tuna* f. *platydisca* (Decaisne) Barton in Haifa Bay. Bull. Res. Council Israel D: Botany 10: 54-58.

Ferreira-Correia, M. M. 1969. Epifitas de Digenia simplex (Wulf.) C. Agardh No Estado do Ceará (Rhodophyta: Rhodomelaceae). Arquiv. Cienc. Marin. 9: 63-69.

Gardner, N. L. 1932. The Myxophyceae from Puerto Rico and the Virgin Islands. Sci. Surv. Porto Rico & Virgin Isl. 8: 249-311.

Humm, H. J. 1964. Epiphytes of the sea grass *Thalassia testudinum* in Florida. Bull. Marine Sci. 14: 306-341.

Ohmi, H. 1960. On epiphytic species of *Porphyra* and their host. Bull. Fac. Fisheries, Hokkaido Univ. II: 38-44.

Prowse, G. A. 1959. Relationship between epiphytic algal species and their macrophytic hosts. Nature 183: 1204-1205.

Tokida, J. 1960. Marine algae epiphytic on Laminariales plants. Bull. Fac. Fisheries, Hokkaido Univ. II: 73-105.

Florida Sci. 36(2-4):128-132. 1973.

Biological Sciences

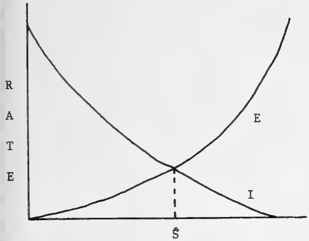
EXPERIMENTAL INSULAR BIOGEOGRAPHY: PONDS AS ISLANDS

Michael D. Hubbard

Department of Biological Science, Florida State University, Tallahassee, Florida 32306
[Present address: Laboratory of Aquatic Entomology,
Florida A&M University, Tallahassee, Florida 32307]

Abstract: *MacArthur and Wilson proposed a species equilibrium model of insular colonization. The applicability and generality of this model were tested using artificial fresh-water ponds as islands. All organisms large enough to be distinguished at 100× were monitored. Colonization, immigration and extinction rate curves are shown to be consistent with the model proposed by MacArthur and Wilson. Apparent non-interactive equilibrium was reached in 25 to 30 days with a turnover rate of between 3 and 5 species per day. The modifications proposed by Simberloff were also found to be consistent with the results of this study.*

In 1963 MacArthur and Wilson proposed an equilibrium theory of insular biogeography which was expanded in a later book (MacArthur and Wilson, 1967). This theory postulates in part that there is a dynamic equilibrium number of species for a given island, which will coincide with the intersection of curves of immigration rate and extinction rate (in spp./time) vs. number of species present (Fig. 1). The theory further postulates the shape of the curves of immigration and extinction rates and the shape of the colonization curve (number of species present vs. time) which may be obtained by integrating the difference between the immigration and extinction rates (Fig. 2). MacArthur and Wilson also proposed that the area of the island and the distance of the island from its source area are related to the equilibrium number of species. An increase in the area of an island will decrease the height of the extinction curve and move the intersection to the right, increasing the equilibrium number of species. As distance from the source area increases the rate of immigration will drop, moving the point of intersection to the left and decreasing the equilibrium number of species.



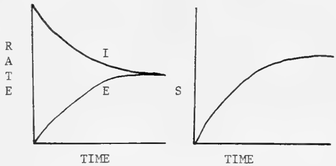


Fig. 1. (left) The equilibrium number of species (Ŝ) can be determined by the intersection of the curves of immigration rate and extinction rate.

Fig. 2. (middle & right) By integrating the difference through time of the immigration rate (I) and the extinction rate (E), the colonization curve (number of spp. present vs. time) can be drawn.

Simberloff (1969) proposed a modification of this theory, for colonization of an island which starts with no species, with the introduction of the concept of a non-interactive equilibrium and a later interactive equilibrium caused by interaction of species occurring as population densities increase with time (Fig. 3). The concept of "island" as related to this theory may be defined as a habitat isolated to some degree from other similar habitats; for example, tide pools, ponds, and host plants for phytophagous insects, as well as typical oceanic islands.

The MacArthur-Wilson species equilibrium model sacrifices precision to realism and generality, one of the three major strategies of model building (Levins, 1966). We are more concerned with the general shape of curves, such as concave or convex, increasing or decreasing. In sacrificing precision to realism and generality, we must deal with inequalities, instead of precise mathematical answers. Thus we cannot in a single experiment prove the validity of the hypothesis, we can only provide supporting evidence.

Little experimental work has been done on the MacArthur-Wilson equilibrium theory. Cairnes et al. (1969) worked with fresh-water protozoan communities; Simberloff and Wilson published a series of papers dealing with insular insect communities (Wilson and Simberloff, 1969; Simberloff and Wilson, 1969, 1970; Simberloff, 1969; Wilson, 1969). Patrick has experimented with diatoms and obtained results which relate in part to the MacArthur-Wilson model (Patrick, 1967, 1970). Maguire (1963) dealt with the dispersal of small aquatic organisms. All of the experiments with the possible exception of those by Simberloff and Wilson suffer from the simplicity of the communities involved (usually one taxon) and the obvious physical artificiality. All results were consistent with the MacArthur-Wilson propositions but none provided particularly strong supporting evidence with the exception of the experiments of Simberloff and Wilson which appeared to demonstrate the existence of an equilibrium species number for an island.

Some field studies have been done which appear, at least by their lack of refutation, to support the equilibrium model. Avifaunal turnover rates on the

Channel Islands of California as observed by Diamond (1969) appear to have no basic discrepancy between the observed rates and those predicted by the MacArthur-Wilson model. In the Solomon Islands it has been found that distribution patterns of certain insects and land Mollusca agree with the model (Greenslade, 1969; Peake, 1969). Whitehead and Jones (1969) pointed out several problems in dealing with exceptionally small islands; the major, and extremely important one, is that one of the causes of the area effect at small areas may be limited habitat rather than area per se.

The MacArthur-Wilson equilibrium model has been also applied in studying other areas. It has been applied to the problem of origination and extinction of Cenozoic land mammals (Webb, 1969) and to the study of cave habitats (Culver, 1970). Janzen (1968) has suggested that host plants can be considered islands in ecological and evolutionary time in studying plant-insect interactions.

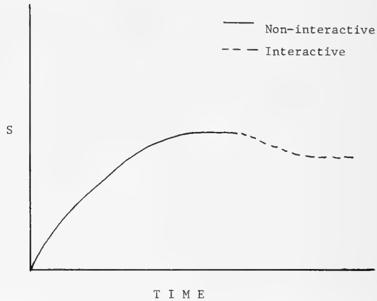


Fig. 3. Colonization curve showing both non-interactive and interactive equilibria.

The purpose of this study was to obtain experimental evidence to help determine the validity and generality of both the original MacArthur-Wilson equilibrium model and the modifications proposed by Simberloff. Artificial fresh-water ponds were used as islands and colonization was studied in them.

The ponds chosen for this study were of approximately the same size and distance from a source area. This enabled the variable components of area and distance to be ignored. These components generally require use of complicated statistical procedures to account for their effects.

Methods and Materials—The ponds used in this experiment are two out of a series of six artificial fresh-water ponds, each of approximately 80 sq m of surface area and about 1.2 m in depth, located on the Mission Road Farm of the Florida State University, Tallahassee. The ponds are arranged linearly about 2 m apart, with the ponds at either end used for the present experiment while the center four were used as fish-holding ponds by other researchers. These ponds are located in a grass pasture in which a few sheep are grazed.

The experimental ponds were lined with polyethylene sheeting to preclude the existence of organisms present in the bed of the ponds. The ponds were filled with well water which was pumped in on Day 0. As no organisms were found to be present on Day 0 with the sampling technique used in this study, it was assumed for the purposes of this experiment that there were none in the well water.

Each of the ponds was monitored in duplicate, thus giving four replicates of the experiment. The ponds were labeled I and II with the replicates called I_a, I_b, II_a, and II_b. The two replicates for each pond were also combined to yield a larger total, labeled I_t and II_t.

Species samples were taken at irregular intervals. Samples were taken near the same time of midmorning each sampling period in an attempt to minimize fluctuations caused by diurnal migrations. The method of sampling was twofold, utilizing both a water sample and a plankton net. The water sample was taken at the same location in the pond each time, by submerging the closed mouth of a bottle about 5 cm below the surface, then opening it. The plankton net, made of no. 12 standard bolting cloth (with a mesh size of 49/cm), was towed the length of the pond near the bottom. Samples were taken back to the laboratory and examined immediately, with no preservation attempted except of the macroorganisms. The plankton was examined under a dissecting microscope and 3 ml of the water sample for each replicate were examined by a compound microscope in a Sedgewick-Rafter counting cell to determine the number of species present. Only those species large enough to be distinguished at 100× were counted. The thickness of the Sedgewick-Rafter cell did not allow a higher power to be used with the microscopes available. Because of the large number of organisms it was deemed best to do the identification myself rather than to enlist the aid of specialists in taxonomy of the various groups. Because of difficulty in taxonomic identification with any degree of certainty, specific determinations were not attempted; instead the various species were merely assigned numbers for identification purposes. Those times when I received expert help my recognition of different species was generally accurate.

Daily rainfall, temperature, and oxygen concentration records were kept for each pond, the measurements being taken near sundown each day. The rainfall was measured by a rain gauge at the edge of one of the ponds and temperature was taken by a maximum-minimum thermometer placed about 25 cm below the surface of each pond. Oxygen concentration was determined by the rapid unmodified Winkler method (Ellis, Westfall, and Ellis, 1948).

Day 0 in the study was 28 July 1970. The study in Pond I was continued for a period of 86 days. The study in Pond II was abruptly terminated after 64 days by the accidental stocking of the pond with garfish by another researcher.

Results and Discussion—Before the results are reported and the discussion begins, it is necessary to provide definitions for several terms as they are used in this paper.

Propagule—the smallest number of individuals capable of population increase under optimal conditions on a particular island. Often this is a single fertilized female, a male and a female, or a single parthenogenetic female. For the purposes of this study, since most of the species are capable of asexual reproduction, a single individual observed will be considered a propagule.

Colonization—the existence of at least one propagule of a species on an island.

Extinction—the disappearance of a species from an island.

Immigration—the arrival of a propagule on an island unoccupied by that species (immigration rate is in terms of species per time).

Invasion—the arrival of a propagule on an island whether or not the island is already occupied by that species (invasion rate is in terms of propagules of a species per time).

The difference between invasion and immigration must be emphasized. An island has an immigration rate but a species on an island has an invasion rate.

Certain species encountered in the study were not included in the species counts. Terrestrial insects which landed in the ponds and do not have aquatic larvae were not included because even under optimal conditions they could not be considered a propagule since the population could not increase. Terrestrial insects with aquatic larvae were counted only if the larvae were actually found to be present, since many insects, such as dragonflies, often flew over the ponds, but this does not constitute colonization since without actual oviposition there is no possibility of population increase. Adult and larval amphibians observed in the ponds were counted since they are known to feed upon aquatic organisms and hence are an integral part of the community.

The factor of seasonality must be considered in a study of this kind. During the course of the experiment there was a gradual decrease in day length, rainfall, and near the end, in temperature (Fig. 4). None of the environmental

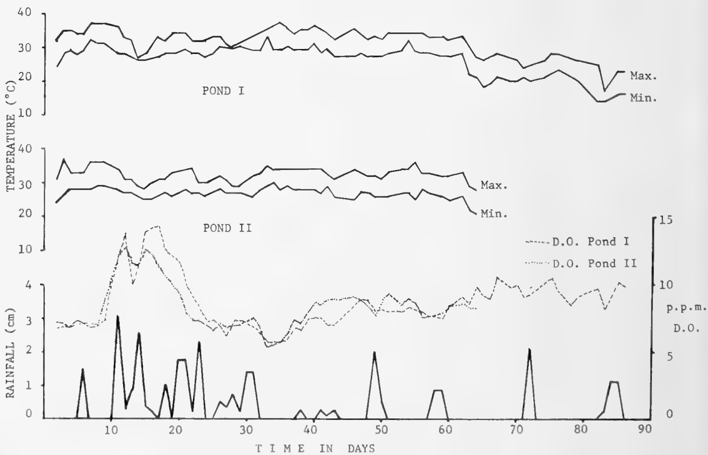


Fig. 4. Environmental data for Pond I and Pond II.

factor changes appear to have caused any fluctuation in the biotic community of the ponds and I therefore believe that, for all practical purposes, seasonality can be neglected in this study. The only way to be sure, however, that seasonality is not a factor in this study would be to repeat the experiment, starting in different seasons.

Maguire (1963) reports that passive dispersal of small aquatic organisms can be accomplished by air currents. These organisms are often precipitated out of the air by rain. Other mechanisms reported by Maguire include phoresy on both birds and insects and the fact that many aquatic organisms are facultative soil dwellers. All of these mechanisms are probably active in this study except for the soil-dwelling organisms which were excluded by the polyethylene sheeting to prevent the ponds from having ready-made inhabitants (although some soil dwellers may well have entered with runoff from very heavy rains).

Altogether there were 124 species of protozoa, 63 species of algae, and 9 miscellaneous species for a species total of 196. There are two possible sources of error in the species samples. The separation of species may be slightly inaccurate in some cases because of inadvertent lumping of two similar species or splitting polymorphic species into two species. The overall error introduced by this is probably very low, however. A second source of error is that species of microorganisms of very low population density had little chance of being counted. Gallagher and Burdick (1970) state that the probability of not finding an organism within a distance r of a point is $^{-4\pi r^3 m/3}$ where m is the density per unit volume of the organism, if that organism is randomly distributed. Thus in six 1 ml samples the probability of finding a species to be present is 0.50 if the density of that organism drops to 346.6/l and only 0.05 if the density drops to 25.6/l. Thus the species counts, especially in the first few days, are likely to be somewhat low, although probably not by more than 10% after about the 15th day. An error of this magnitude should not greatly affect the shapes of the resulting curves.

The colonization curves (number of species present vs. time) are shown in Fig. 5. The curves seem to follow the general colonization curve proposed by MacArthur and Wilson (1963, 1967) with the non-interactive equilibrium being reached in Pond I at about Day 30 and in Pond II at about Day 25.

There is a distinct possibility, however, that the non-interactive equilibrium was never reached, but that population densities increased enough to cause a leveling off of population increase and a gradual fall toward the interactive equilibrium proposed by Simberloff (1969). The colonization curve of Pond I shows a slight drop between Day 46 and Day 71 which very likely represents a drop to the interactive equilibrium after reaching a substantial portion of the non-interactive equilibrium.

The sample for Pond II at Day 37 was accidentally spilled after only 3 ml were examined so the examined portion of this sample was counted as both II_a and II_b. It can therefore be supposed that the number of species in II_t should be about 49 or 50 species instead of the 30 species shown since the

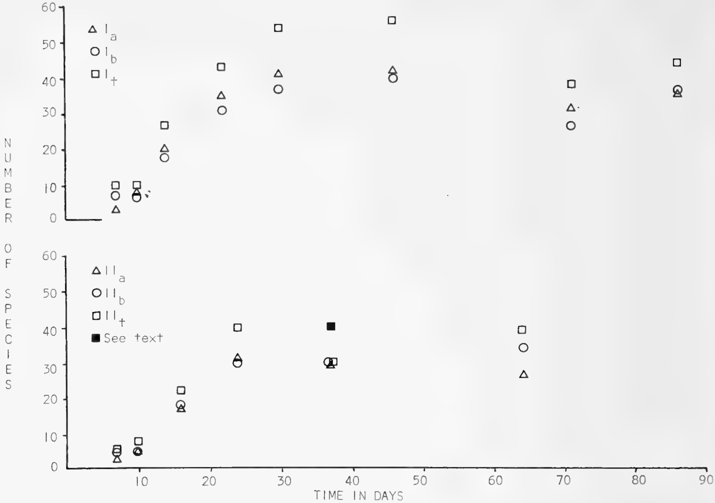


Fig. 5. Colonization curves for Pond I and Pond II.

number of species in each of the replicates is about the same as in the preceding and following samples (this is shown on the figure by a solid square). The equilibrium number of species in Pond II appears to be about 25% lower than that in Pond I (40 as compared to 55). Because of extremely low population densities in the early part of the experiment, causing some species to be missed, the first portion of the colonization curves may be slightly low.

The colonization rate curves (change in number of species present vs. time, i.e., $\Delta s/\Delta t$ vs. t) for I_t and II_t are shown in Fig. 6. If colonizing species have a high rate of success, the immigration rate at the beginning should approach the colonization rate (MacArthur and Wilson, 1967). Thus the colonization rate may be taken as the extreme lower limit for the immigration rate. In this study, however, the observed immigration rates are higher than the colonization rates, rendering this estimate of the lower limit unnecessary as will be explained later.

The shapes of the observed immigration and extinction rate curves (number of spp. immigrating or going extinct/day vs. number of spp. present) are actually of very little interest since so many factors lead to their inaccuracy, especially in the early portion of the study. Since a species may immigrate and become extinct in a very short period of time many species will not be counted in obtaining the rates since this process will occur between sampling periods. The longer the time between sampling periods, the greater the chance for a species to immigrate and to become extinct without being detected (Simberloff, 1969). Therefore observed rates for immigration and extinction are dependent upon the amount of time between sampling periods.

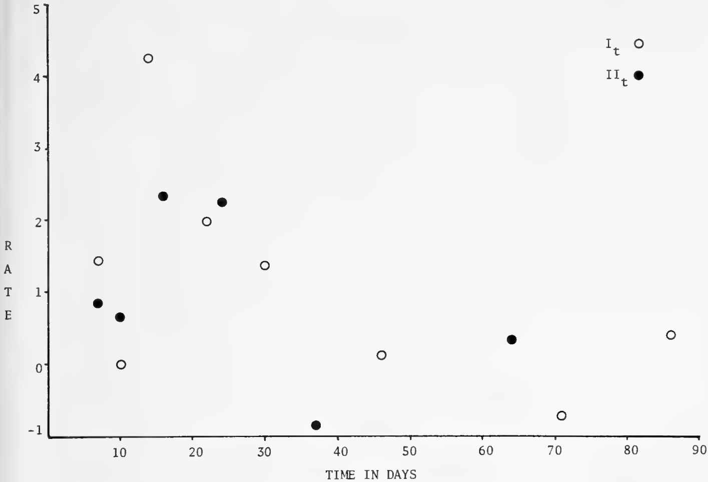


Fig. 6. Colonization rate curves ($\Delta S/\Delta T$) for I_t and II_t.

When the observed rates for the portion of the study at apparent equilibrium were plotted vs. time between samples a slope of about –0.1 was obtained (although because of the small number of points this slope is not statistically significant), hence roughly 0.1 of the observed value may be added for each day between sampling periods to arrive at a measure of the lower limit for immigration and extinction rates. Modified immigration and extinction time rate curves are shown in Fig. 7.

Colonizing species have two major evolutionary strategies open to them; they may evolve to be extremely good dispersers and be among the first to colonize new areas, or they may become adapted to surviving better once they have colonized an area. This is generally the concept of "r" and "K" selection of MacArthur and Wilson (1967). It is unlikely that many species will perfect both of these strategies, therefore the best dispersers are likely to have a high probability of extinction, especially at low population densities. This factor will especially affect the early portion of the rate curves; since the species with the highest invasion rates (i.e., the first to arrive) will also have a high probability of quickly becoming extinct, yielding a very high turnover rate until these species develop high enough population densities to lower greatly the probability of extinction. This is probably a factor throughout the entire study but is greatly magnified when the number of species present is low. Thus I would expect these curves to be low for the entire study. To arrive at an equilibrium turnover rate, observed equilibrium immigration and extinction rates vs. time were plotted back to the ordinate to yield an equilibrium turnover rate of between three and five species per day. For reasons listed above, this turnover rate should be considered a lower limit.

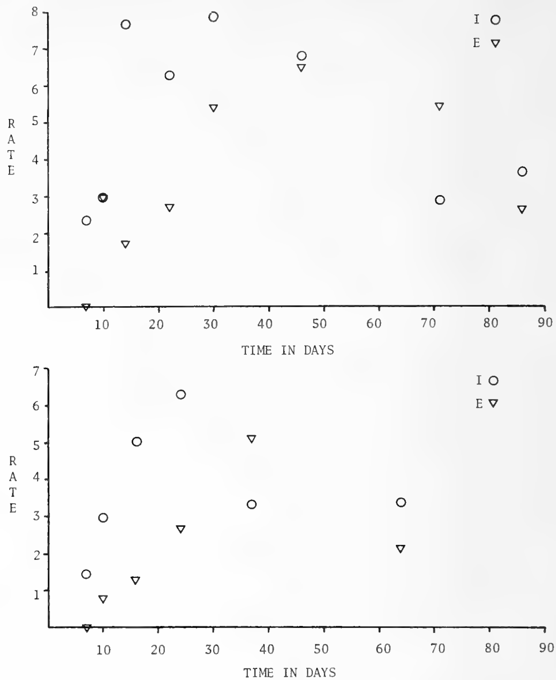


Fig. 7. Modified (see text) immigration and extinction rate time curves for I_1 (above) and II_1 (below).

Conclusions—The results of this study are consistent with the species equilibrium model proposed by MacArthur and Wilson. The colonization curves are of the same form as that proposed by MacArthur and Wilson and also point to the validity of the interactive equilibrium proposed by Simberloff. Inability to obtain accurate immigration and extinction rates during the early portion of the study prevents comparison of the shapes of these curves with those of the MacArthur-Wilson model but the latter portions of these curves are similar to those postulated. The early portions of the immigration and extinction rate curves can probably never be obtained in a study which deals with a large enough community to be considered a valid test of the theory.

This study, particularly when taken in conjunction with those done by Simberloff and Wilson, provides experimental evidence which agrees with the MacArthur-Wilson species equilibrium model and the modifications proposed by Simberloff, especially the concepts of both non-interactive and interactive equilibria and the idea of a very large turnover rate (in this study, 3-5 species per day).

ACKNOWLEDGMENTS—I would like to thank Dr. William Herrnkind, Dr. R. Winston Menzel, and Michael N. Horst for their helpful comments and criticisms. I would especially like to thank Dr. Daniel S. Simberloff without whose help this would not have been possible. I am grateful to my wife whose patience and support have been invaluable.

LITERATURE CITED

CAIRNES, J., JR., M. L. DAHLBERG, K. L. DICKSON, N. SMITH, AND W. T. WALLER. 1969. The relationship of fresh-water protozoan communities to the MacArthur-Wilson equilibrium model. Amer. Nat. 103: 439-454.

CULVER, D. C. 1970. Analysis of simple cave communities. I. Caves as islands. Evolution 24: 463-474.

DIAMOND, J. M. 1969. Avifaunal equilibria and species turnover rates on the Channel Islands of California. Proc. Nat. Acad. Sci. U. S. 64: 57-63.

ELLIS, M. M., B. A. WESTFALL, AND M. D. ELLIS. 1948. Determination of water quality. U. S. Fish and Wildl. Ser. Res. Rep. 9.

GALLAGHER, B. S., AND J. E. BURDICK. 1970. Mean separation of organisms in three dimensions. Ecology 51: 538-540.

GREENSLADE, P. J. M. 1969. Insect distribution patterns in the Solomon Islands. Phil. Trans. Roy. Soc. B 255: 271-284.

JANZEN, D. H. 1968. Host plants as islands in evolutionary and contemporary time. Amer. Nat. 102: 592-595.

LEVINS, R. 1966. The strategy of model building in population biology. Amer. Sci., 54: 421-431.

MACARTHUR, R. H., AND E. O. WILSON. 1963. An equilibrium theory of insular zoogeography. Evolution 17: 373-387.

________, AND ________. 1967. The theory of island biogeography. Princeton Univ. Press. Princeton, N.J.

MAGUIRE, B., JR. 1963. The passive dispersal of small aquatic organisms and their colonization of isolated bodies of water. Ecol. Monogr. 33: 161-185.

PATRICK, R. 1967. The effect of invasion rate, species pool, and size of area on the structure of the diatom community. Proc. Nat. Acad. Sci. U. S. 58: 1335-1342.

________. 1970. Benthic stream communities. Amer. Sci. 58: 546-549.

PEAKE, J. F. 1969. Patterns in the distribution of Melanesian land Mollusca. Phil. Trans. Roy. Soc. B 255: 285-306.

SIMBERLOFF, D. S. 1969. Experimental zoogeography of islands. A model for insular colonization. Ecology 50: 296-314.

________, AND E. O. WILSON. 1969. Experimental zoogeography of islands. The colonization of empty islands. Ecology 50: 278-296.

________, AND ________. 1970. Experimental zoogeography of islands. A two-year record of colonization. Ecology 51:934-937.

WEBB, S. D. 1969. Extinction-origination equilibria in late Cenozoic land mammals of North America. Evolution 23: 688-702.

WHITEHEAD, D. R., AND C. E. JONES. 1969. Small islands and the equilibrium theory of insular biogeography. Evolution 23: 171-179.

WILSON, E. O. 1969. The species equilibrium. Brookhaven Sympo. Biol. 22: 38-47.

________, AND D. S. SIMBERLOFF. 1969. Experimental zoogeography of islands. Defaunation and monitoring techniques. Ecology 50: 267-278.

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ANTIPYRETICS AND HEAT TOLERANCE OF WHITE LEGHORN CHICKS[1]

H. R. Wilson, A. E. Armas, I. J. Ross, C. D. Baird and R. A. Voitle

Department of Poultry Science, University of Florida, Gainesville, Florida 32601

Abstract: Acetylsalicylic acid and acetaminophen caused exaggerated increase in body temperature during heat stress. No beneficial effect was determined for survival time under heat stress.

Improvement of four to six percent in egg production of Leghorns fed 0.05 percent acetylsalicylic acid (aspirin) was reported by Reid et al. (1964). Since the response occurred in cool weather as well as hot, they did not attribute the improvement to antipyretic effects. Feeding acetylsalicylic acid at levels of 0.05 percent (Adams and Rogler, 1968) or 0.005 to 0.08 percent (Reid et al., 1964) for four wk did not significantly affect growth or feed conversion of broiler chicks. Thomas et al. (1967) found that dietary levels of 0.05 to 0.30 percent acetylsalicylic acid did not significantly affect growth of broiler chicks. Glick (1963) also noted no beneficial effect on growth from feeding 0.15 or 0.30 percent acetylsalicylic acid, but did report a significant decrease in weight from feeding 0.60 percent acetylsalicylic acid. Thomas et al. (1967) reported improvement in growth of chicks fed another antipyrogen, acetaminophen, at 0.35 percent of the diet.

Glick (1963) reported a beneficial effect on body temperature (reduced as compared to controls) of chicks fed 0.15, 0.30 or 0.60 percent acetylsalicylic acid and subjected to 43.3°C (110°F) for 20 min. Acetylsalicylic acid did not affect normal body temperature. Feeding 0.05 percent acetylsalicylic acid for four wk reduced body temperature of chicks grown in a 29°C environment (Adams and Rogler, 1968). Sodium salicylate fed at levels of 0.1, 0.25 and 0.5 percent to chicks grown at 40.6°C (105°F) partially prevented an increase in body temperature (Hutchins et al., 1962).

Feeding 0.0055 or 0.0110 percent acetaminophen for four wk was reported by Subaschandran and Balloun (1967) to reduce body temperature of chicks held at 37.8°C (100°F) from five to nine wk of age. On the other hand, Yokoi (1969) reported that antipyrogens exaggerated the increase in body temperature of rabbits subjected to a sudden increase in environmental temperature (25 to 35°C).

The following experiments were conducted to determine the effects of antipyretics on chicks subjected to acute heat stress.

Methods—Two experiments, utilizing a total of 105 birds, were conducted to determine the effect of the antipyrogens, acetylsalicylic acid and acetaminophen, on body temperature and survival time of 5-wk old White Leg-

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horn chicks. The birds were grown under heat lamps in litter floor pens. Acetylsalicylic acid and acetaminophen were administered orally in doses of 3, 30 or 300 mg 15 to 30 min prior to placing the bird in a heat chamber (Wilson et al., 1966) at 40.6°C (105°F) and 75 percent relative humidity. Body temperature was measured using a potentiometer with a thermocouple attached to each bird subcutaneously on the body wall approximately over the oblique process of the sternum. A rectal placement was not used because it was found to prolong survival time. Survival time was determined by observation through a glass window. Three birds on each of seven treatments were run simultaneously.

In experiment 3, 18 White Leghorn chicks per treatment were fed acetylsalicylic acid at levels of 0.025 or 0.05 percent for six hr or six days prior to acute heat stress at four wk of age. Body temperature was not measured in this experiment.

Results and Discussion—The antipyrogens acetylsalicylic acid and acetaminophen given in oral doses of 3, 30 or 300 mg did not significantly affect survival time of 5-wk old chicks under acute heat stress (Table 1). There was a tendency for acetylsalicylic acid to have a beneficial effect on survival. Acetaminophen showed essentially no indication of being beneficial.

Table 1. The effect of antipyretics on survival of chicks under acute heat stress.

Treatment	Survival time (min)
Control	72 ± 5*
Acetylsalicylic acid	
3 mg	81 ± 8
30 mg	74 ± 6
300 mg	84 ± 7
Acetaminophen	
3 mg	69 ± 8
30 mg	72 ± 4
300 mg	78 ± 6

*Standard error.

Body temperature of birds under heat stress was adversely affected (increased) by all levels of acetylsalicylic acid and acetaminophen (Fig. 1). The most rapid increases in body temperature occurred in birds treated with 300 mg of acetaminophen and with those treated with 30 mg acetylsalicylic acid. After 30 min heat stress the body temperatures of birds on all treatments had increased more than that of control birds. All treated birds reached a higher maximum body temperature than did the controls. The maximum increase in body temperature (4.7°C) occurred in the birds treated with 300 mg acetaminophen, and the least increase (3.8°C) occurred in the controls. The rate of body temperature increase and the maximum body temperature reached did not appear to be associated with the ability of the bird to survive under heat stress.

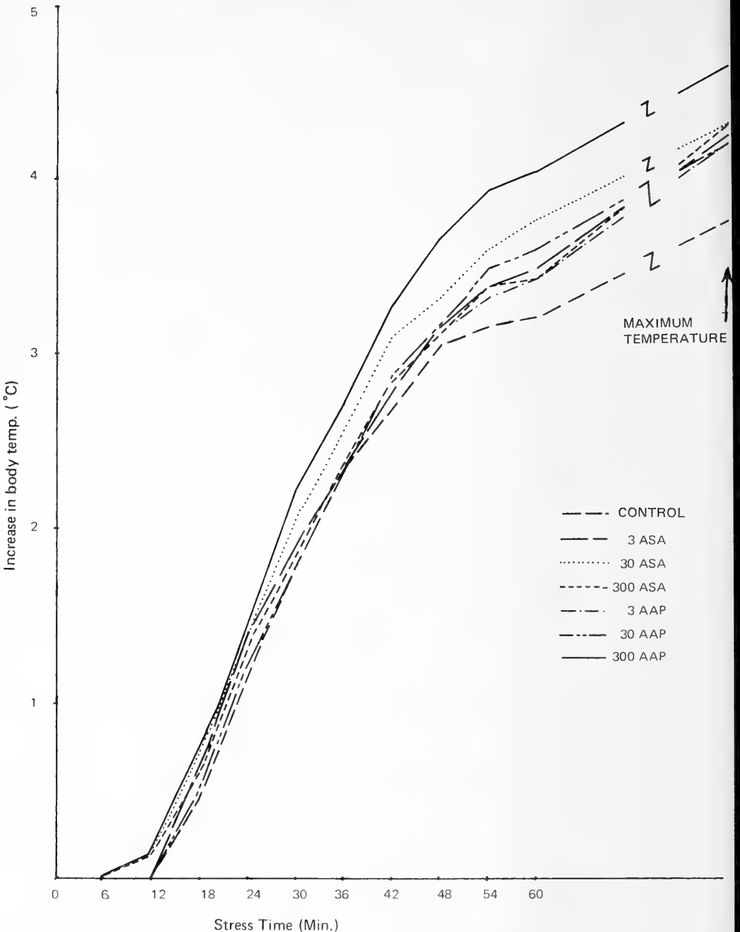

Fig. 1. Increase in body temperature during heat stress. ASA = acetylsalicylic acid; AAP = acetaminophen.

Feeding acetylsalicylic acid at levels of 0.025 or 0.05 percent for six hr or six days did not affect the survival time of birds heat stressed at four wk of age (Table 2). These levels are somewhat lower than those used by Glick (1963); however, the higher level is the same as that which Reid et al. (1964) reported gave a response in egg production.

TABLE 2. The effect of feeding acetylsalicylic acid on survival of chicks under acute heat stress.

Treatment	Survival time (min)
Control	59
.025%-6 hours	57
.025%-6 days	61
.050%-6 hours	60
.050%-6 days	60

The data from these experiments indicated that the antipyrogens, acetylsalicylic acid and acetaminophen, do not aid the bird under heat stress. In fact, the body temperature increase occurring during heat stress was exaggerated by the drugs similar to the effect reported in rabbits by Yokoi (1969).

SUMMARY—Three experiments were conducted with White Leghorn chicks to determine the effects of antipyrogens on heat stressed birds. Acetylsalicylic acid and acetaminophen were each given to 5-wk old birds in a single dose of 3, 30 or 300 mg 15 to 30 min prior to heat stress. In addition, acetylsalicylic acid was fed at levels of 0.025 or 0.05 percent for either six hr or six days prior to heat stress at four wk of age.

The antipyrogens had no significant effects on survival time, although acetylsalicylic acid showed a tendency to be beneficial. Both antipyrogens caused an exaggerated increase in body temperature during heat stress. Feeding acetylsalicylic acid for six hr or six days prior to stress had no beneficial effect on survival time.

LITERATURE CITED

ADAMS, R. L., AND J. C. ROGLER. 1968. The effects of dietary aspirin and humidity on the performance of light and heavy breed chicks. Poultry Sci. 47: 1344-1348.

GLICK, B. 1963. Influence of acetylsalicylic acid on the body temperature of heat-stressed chickens. Nature 200: 603.

HUTCHINS, M. O., W. S. NEWCOMER AND R. H. THAYER. 1962. Effects of sodium salicylate on thyroid function in heat-stressed chickens. Poultry Sci. 41: 1807-1815.

REID, B. L., A. A. KURNICK, J. M. THOMAS AND B. J. HULETT. 1964. Effect of acetylsalicylic acid and oxytetracycline on the performance of White Leghorn breeders and broiler chicks. Poultry Sci. 43: 880-884.

SUBASCHANDRAN, D. V., AND S. L. BALLOUN. 1967. Acetyl-p-aminophenol and vitamin C in heat-stressed birds. Poultry Sci. 46: 1073-1076.

THOMAS, J. M., H. S. NAKOVE AND B. L. REID. 1967. Effect of acetyl-salicylic acid and some chemical analogs on chick growth and selected biochemical parameters. Poultry Sci. 46: 1216-1219.

WILSON, H. R., A. E. ARMAS, I. J. ROSS, R. W. DORMINEY AND C. J. WILCOX. 1966. Familial differences of Single Comb White Leghorn chickens in tolerance to high ambient temperature. Poultry Sci. 45: 784-788.

YOKOI, Y. 1969. Effect of heat and cold stress on thermal responses to antipyretic drugs. Federation Proc 28: 1115-1117.

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CHLOROPHYLL STUDIES IN A SOUTHERN HARDWOOD FOREST IN NORTH CENTRAL FLORIDA[1]

ARIEL E. LUGO[2], TERRY RAMSEY[3], AND JILL HOY[4]

[2]Department of Botany, University of Florida, Gainesville, Florida 32601;
[3]92 NE 10 St., Homestead, Florida 33030; [4]1581 NE 42 St., Pompano Beach, Florida 33060

ABSTRACT: *Seventy extractions of chlorophyll* a *from leaves along a vertical profile yielded the following results: 1) chlorophyll* a *content in g/m² leaf surface was 0.289 (0.021 to 0.396); 2) leaves from different species did not indicate any clear differences; 3) Margalef ratios (OD_{430}/OD_{665}) averaged 2.04 with 4.00 observed for leaf litter; and 4) chlorophyll* a *content was 1.7 g/m² ground surface. It is suggested that a uniform chlorophyll distribution in the forest permits quick responses in the photosynthetic machinery to changes in solar energy inputs, thus maintaining optimum power output of photosynthesis. Comparison of several steady-state and successional systems suggests that Margalef ratios may not be useful as indicators of succession for terrestrial ecosystems.*

THE southern mixed hardwood forest is considered by many (Laessle, 1942, and Monk, 1965) as the climax ecosystem for the north central Florida region. Recently, Lugo, Snedaker and Gamble (1972) and Gamble (1972) have described and presented preliminary data for the major matter and energy flow pathways in this ecosystem. The present study, combined with those cited above and the work of Ewel (1969), represents efforts to derive measurements and indices of ecosystem structure and function useful for comparative systems analysis. The specific objectives of this study were to survey the content and distribution of chlorophyll *a* and other pigments in the southern mixed hardwood ecosystem (also known as the mesic hammock ecosystem).

METHODS—The study was done during the summer of 1971 in the University of Florida Horticultural Unit Farm located ten miles NW of Gainesville on State Road 329. The method utilized for chlorophyll extractions followed the procedure used by Odum and Cintron (1970) in the rain forest of Puerto Rico.

Seventy samples of green tissue from trees, shrubs, herbs, and mosses, and dead leaves were collected along a vertical profile from the study site. Two hours after collection, they were ground and the chlorophyll extracted with 90% acetone saturated with $MgCO_3$. The chlorophyll extracts were then centrifuged, incubated overnight in a dark cold room, and their optical densities (OD) at 665, 645, and 630*nm* determined with a Coleman model 14 spectrophotometer. Chlorophyll *a*, expressed in g/m² of leaf surface, was calculated using the following relationship:

$$\text{g chl. } a/\text{m}^2 = \frac{(\text{ml extract})(15.6)(OD_{665})-(2.0)(OD_{645})-(0.8)(OD_{630})}{(\text{Area of sample in cm}^2)(10^2)}$$

[1]Study conducted while the junior authors were participating in the summer science research participation program for secondary school students, sponsored by the College of Education, University of Florida.

The absorption spectra from 350 to 700*nm* were determined on a Beckman model DB-G grating spectrophotometer for 20 chlorophyll extractions obtained from various forest compartments. Margalef ratios (OD_{430}/OD_{665}) were calculated from these determinations.

RESULTS—Table 1 summarizes all the chlorophyll determinations for the dominant species in the forest, a species of moss growing on a tree trunk, and dead leaves from the forest floor. The average for all determinations was 0.289 g/m^2 with a range of 0.021 for leaf litter to 0.396 for an unidentified species of the genus *Smilax*. The results are variable and no trends between

TABLE 1. Mean chlorophyll *a* content of several plant species and leaf litter from a southern mixed hardwood forest of north central Florida. The number of determinations are shown in parenthesis under each mean.

Species	Chlorophyll content g/m^2 leaf surface $\pm$1 SD
Quercus nigra	0.307 $\pm$ 0.060 (4)
Quercus laurifolia	0.323 $\pm$ 0.054 (14)
Quercus michauxii	0.256 $\pm$ 0.063 (7)
Carya glabra	0.255 $\pm$ 0.041 (6)
Ostrya virginiana	0.237 $\pm$ 0.093 (9)
Liquidambar styraciflua	0.244 $\pm$ 0.028 (4)
Magnolia grandiflora	0.350 $\pm$ 0.051 (8)
Cornus florida	0.231 (2)
Serenoa repens	0.339 (2)
Vitis rotundifolia	0.284 (2)
Smilax Bona-Nox	0.368 (2)
Gelsemium sempervirens	0.367 (2)
Smilax pumila	0.239 (1)
Smilax sp.	0.396 (1)
Vaccinium arboreum	0.257 (1)
Rubus trivialis	0.142 (1)
Moss on a tree trunk	0.190 (1)
Leaf litter	0.021 (1)
Mean	0.289 $\pm$ 0.077 (67)

species and leaf position in the canopy are observed. The value for leaf litter (0.021 g/m^2) however, was much lower than any other determination due to the loss of chlorophyll to decomposition.

Chlorophyll values are also reported as a function of height in Table 2. The data collected suggests a uniform distribution of chlorophyll *a* between species and leaves along a vertical profile of the forest. On a meter square of ground, however, the leaf area is higher in the upper part of the canopy than below and, therefore, the total chlorophyll is higher at the top of the forest than below. Using a leaf area index of 6.2 (Lugo, Snedaker, and Gamble, 1972) the total chlorophyll for the forest was calculated at 1.79 g/m^2. In Table 3 a value of 1.7 g chlo. *a*/m^2 was calculated utilizing the basal area of the dominant species as an index of their contribution to the leaf area of the forest.

TABLE 2. Mean chlorophyll content of leaves at different canopy heights.

Height (m)	No. of determinations	Chlorophyll *a* (g/m^2 leaf surface)	Range
0-10	39	0.293	+0.15
10-20	17	0.263	+0.06
$\geq$ 20	12	0.284	+0.10

Table 4 contains the results expressed as the ratio described by Margalef (1963), herein called Margalef ratios. For leaf extractions, the mean calculated was 2.04 with a range from 1.95 for dogwood (*Cornus florida*) to 2.19 for hophornbeam (*Ostrya virginiana*). The moss on the tree trunk, and the leaf litter showed high ratios (2.26 and 4.00 respectively) indicating a predominance of carotenoids. Table 5 contains unpublished data from C. Richardson for a similar forest near the study site. His calculations of Margalef ratios are similar to those calculated in this study. On a vertical distribution, the value of the ratio did not change appreciably, although the tendency for an intermediate value between 5 and 15 m was observed.

TABLE 3. Calculation of Chlorophyll *a*/m^2 of ground surface for the dominant forest species. Basal area data courtesy of Dr. S. C. Snedaker.

Species	Basal Area ($\frac{m^2}{ha}$)	% of Total	Leaf Area Index	Chlorophyll *a*/m^2
Carya glabra	11.516	34.8	2.16	0.581
Quercus nigra	9.924	30.0	1.86	0.535
Quercus laurifolia	2.602	7.8	0.48	0.136
Liquidambar styraciflua	1.718	5.2	0.32	0.079
Quercus michauxii	1.055	3.2	0.20	0.044
Ostrya virginiana	0.996	3.0	0.18	0.036
All other species (> 2.5 cm DBH)	5.278	16.0	1.0	0.293
Total	33.089	100.0	6.20	1.704

TABLE 4. Margalef ratios of selected plant species in the southern mixed hardwood forest of north central Florida.

Species	Margalef ratio (OD_{430}/OD_{665})	Number of Determination	Range
Quercus nigra	2.01	4	+0.08
Quercus laurifolia	1.96	2	+0.04
Quercus michauxii	2.16	1	—
Carya glabra	2.10	5	+0.10
Ostrya virginiana	2.19	1	—
Liquidambar styraciflua	2.00	1	—
Cornus florida	1.95	2	+0.01
Serenoa repens	2.02	1	—
Herbaceous weed	2.04	1	—
Moss on tree trunk	2.26	1	—
Dead leaf[a]	4.00	1	—
Mean	2.04	20	+0.22

Mean for 0-5 m: 2.10 SD +0.900
Mean for 5-15 m: 2.01 SD +0.087
Mean for 15 m and above: 2.04 SD +0.031

[a]Not included in the calculation of the mean.

Figure 1 depicts the absorption spectra for an emergent leaf (*Carya glabra*), a leaf in the center of the canopy (*Quercus nigra*), an understory leaf (the saw palmetto *Serenoa repens*), and leaf litter on the forest floor. The absorption peaks for chlorophyll (665 and 430*nm*) are easily identified. With the exception of the leaf litter, no significant differences were detected in the absorption spectra at the various canopy levels.

TABLE 5. Margalef ratios calculated by C. Richardson (unpublished) in the San Felasco hammock (a mesophytic hardwood forest 3 miles west of the study area).

Species	Margalef ratio[a] OD_{430}/OD_{665})
Quercus michauxii	2.2
Ostrya virginiana	2.2
Liquidambar styraciflua	2.7
Magnolia grandiflora	2.6[b]
Vitis munsoniana	2.0
Ilex opaca	2.0
Parthenocissus quinquefolia	1.9
Mean	2.2 + 0.2 (7)

[a]Three one sq m determinations, which included all the species present in the sq m and extracted in the observed proportion, yielded ratios of 3.1, 2.6, and 2.9 for an average of 2.8.

[b]Three determinations.

DISCUSSION—Steady-state ecosystems have maximized the flow of useful energy, and thus their competitive position in the biosphere, by means of many attributes which include diversity, efficient mineral cycling, and the display of their energy receptors (i.e., chlorophyll and carotenoids). Since the energy input into ecosystems is variable on short-term and seasonal basis,

TABLE 6. Chlorophyll content and Margalef ratios for some ecological systems.

Ecosystem Type	Chlorophyll *a* g/m^2	Margalef Ratio OD_{430}/OD_{665}	Reference
Steady-State			
Alpine and Tundra	0.32-0.90[a]	—	Bliss, 1960 Billings & Mooney, 1968
Granite outcrop system	0.88	3.94	Lugo, 1969
Southern Mixed Hardwood Forest	1.7	2.04	This study
Southern Mixed Hardwood Forest	—	2.31	Richardson, unpublished
Longleaf Pine-Turkey Oak Forest	—	2.06	Richardson, unpublished
Conifer-Hardwood Forest	3.10[a]	—	Bray, 1960
Lower Montane Rain Forest	0.80-4.50	2.15	Odum and Cintron, 1970
Mossy Forest	1.68	2.50	Odum and Cintron, 1970
Coral Reef	0.15	4.20	Odum and Cintron, 1970
Successional			
Corn field	1.60[a]	—	Bray, 1960
Lower Montane Rain Forest	0.50	2.10	Odum and Cintron, 1970
Salt brine ponds	0.10	3.00	Nixon, 1970
Old Field	0.30-0.60[a]	—	Bray, 1960

[a]Total chlorophyll estimates.

one would expect concurrent changes in their chlorophyll content in order to maintain optimal energy flows. While seasonal patterns are easy to observe and measure, short term changes in the chlorophyll content of plants are difficult to detect. Spacially, however, Odum and Cintron (1970) described the chlorophyll patterns in a lower montane tropical forest. They reported 1800 determinations which included leaves in many states of development and position in the canopy. In general, our results are similar to theirs and both forests had uniform chlorophyll distribution. It must be emphasized however, that within a tree canopy, differences in chlorophyll are observed as leaves mature or as they change in morphology from sun-adapted to shade-adapted leaves. Similarly, successional and climax species, and species of different ecosystems, depending on their energy input loads, do show differences in chlorophyll content. These patterns have been described by Odum and Cintron (1970).

In the study forest we found a total chlorophyll *a* content of 1.7g/m^2 of ground. This is a finite amount of pigment responsible for the transfer of light energy into chemical energy (power output of photosynthesis) and does so by cycling between a receptive and an activated state depending upon the energy load (solar input). One might speculate that in a system such as the hardwood mesic hammock, the observed uniform distribution of chlorophyll *a* among species and among leaf position in the canopy (Tables 1 and 2 and

Fig. 1), are adaptations that allow fast power output responses to changes in energy inputs delivered at varied programs (i.e., sunflecks, cloud interference, and daily variations). For example, as sunflecks penetrate the canopy, leaves in the understory react to the increased light intensity by increasing light absorption and gross photosynthesis. The net result is an even power output delivery of photosynthesis under changing light conditions (described by Odum, McConnell, and Abbott, 1958) which serves to maximize the total flow of energy.

As indices for comparing ecosystems, chlorophyll per unit area of land surface (g/m^2) and the Margalef ratio are useful. Table 6 compares the study area with several ecological systems for which data were available. Bray (1960) has related the chlorophyll content of herbaceous communities in Minnesota to their biomass. These correlations however, apply only to systems of one type under similar environmental conditions. Instead of biomass,

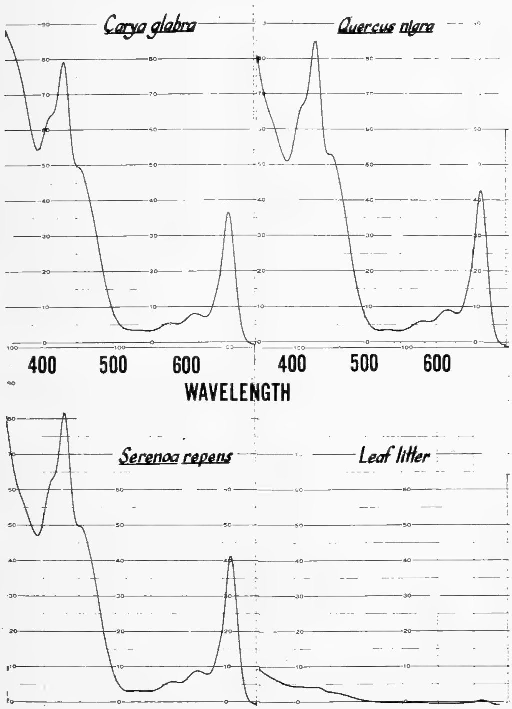

Fig. 1. Absorption spectra of chlorophyll from three plant species and leaf litter in the southern mixed hardwood forest in north central Florida.

however, it has been suggested that chlorophyll content per unit area is related to the adjustment of power output of photosynthesis which in turn is dependent on energy input loads, the mineral cycles, or any other factor that may limit power delivery (Odum, McConnell, and Abbott, 1958). The mesic hardwood forest, with its rapid mineral cycles, complex structure, high diversity, and long growing season (Lugo, Snedaker, and Gamble, 1972) contains a relatively high amount of chlorophyll *a* per unit area in contrast to granite outcrop communities (Lugo, 1969), salt brine communities (Nixon, 1970), and alpine tundra (Bliss, 1960) which are limited by nutrients and/or water. The hardwood system also has higher chlorophyll values than those successional systems cited in Table 6. However, the corn field (Bray, 1960) subsidized by man with nutrients and cultivators using fossil fuel, approaches the forest in its chlorophyll content.

Margalef ratios were proposed as indicators of the successional status of aquatic ecosystems (Margalef, 1963). Successional ecosystems with low species diversity are expected to have low ratios while steady-state ecosystems with high diversity have high ratios. However, Margalef ratios are probably more valid as indicators of photorespiration than as indicators of successional status as originally intended by Margalef (1963) (Nixon, 1970; Odum, Nixon, and DiSalvo, 1972). For example, both rain forest and hardwood forest showed low values for the ratios in spite of being steady-state systems. In contrast, high values of the Margalef ratios were observed in steady-state granite outcrop ecosystems, in salt brine ecosystems, and a shaded portion of a coral reef (Table 6). These systems are found in high light environments and may exhibit photorespiration (Nixon, 1970; Odum, Nixon, and DiSalvo, 1972). However, it is possible that within a given successional sere the ratio does change as predicted by Margalef, but preliminary data from the rain forest succession (Odum and Cintron, 1970) suggest little change. Thus, the usefulness of Margalef ratios as indicators of succession in terrestrial systems needs further study.

In conclusion, the findings of chlorophyll content and distribution in the mesic hammock are in agreement with reported results for other ecological systems (Table 6). As a complex, steady-state system, the mesic hammock absorbs strongly on the visible light spectrum (Ewel, 1969) and contains a large amount of chlorophyll *a* (1.7 g/m^2) distributed uniformly among the many species that form its canopy. However, due to the distribution of the leaf area in the forest, the chlorophyll is found mostly in the upper layers of the canopy. In the forest, the Margalef ratio is high in the leaf litter but low in most plant species studied (average of 2.04). These low values for Margalef ratios indicate a predominance of chlorophyll *a* and probably a low photorespiration in these leaves during the summer. The Margalef ratio is not an indicator of the successional status of the ecosystem studied and perhaps is not an indicator of the successional status of terrestrial ecosystems in general.

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LITERATURE CITED

Billings, W. D. and H. A. Mooney. 1968. The ecology of arctic and alpine plants. Biol. Rev. 43: 481-529.

Bliss, L. C. 1960. Net primary production of tundra ecosystems. pp. 35-44 *In* H. Lieth (ed.) Die Stoffproducktion der Pflanzendecke.

Bray, J. R. 1960. The chlorophyll content of some managed plant communities in central Minnesota. Canad. J. Bot. 38: 313-333.

Ewel, J. 1969. Spectral solar radiation intensity in two Florida forests. Quart. J. Fla. Acad. Sci. 32: 164-170.

Gamble, J. F. 1971. A proposed mechanism for the recycling of radio-cesium in Florida soil plant systems. pp. 133-139 *In* D. J. Nelson (ed.) 3rd Natl. Symp. on Radioecology USAEC, Oak Ridge, Tenn.

Laessle, A. M. 1942. The plant communities of the Welaka area. Univ. Fla. Publ. 4(1). 143 pp.

Lugo, A. E. 1969. Energy, water and carbon budgets of a granite outcrop community. 233 pp. Ph.D. dissertation, University of North Carolina at Chapel Hill.

Lugo, A. E., S. C. Snedaker, and J. F. Gamble. 1971. Models of matter flow in a southern mixed hardwood forest in Florida: Preliminary results. pp. 929-935 *In* D. J. Nelson (ed.) 3rd Natl. Symp. on Radioecology USAEC, Oak Ridge, Tenn.

Margalef, R. 1963. On certain unifying principles in ecology. Amer. Nat. 97: 357-374.

Monk, C. D. 1965. Southern mixed hardwood forest in north central Florida. Ecol. Monogr. 35: 335-354.

Nixon, S. W. 1970. Characteristics of some hypersaline ecosystems. 401 pp. Ph.D. dissertation, University of North Carolina at Chapel Hill.

Odum, H. T. and G. Cintron. 1970. Forest chlorophyll and radiation. *In* H. T. Odum and R. F. Pigeon (ed.) in A Tropical Rain Forest. Chaps 1-2. Div. Tech. Inf. USAEC, Oak Ridge, Tenn.

———, S. W. Nixon, and L. H. DiSalvo. 1972. Adaptations for photoregenerative cycling. *In* J. Cairns (ed.) The Structure and Function of Fresh-water Microbial Communities. Res. Monogr. 3: 1-29. VPI and State University. Blacksburg, Va.

———, W. McConnell, and W. Abbott. 1958. The chlorophyll *a* of communities. Publ. Inst. Marine Sci. Univ. Tex. 5: 65-96.

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PRELIMINARY THERMAL STUDIES ON YOUNG *PANULIRUS ARGUS*[1]

Ross Witham

Florida Department of Natural Resources,
Marine Research Laboratory, St. Petersburg, Florida 33701

Abstract: *Spiny lobsters grown under several regimes of temp were intolerant of sustained temp below 15.6°C and above 30°C. Thus, "marching" of lobsters across deep straits as previously theorized seems unlikely.*

Spiny lobster, *Panulirus argus* (Latreille) is widely distributed in the tropical and subtropical waters of the western Atlantic Ocean, and is of considerable economic importance to fisheries of the area. It is generally considered to require warm temperatures for survival. All species of *Panulirus* tend to occur in areas with approximate annual average temperatures of 20-25°C (George and Main, 1967). However, there appears to be little in the literature concerning the effects of temperature upon survival and growth.

Materials and Methods—Five aquaria of about 150 gal capacity each were used for the study. Seawater was supplied from a well. Water for the ambient temperature aquarium was continuously exchanged, and aeration was provided by a jet of water entering the surface water of the aquarium. Reduced water exchange was maintained in the hyper and hypothermal aquaria to prevent variations in salinity. Aeration for the hyperthermal aquaria was provided by a Silent Giant aquarium pump, while circulation of water by the cooling units was sufficient for aeration of hypothermal tanks.

Elevated temperatures were maintained by six 200-watt Heatmaster Supreme aquarium heaters in each hyperthermal aquarium. Frigid Units, Inc., Model DT-33-T aquarium coolers with titanium immersion coils were used in hypothermal aquaria. Lobsters were placed in aquaria at ambient temp which were then adjusted to the desired levels.

Lobsters used in the first experiment were caught in the Indian River and kept in aquaria for several mo prior to the study. Those used for subsequent experiments were usually juveniles and came from the Florida Keys; however, a few pueruli were taken from habitats at the House of Refuge dock. Amphipods, *Elasmopus* sp., and gastropods, *Batillaria minima* and *Haminoea antillarum* Orbigny, were provided as food. All surviving lobsters were returned to ambient temp.

Proposed temp during the first study were: ambient; 10°C, 15.6°C, 26.7°C, and 32.2°C. Second experiment temp were to be: ambient; 15.6°C, 32.2°C, 35.0°C, and 37.8°C. Temp were checked daily with maximum-minimum thermometers. Salinities were checked weekly with an American Optical Corporation refractometer, Model 10419.

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[1]Contribution no. 234 of the Marine Research Laboratory.

RESULTS AND DISCUSSION—The first experiment was started November 25, 1969, and ended January 26, 1970. Average temp varied less than 1°C from selected temp, except for the 32.2°C aquarium where the average was 28.9°C. All aquaria were exposed to cold northerly winds and temp in the ambient aquarium ranged 7.2–26.1°C. Six of the seven lobsters at ambient temperatures survived for 2 mo during the first study, and avg carapace length increased from 19.8 mm to 25.1 mm (27%). At 10.0°C the first death occurred at 4 da and none lived longer than 10 da. Duplicate experiments yielded similar results. At 15.6°C, six of seven juvenile lobsters with carapace lengths 15.0 mm to 34.6 mm survived. Five pueruli added during the experiment did not survive. Average carapace length increased from 19.6 to 20.0 mm (2%) for six survivors. Six of seven of those held at 26.7°C were alive at the end of the 2 mo and avg carapace length increased from 19.9 mm to 26.5 mm (28%). Cannibalism was observed twice at 32.2°C, and may have occurred on one other occasion. These lobsters were initially avid, aggressive feeders, but feeding ceased and all were dead a week before the scheduled end of the experiment. Five of these were measured after they died, and avg carapace length was 27.3 mm, an increase of 35 percent (Table 1).

TABLE 1. Temperature, survival and growth during experiment I.

	Temperature °C				No.	Carapace Length (mm)			
	Proposed	Observed							
Date		Max.	Min.	Avg.	Lobsters	Max.	Min.	Avg.	Remarks
11-25-69	Ambient	26.1	7.2	19.7	7	30.0	11.6	19.8	Start
1-26-70					6	31.7	20.0	25.1	Termination
11-25-69	10.0	12.2	8.3	9.3	7	25.0	12.0	19.8	Start
12- 5-69					0				All dead
12- 9-69					7	Pueruli			Start
12-15-69					0				All dead
12-15-69					6	Pueruli			Start
12-22-69					0				All dead
11-25-69	15.6	18.3	8.9	15.7	7	34.6	15.0	19.6	Start
12- 9-69					5[1]	Pueruli			Addition
1-26-70					6	34.7	14.8	20.0	Termination
11-25-69	26.7	30.0	19.4	26.0	7	25.0	15.5	19.9	Start
1-26-70					6	31.6	21.8	26.5	Termination
11-25-69	32.2	33.9	12.8	28.9	7	27.3	13.8	20.2	Start
1-19-70					0[2]	31.9	23.9	27.3	All dead

[1]Five pueruli added on 9 Dec., none survived.
[2]Cannibalism observed 1 Dec. and 29 Dec. Five died before end of experiment and their carapace lengths were measured when found.

The second experiment started April 3, 1970, and terminated June 3, 1970 (Table 2). Survival at ambient temp (21.1–33.2°C) was very good with 15 of 17 living for 2 mo. Average carapace length increased from 7.5 mm to 11.6 mm (55%). At 15.6°C 16 of 17 lobsters lived throughout the study; however, their average carapace length increased from 7.6 mm to 8.9 mm (17%). Lobsters at 15.6°C during both experiments were never observed active or feeding. Although at 32.2°C only 5 of 17 survived, two of the deaths occurred on the day the experiment ended. Average carapace length of those living increased from 6.9 to 14.5 mm (110%). If the two found dead on the last day are included, the average carapace length increased from 6.9 mm to 15.5 mm (125%). Groups of 16 and 35 lobsters were tested at 35.0°C and all were dead within 48 hr. Two more groups of 16 and 35 were tested at 37.8°C, and all died in less than 24 hr.

TABLE 2. Temperature, survival and growth during experiment II.

	Temperature °C				No.	Carapace Length (mm)			
	Proposed	Observed							
Date		Max.	Min.	Avg.	Lobsters	Max.	Min.	Avg.	Remarks
4- 3-70	Ambient	33.2	21.1	24.7	17	10.5	6.0	7.5	Start
6- 3-70					15	15.8	7.5	11.6	Termination
4- 3-70	15.6	22.2	14.4	15.6	17	10.5	6.0	7.6	Start
6- 3-70					16	10.2	7.5	8.9	Termination
4- 3-70	32.2	34.4	22.8	31.8	17	9.5	6.0	6.9	Start
6- 3-70					5[1]	16.5	12.8	14.5	Termination
4- 3-70	35.0	36.1	22.2	31.9	16	9.0	6.0	7.4	Start
4- 5-70					0				All dead
4-16-70					35	7.5	6.0	6.5	Start
4-17-70					10				25 dead
4-18-70					0				All dead
4- 3-70	37.8	37.8	22.2	30.1	16	10.5	6.0	7.4	Start
4- 4-70					0				All dead
4-16-70					34	7.5	6.0	6.4	Start
4-17-70	0				All dead				

[1]Two dead on 3 June, carapace lengths 16.9 and 19.5 mm.

When returned to ambient temp following the experiments, all survivors resumed normal activity.

Salinities during the first experiment ranged from 32.00 to 29.00 o/oo and averaged 30.48 o/oo, and during the second series ranged from 33.00 to 31.00 o/oo and averaged 32.22 o/oo.

It is assumed by Vernberg and Vernberg (1969) that each stage in the life cycle of invertebrates is adapted metabolically to the temp normally encountered, and Heinle (1969) reports that the metabolism of zooplankton is temp dependent and rises linearly with increase.

Preliminary experiments with early postlarval *Panulirus argus* indicate that they respond to temp variations with differing rates of survival and growth, as did phyllosomes of *Scyllarus americanus* (Robertson, 1968). Hughes and Matthiessen (1962) established, from laboratory studies, that temp was an important factor in the length of larval life of the American lobster, *Homarus americanus*, with higher temp resulting in a shorter time required to pass through the various stages. Hughes (personal communication, 1970) also reports that laboratory study of postlarval molting and growth for this species follows a similar pattern. Food type, food supply, and temp were shown by Knowlton (1965) to influence molting frequency and growth of the shrimp, *Palaemonetes vulgaris*. Other workers have reported the effects of temp on crustaceans, mollusks, and fishes. Allen and Strawn (1967) suggest that heat tolerance of channel catfish is genetically based, and that indirect heat death may occur after a long period of time due to increasing the metabolic rate beyond the rate at which the fish can consume food. However, Carlisle and Cloudsley-Thompson (1968) state, from their work with gastropods and terrestrial crustaceans, that the high respiratory quotient of cold-blooded animals exposed to high temp is transient. Allen and Strawn's (1967) suggestion may apply to *P. argus* based on results observed at 32.2°C.

It has been theorized that adult spiny lobsters crawl from the Bahamas to the east coast of Florida. Rao and Bullock (1954) and others suggest that the young of most poikilothermic animals are better able to adjust to cold than are older ones. Witham (1971), while studying live shipping of spiny lobsters, found that mature *P. argus* died in less than 47 hr when held without packing material at 10.0°C. The low temperature of 7.0°C reported by the *Ben Franklin* (Dolan, 1969) in deep Florida Current waters off Lake Worth Inlet indicates that "marching" migrations (Herrnkind, 1970) of adult lobsters between Florida and the Bahamas would be halted by inactivation, and probably death, before they reached the depths required to cross the stream. Smith (1948) reported no evidence that mature lobsters could cross deep straits, and suggested that these would be a deterrent to migration.

SUMMARY—Preliminary studies suggest that *P. argus* has a relatively narrow range of desirable temp. Early postlarval lobsters die in a few days at 10.0°C, in less than 48 hr at 35.0°C, and in less than 24 hr at 37.8°C. Initial survival was good and an avg growth rate of 125 percent for a period of 2 mo was recorded at 32.2°C; however, very few survived that long.

Growth rates at the lowest survival temperature, 15.6°C, were as low as 2 percent, while lobsters of the same size range at the start of the experiment and held at 26.7°C increased their avg carapace length by 28 percent during the same 2-mo period. Smaller lobsters held at 15.6°C increased their avg carapace length by 17 percent, and those of the same size at ambient temp averaging 24.7°C had an avg carapace length increase of 55 percent over a 2-mo period.

Low temperatures in deep waters of the Florida Current would appear to be a deterrent to migrations of "marching" lobsters between Florida and the Bahama Islands.

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LITERATURE CITED

Allen, K. O. and K. Strawn. 1967. Heat tolerance of channel catfish. Proc. 21st Ann. Conf. Southeast. Assoc. Game Fish Comm. pp. 399-410.

Carlisle, D. B. and J. L. Cloudsley-Thompson. 1968. Respiratory function and thermal acclimation in tropical invertebrates. Nature 218: 684-685.

Dolan, F. J. 1969. *Ben Franklin* Gulf Stream Mission Report OSR-69-19. pp. 1-11. Grumman Aerospace Corp. Ocean Syst. Dept. Bethpage, New York.

George, R. W. and A. R. Main. 1967. The evolution of spiny lobsters (Palinuridae): a study of evolution in the marine environment. Evolution 21: 803-820.

Heinle, D. R. 1969. Temperature and zooplankton. Chesapeake Sci. 10: 186-209.

Herrnkind, W. F. 1970. Migration of the spiny lobster. Nat. Hist. 79: 36-43.

Hughes, J. T. and G. C. Matthiessen. 1962. Observations on the biology of the American lobster, *Homarus americanus*. Limnol. Oceanogr. 7: 414-421.

Knowlton, R. E. 1965. Effects of some environmental factors on the larval development of *Palaemonetes vulgaris* (Say). J. Elisha Mitchell Sci. Soc. 81: 87.

Rao, K. P. and T. H. Bullock. 1954. Q^{10} as a function of size and habitat temperature in poikilotherms. Amer. Nat. 88: 33-44.

Robertson, P. B. 1968. The complete larval development of the sand lobster, *Scyllarus americanus* (Smith) (Decapoda, Scyllaridae) in the laboratory, with notes on larvae from the plankton. Bull. Mar. Sci. Gulf Carib. 18: 294-342.

Smith, F. G. W. 1948. The spiny lobster industry of the Caribbean and Florida. Carib. Res. Counc. Fish. Ser. 3: 1-49.

Vernberg, F. J. and W. B. Vernberg. 1969. Thermal influence on invertebrate respiration. Chesapeake Sci. 10: 234-240.

Witham, R. 1971. Live shipping of Florida's spiny lobster. Quart. J. Florida Acad. Sci. 33: 211-220.

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MILO DIETS WITH ADDED SULFATE FED TO RATS[1]

W. E. MAXSON AND R. L. SHIRLEY

Department of Animal Science, University of Florida, Gainesville, Florida 32611

ABSTRACT: *Among 60 female rats fed milo, those on high tannin diets weaned fewer offspring and had lower feed efficiency with or without added sulfate.*

MILO or sorghum grain has frequently undergone extensive destruction by birds prior to harvest. A bird-resistant type has been developed, but it often contains high levels of tannins (Harris and Burns, 1970; Harris et al., 1970). Chang and Fuller (1964) reported that tannins in bird-resistant types of milo resulted in reduced growth in chicks. Tannins in purified diets were demonstrated to be toxic for rats by Glick and Joslyn (1970a, 1970b). Addition of methionine or choline detoxified tannic acid for both chicks (Chang and Fuller, 1964) and rats (Booth et al., 1961). Animals also excrete tannins in the urine as sulfate derivative of phenolic compounds (Hawk and Bergheim, 1943). On the basis of that report, sulfate was considered a possible detoxifying agent for tannins in the present study.

The present investigation was designed to study the effect of added tannic acid and sodium sulfate to bird-resistant and non-bird-resistant types of milo diets upon growth, feed intake, feed efficiency and reproduction in rats.

MATERIALS AND METHODS—Sixty weanling Long-Evans female rats were randomly allotted among six dietary treatments. The treatments were diets that contained bird-resistant milo (BR), BR milo plus 0.9% sodium sulfate, BR milo plus 3.0% tannic acid, non-bird-resistant milo (NBR), NBR milo plus 0.9% sodium sulfate and NBR milo plus 3.0% tannic acid as presented in Table 1. Rats were individually caged on a rack in an air conditioned room. The animals were fed *ad libitum* with the weighback feed recorded every other day with animals being weighed weekly. Duncan's multiple range test was used as outlined by Dixon and Massey (1969) for statistically analyzing the treatment effects on completion of the sixth and tenth weeks of feeding the diets. At the end of the tenth week, the females were grouped two per cage and each pair exposed to a male for five days. After five days, the males were rotated to another pair of females for five days. Approximately one week prior to parturition, the females were transferred to individual littering cages and the litter remained intact until weaning at 21 days.

Feed samples were analyzed for moisture, protein, ether extract, crude fiber, ash, gross energy, sulfur and tannic acid. The proximate composition, energy and sulfur analyses were carried out by A.O.A.C. (1970) procedures, and tannins by the method outlined by Burns (1963).

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TABLE 1. Ingredients of Diets.

	Diets					
	BR Control	NBR Control	BR + SO_4	NBR + SO_4	BR + T.A.	NBR + T.A.
Bird-resistant milo	81.55	00.00	80.82	00.00	79.17	00.00
Non-bird-resistant milo	00.00	81.55	00.00	80.82	00.00	79.17
Soybean meal, 49% protein	15.50	15.50	15.36	15.36	15.04	15.04
Deflourinated phosphate	1.10	1.10	1.09	1.09	1.06	1.06
Ground limestone	0.75	0.75	0.74	0.74	0.72	0.72
Iodized salt	0.50	0.50	0.49	0.49	0.48	0.48
Trace mineral[1]	0.10	0.10	0.09	0.09	0.09	0.09
Vitamin premix[2]	0.50	0.50	0.49	0.49	0.48	0.48
Sodium sulfate	0.00	0.00	0.82	0.82	0.00	0.00
Tannic acid	0.00	0.00	0.00	0.00	2.96	2.96
Total	100.00	100.00	100.00	100.00	100.00	100.00

[1]One percent of mix added to the diet provides in ppm: Manganese, 5; iron, 5; copper, .5; cobalt, .005; iodine, .15; zinc, 5; and calcium, 4.5.

[2]One percent of mix added to the diet provides: A (551 I.U.), D (55.1 I.U.), riboflavin (.88 mg), pantothenic acid (2.65 mg), niacin (4.41 mg), choline chloride (8.82 mg), and vitamin B_{12} (1.98 mg).

The diets were similar in nutrient composition (Table 2) and the energy values expressed on the dry matter basis are equivalent in the diets. The BR milo diets contained slightly more than four times as much tannic acid as the corresponding NBR milo diets when unsupplemented with this substance. The addition of tannic acid and sulfate to the diets is reflected in the corresponding higher analytical values for these additives presented in Table 2.

RESULTS AND DISCUSSION—Data representing feed intake, weight gain and feed efficiency for the rats are shown in Table 3. During the first six weeks of the experiment, the rats fed either type of milo plus tannic acid had the least ($P<0.01$) growth of the various treatment groups. This lack of growth with added tannins to milo diets is similar to the results reported by Glick and Joslyn (1970a) when they fed purified diets containing 4% tannic acid to rats. Glick and Joslyn attributed lack of growth in animals fed their diets to decreased feed intake. Feed intake was not reduced when tannic acid was added to milo diets. The groups fed NBR and NBR plus sulfate diets were the most efficient in utilization of feed ($P<0.01$). Added tannic acid decreased ($P<0.01$) feed efficiency of both types of milo during the initial six weeks of feeding.

At the end of 10 weeks of feeding the diets, growth was no longer significantly affected by the treatment. This supports the conclusions of Glick and Joslyn (1970a) that older rats are less affected than young ones by tannins in their diets. After 10 weeks, the BR control dietary group ate more ($P< 0.01$) than rats fed any of the three NBR diets. With BR or NBR milo diets, added tannic acid did not depress growth or feed intake. Feed efficiency was decreased ($P<0.01$) in rats fed both BR and NBR diets that contained added tannic acid compared to those fed the NBR diets without tannic acid. The feed efficiency was only slightly less with tannic acid diets than with the BR diets without added tannic acid.

There was a slightly reduced conception rate with rats fed the BR plus tannic acid diet as shown in Table 4. Those animals that failed to conceive were sacrificed and none showed any gross physical abnormalities in their reproductive tracts. The large number of young born dead in the group fed the NBR plus sulfate diet was due to one dam that exhibited difficulty in parturition and her 13 offspring were born dead. The two groups fed added tannic acid in their diets weaned a lower ($P< 0.05$) percentage of their offspring than the two sulfate and NBR control groups. The tannic acid dietary groups weaned only slightly fewer offspring than the BR group. The added sulfate dietary groups had slightly greater weaning percentage and weaning weights of offspring than rats fed diets containing either type of milo without sulfate. There was no significant difference in weaning weight of any group due to dietary treatments.

SUMMARY—Sixty female rats were fed bird-resistant and non-bird-resistant types of milo each with or without added sulfate and tannic acid to determine the diets' effects on weight gain, feed efficiency and reproductive efficiency.

Added tannins had a depressing effect on weight gains of weaning rats

TABLE 2. Chemical and Energy Components of Diets, as Fed Basis.

	BR Control	NBR Control	BR + SO_4[1]	NBR + SO_4[1]	BR + T.A.[2]	NBR + T.A.[2]
Moisture, %	13.88	9.58	17.55	9.84	15.30	10.35
Protein, %	16.07	16.22	16.76	15.39	16.63	15.80
Ether Extract, %	0.70	1.60	0.82	1.79	0.66	1.86
Crude fiber, %	3.62	2.67	3.60	2.42	4.28	2.62
Ash, %	4.66	4.38	5.08	5.26	4.56	4.44
N.F.E., %[3]	61.07	65.55	56.19	65.30	58.45	64.93
Energy, in cal/g dry wt[4]	4333	4409	4536	4343	4314	4319
Tannic acid, %	2.2	0.4	2.3	0.5	5.1	3.5
Sulfur, %	.12	.10	.44	.35	.12	.12

[1]Sodium sulfate, 0.9% added.—[2]Tannic acid, 3% added, M.E. 1701.—[3]Nitrogen-Free-Extract.—[4]Gross energy of diets, oxygen adiabatic calorimeter.

TABLE 3. Feed Intake, Body Weight Gain, and Feed Efficiency of Rats.

Diet	Total Feed Intake g dry wt		Weight Gain g		Feed Efficiency g feed/g gain	
	6 wks.	10 wks.	6 wks.	10 wks.	6 wks.	10 wks.
BR control	504.2 + 35.3[a]	842 + 54[a]	115.8 + 16.7[ab]	149.6 + 23.3[a]	4.40 + 0.49[a]	5.72 + 0.69[ab]
NBR control	463.9 + 25.3[a]	758 + 37[b]	119.5 + 10.3[ab]	145.1 + 11.6[a]	3.98 + 0.30[b]	5.25 + 0.39[b]
BR + SO_4[2]	481.8 + 40.4[a]	793 + 79[ab]	110.0 + 13.7[ab]	138.4 + 19.1[a]	4.41 + 0.40[a]	5.75 + 0.52[ab]
NBR + SO_4[2]	467.4 + 42.2[a]	759 + 64[b]	117.0 + 17.3[a]	148.1 + 24.9[a]	3.95 + 0.36[b]	5.21 + 0.58[b]
BR + T.A.[3]	472.7 + 35.2[a]	804 + 67[ab]	100.3 + 9.2[ba]	132.0 + 12.9[a]	4.75 + 0.55[c]	6.13 + 0.65[a]
NBR + T.A.[3]	470.3 + 33.8[a]	778 + 61[b]	102.7 + 10.2[ba]	133.7 + 12.5[a]	4.63 + 0.61[c]	5.86 + 0.70[a]

[1]Values within columns with different superscript letters are significantly different, ($P < .01$).—[2]Sodium sulfate, 0.9%.—[3]Tannic acid, 3% added, M.W. 1701.

TABLE 4. Conception Rate, Number of Live and Still Births, Weaning Percentages and Weaning Weights.

Diets	No. Dams conceived	% Conception	Number born Alive	Number born Dead	% Weaned[1]	Av. weaning wt/rat
BR control	10	100	84	3	57.1 + 43.5[ab]	31.58 + 10.3[a]
NBR control	9	90	85	0	79.0 + 36.2[b]	30.36 + 3.1[a]
BR + SO_4[3]	9	90	79	1	86.0 + 16.4[b]	32.35 + 7.6[a]
NBR + SO_4[3]	8	88	65	13	87.0 + 15.4[b]	34.67 + 5.2[a]
BR + T.A.[4]	7	77	52	0	35.0 + 45.6[a]	26.08 + 8.4[a]
NBR + T.A.[4]	8	88	68	0	30.0 + 40.9[a]	23.18 + 2.8[a]

[1]Percent weaned calculated from number born alive.
[2]Values within columns with different superscript letters are significantly different, ($P < .05$).
[3]Sodium sulfate, 0.9% added.
[4]Tannic acid, 3% added, M.W. 1701.

through the first six weeks of growth but no effects were observed at the end of 10 weeks on the diets. Type of milo did not have a significant effect on growth. Those diets lowest in tannins always had the best feed efficiencies.

Adding tannins decreased the percentage of offspring weaned with both types of milo diets. Added sulfate to both types of milo had no statistically significant effect on weaning percentage and weaning weights of offspring.

Bird-resistant milo and non-bird-resistant milo diets gave equivalent rates of gain, but the non-bird-resistant milo diets resulted in greater feed efficiency.

LITERATURE CITED

A.O.A.C. 1970. Official Method of Analysis (9th Ed.). Association of Official Agricultural Chemist. Washington D.C.

BOOTH, A. N., D. J. ROBBINS AND F. DEEDS. 1961. Effect of dietary gallic acid and pyrogallol on choline requirement of rats. J. Nutr. 75: 104-105.

BURNS, R. E. 1963. Methods of tannin analysis for forage crop evaluation. Univ. Georgia Tech. Bull. N.S. 32: 5-7.

CHANG, S. I. AND H. L. FULLER. 1964. Effects of tannin content of grain sorghums on their feeding value for growing chicks. Poul. Sci. 43: 32-36.

DIXON, W. J. AND F. J. MASSEY. 1969. Introduction to Statistical Analysis. McGraw-Hill Book Co. New York.

GLICK, Z. AND M. A. JOSLYN. 1970a. Food intake depression and other metabolic effects of tannic acid in the rat. J. Nutr. 100:509-515.

GLICK, Z. AND M. A. JOSLYN. 1970b. Effect of tannic acid and related compounds on the absorption and utilization of proteins in the rat. J. Nutr. 100: 516-519.

HARRIS, H. B. AND R. E. BURNS. 1970. Influence of tannin content on preharvest seed germination in sorghum. Agron J. 62: 835-836.

_________, D. G. CUMMINS AND R. E. BURNS. 1970. Tannin content and digestibility of sorghum grain as influenced by bagging. Agron J. 62:633-636.

HAWK, P. B. AND O. BERGHEIM. 1943. Practical Physiological Chemistry. Blakiston Co. Philadelphia.

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MESENTERIAL FILAMENTS FROM *MANICINA AREOLATA* (LINN.)

Raymond K. Duros

Harza Engineering Company, 150 S. Wacker Drive, Chicago, Illinois 60606

Abstract: *Young rose corals were intentionally undernourished to ease dissection of mesenterial filaments. Two types of capsular nematocysts were found in the filament; the distal ones being cylindrical and the proximal ones being tapered with a prominent axial shaft at the thicker end. Functions of these holotrichs and microbasic p-mastigophorea are not clear although extension of mesenterial filaments may have a defense/sacrifice role.*

This report is based largely on a Student Research Project at the University of Miami. The subject matter involved developed from earlier observations in studies of the effect of sedimentation on corals. During these studies, the extrusion of many filaments was observed and microscopic examination revealed that tremendous numbers of capsules occurred in the filaments. The original objective was to identify these capsules as to whether they were living or non-living entities. This goal was accomplished readily, and it was then decided that an overall study of their relationship to the filaments and the rest of the coral would be of interest.

Materials and Methods—*Manicina areolata* (Linnaeus), the rose coral, specimens were collected from Harry Harris Park on Key Largo, Florida, from a depth of three ft. The corals ranged from 1.7 cm × 3.0 cm to 2.5 cm × 6.3 cm and had 2 to 14 stomodeae. Specimens of this size of this species must be considered young. They were kept in two aquaria, one at the University and one at the author's residence, along with a number of other invertebrates. The coral were fed frozen brine shrimp for the first week, and then this food was withheld and the corals were allowed to feed on whatever planktonic and other food materials were available in the aquaria. Of the four specimens in the University aquarium, three became undernourished within 3-4 weeks, while the remaining one was in good condition.

After extrusion from the corals, the filaments were obtained by cutting them off with a specially sharpened probe. The amputation was made as close to the coral as possible. Pieces of filament were kept alive for as long as 1.5 hrs by immersion in sea water. A micro-dissection kit was prepared by sharpening steel probes into pricks, knives, teasers and other tools. All observations were done on live preparations in sea water, unless otherwise noted. A dissecting scope was used to make gross observations at 10× and 20× of the coral and filaments, while a compound microscope was utilized to study wet mounts of the filaments and capsules. Relative measurements were made by noting units on the ocular micrometer together with the power at which the measurement was made for later size estimates.

Dissection of a healthy coral was very difficult to do correctly; the firm attachment of the coral polyp to its exoskeleton caused the polyp tissue to tear in most cases. It was found that if one starved the coral for three weeks or more, the dissection was much easier. While it is acknowledged that this procedure is somewhat drastic and may not be in keeping with the best principles of observation in the natural state, it was the best method found to get around the problem. Comparative observations on fresh, newly collected corals and those which had been kept in a starved condition showed no discernible differences in the mesentarial filaments.

Observations—When handled roughly or irritated strongly, such as by making an incision into the polyp, numerous white filaments could easily be seen to extrude from the coral. The filaments were white in color, were usually shaped similar to a shepherd's hooked staff, and had a variable length of as much as 507 mm and a diam of less than 1 mm (Fig. 1). At the tip of the hook and running down the shaft of the filament was a thin sheet of mesentery. These filaments extruded all over the coral polyp. On several occasions the filaments appeared exclusively around the periphery of the living polyps, but most of the time they appeared at random over the surface of the coral. In coral which had been starved, the filaments could clearly be seen on the interior of the coral. It was possible to look through the now-transparent polyp wall and observe them moving in the gastrovascular cavity. The mesenterial filaments moved considerable distances in the coral interior. Their movement toward the edge of the coral was notable in that the filaments moved between the ridges of the exoskeleton toward the periphery of the coral, but in more than one instance, it was seen that the filaments crossed the ridges (probably by way of holes in the septa of the coral). When the coral was injured by cutting the polyp, the extrusion of the filaments was not limited to the area of injury, but occurred on the whole coral. Extrusion of the filaments through the pharynx occurred on several occasions, but these instances were numerically insignificant.

On microscopic examination of these filaments, the filament shaft and the mesentery sheet could be seen. The filament exhibited three distinct regions at 100× (Fig. 1). Moving from the outside of the filament inward, the following areas could be seen: outermost was a dark brown area in which could be seen numerous capsular objects; the next region was light brown with a number of more or less spherical, dark reddish-brown, objects dispersed throughout; innermost was the mesenterial tissue in the form of a sheet approximately 3-4 times as wide as the filament shaft. The filament shaft, excluding the mesenterial sheet, was found to be single lobed, roughly cylindrical, and very highly ciliated over its entire surface. By gently pressing on the cover slip, it was determined that the capsules were covered by a layer of cells and a surface membrane. The membrane was demonstrated clearly by the fact that, on the local rupturing of this membrane, the capsules and other filament contents seeped out of the filament; when the mem-

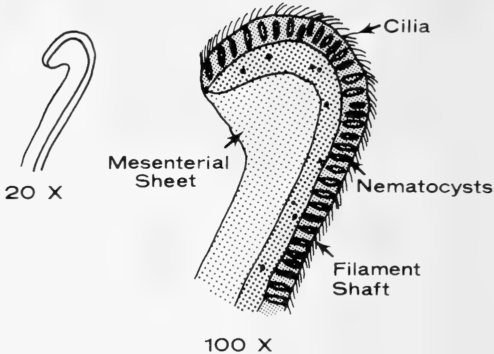

Figure 1

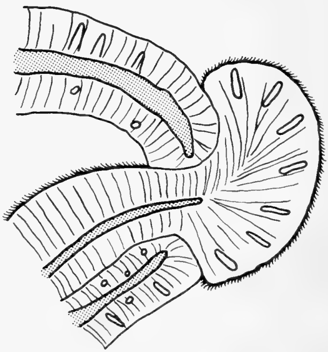

Figure 2

Fig. 1. Mesenterial filaments extruded from *Manicina areolata* (Linn.).

Fig. 2. Mesenterial filament extruding through the body wall of a stony coral. (from Duerden, 1902).

brane was intact, the contents remained in place. The squashed filament released the capsules from the filament and they could be seen clearly.

The capsules were of two types (Fig. 3). Most capsules seen in the upper filament and hook were cylindrical with some slightly bent, ca. $105 \times 20\mu$ ($30U \times 6U$ @ $400\times$). A long tube was coiled about the inner wall of the capsule. Coiling was present in capsules both inside and outside the filament. At one end of the capsule the tube was attached to the capsule wall. There seemed to be a "cap" at this same end. No movement of the capsules was observed except when the tube was seen to be extruded suddenly or discharged from the capsule. This happened often. After this occurred, the capsule appeared empty and the tube extended outside the capsule ca. 1750μ (500U@ $400\times$), and its proximal diameter was slightly greater than the tip which was ca. 3.5μ. Its path was usually a straight line, but in several cases it took a long, wide arch. When it hit a solid object, it recocheted off. Close microscopic examination showed a tube with a single helix in or on the tube. Both tube and helix were difficult to see precisely, because they consisted of a number of "bumps." In the undischarged capsules, the tubes were smooth. The author was able to observe and follow the elongation of these tubes in some cases and found that, as the tube lengthened, the distal portion was darker than the proximal part, and as the tube got longer, the dark area decreased in length until it vanished, reminiscent of some type of evagination.

Another type of capsule could be seen in several sections of filament other than the tip. This type was not visible in most of the tip sections, but occurred in large numbers in sections farther down the filament. In those sections of the tip where this type of capsule did occur, it was only 1/50th of the number of capsules described above. In the second capsule's charged state, the capsule was slightly tapered at one end and slightly shorter than the previously described capsule. Its most noticeable characteristic was a prominent axial shaft at the thicker end of the capsule. In its discharged configuration, there was a proximal tube of ca. 3.5μ which suddenly diminished or thinned into a thread. The tube was 1-2 $\times$ as long as the capsule and had "hair"-type projections giving it a bushy appearance. The overall assemblage may reach ca. 875μ (250 U @ $400\times$). Both capsules are shown in Fig. 3 in both charged and discharged configurations.

Discussion—Much has been written on coelenterate physiology in recent years, but it seems that the Madreporarian, or stony corals, may be a "poor cousin" next to the hydras and sea anemones, as far as research is concerned. Much detailed and impressive work, volumes of papers on observations at the electron microscopic level, has been done on the hydras and sea anemones, while few modern scientists have studied stony corals. Since the early decades of this century when Yonge (1930), Duerden (1902), and Vaughan and Wells (1943) contributed studies in this field, there has been a noticeable lack of interest in direct, intensive study of corals. The reasons include: ease of raising sea anemones, simple anatomy, and the ease of obtaining relatively pure tissue samples, to name a few. However much is known about hydras

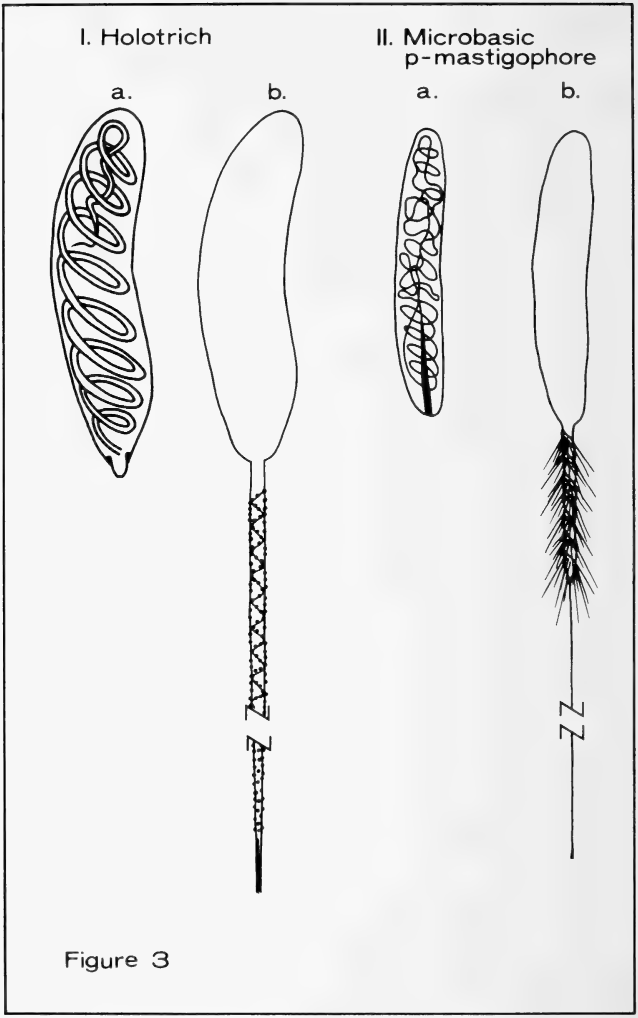

Fig. 3. Two nematocysts found in mesenterial filaments of *Manicina areolata* (Linn.). a—charged, b—discharged, configurations.

and sea anemones; it is imperative to determine whether those facts apply to other coelenterates. While filament extrusion in corals is adequately covered in the literature, most data on the capsules must be drawn from published material based on hydras and sea anemones.

Filament Extrusion: That the extruding filaments are indeed mesenterial filaments is quite clear from careful observation of the extruded filament and tracing it back to its origin. This origin was a complex, convoluted mass of mesentery filaments. The mesentery could be seen to be attached to the filaments, and the mesentery sheet could be seen along the entire extruded filament. The appearance of this sheet is significant in that it separates these filaments from very similar structures, acontia, which occur in the order Actinaria, the sea anemones. Another distinctive feature separating these two structures is that the acontia, in most Actinarians, is trilobed, while the mesenterial filament has but a single median lobe (Duerden, 1902). Otherwise, the two appear to be similar in function and structure. Yonge (1930) found that mesenterial filaments constitute the digestive organs of the Madreporian corals and that the acontia, together with the true mesenterial filaments of which the acontia are extensions (in Actinarians) serve the same functions.

Extrusion of mesenterial filaments has been observed in various species for some time. Duerden described the same reaction as that given in this paper when he handled the specimen roughly or strongly irritated it. He found that this reaction occurs more severely in fissiparous genera than in those genera reproduced by gemmation, but he contended that this reaction happens in most coral to a greater or lesser degree.

Yonge (1930), in his report on the Great Barrier Reef Expedition of 1928-29, reported that natural extrusion of mesenterial filaments occurs in a number of species. He put forward a hypothesis that mesenterial filaments are freely extruded in certain genera, including the meandrines, of which *Manicina* is a member, where the power of expansion of the polyp above the exoskeleton is limited or where the food is too large to be swallowed at once. In this latter case, digestion and absorption occur, either wholly or in part, extracellularly. Yonge also quoted Vaughan on *Manicina gyrosa*, which is found in the Tortugas, as having mesenterial filaments extruding outside the tentacular rows.

From the present study, it is difficult to shed any further light on the purpose, if any, of filament extrusion. There are various explanations of this extrusion when the coral is irritated. One possibility is that the reaction is defensive in nature, for the filaments are packed with nematocysts and give some sort of protection to the polyp. This hypothesis is questionable, however, in that these nematocysts seem to affect small organisms, but have little if any effect on an animal of any significant size. Marine angelfish and butterfly fish, for example, relish rose coral and eat the whole polyp including tentacles and filaments (Straughan, 1970). Hegner and Engeman (1968) give defense as a probable function of the acontia in sea anemones so this may be the case here to some degree.

A second possibility is that perhaps the filaments are extruded so that whatever is disturbing the polyp will take the filaments and leave the rest of the polyp alone. Sacrifice of parts, even limbs, to deter or satisfy an enemy is widespread in the animal kingdom. This may be another instance of it.

The question of whether or not there are special pores or sites through which the mesenterial filaments extrude is in doubt. In sea anemones, the acontia may extrude through the mouth or through special pores in the body wall, known as cniclides (Duerden, 1902; Pratt, 1935; Vaughan and Wells, 1943). The mesenterial filaments in coral have been seen to project out of the mouth during feeding, but also may project through any part of the body (Fig. 2). In this study, the latter case occurred 50 times more often than the former. Do special pores exist in the Madreporaria, similar to those that are found in sea anemones? Duerden is of the opinion that no cniclides are present, as such, in the stony corals, but that they make their own opening in the body wall, which may remain open for some time after the filaments have withdrawn into the coral, but which eventually disappear (Fig. 2). The author could find no definite structures like cniclides in the rose coral while using a dissecting scope and observing the extrusion of a number of the filaments. It did appear, however, that the filaments extruded in certain light areas. The possibility that these pinpoint areas were physical pores deserves more study.

Capsule Classification: It was clearly and definitely established early in the observations that the capsules appearing so prominently in the filaments were nematocysts, which are known to occur in both actinarian acontia (Blanquet and Lenhoff, 1966) and madreporarian mesenterial filaments. After establishing this fact, the next task was to classify them. Many classification schemes have been proposed. The works of Weill and of Carlgren (using modifications of Weill) have been used most frequently (Lenhoff and Loomis, 1961). These schemes have been re-evaluated by several people, including Cutress (1955). The author used the scheme by Cutress, for it appears to be the best one available. Cadet Hand and several others, for various reasons, disagree with Cutress in his classification categories, but even Hand admits to a lack of knowledge in this area and to the possibility that further studies on the nematocysts, particularly at the level of the electron microscope, may support Cutress' contentions (Lenhoff and Loomis, 1961).

In any case, using Cutress' classification scheme readily showed that the first nematocyst was a holotrich, while the second was a microbasic p-mastigophore (Fig. 3). These classifications were made on the following points. The holotrich nematocyst, in its charged state, had its tube loosely coiled within the capsule; no part of the tube was straight, denoting equal diameter in the tube. In its discharged state, the tube was of more or less uniform diameter, and armature (the beads) appeared along its entire length.

The microbasic p-mastigophore had a tube which suddenly turned into a distal thread and bore armature for less than 3 × the length of the capsule.

In its undischarged state, the proximal shaft in the discharged state appeared as a rod at one end, and the thread lay in many coils at the opposite end.

The importance of nematocysts (or cnidae) as to the classification of the coelenterates is rapidly becoming recognized. Cutress (1955) stated that when "the cnidom is well known for all species of a genus or family, it is frequently found that the distribution together with the morphological characteristics of the cnidae is also diagnostic of the genus and family." Hand is more determined when he states, "Many coelenterates can be positively identified by their nematocysts alone (Lenhoff and Loomis, 1961)." Such an important tool would help taxonomists immeasurably. There are still many problems to be worked out, however. Certain nematocysts may occur in general regions of the organism (such as in both ectoderm and endoderm), while others are restricted to certain areas, regions or organs (spirocysts occur only in ectoderm). Size is unimportant to the classification of nematocysts, for giants and dwarfs occur in many organs and tissues. The age of the organism affects both the size of the nematocysts and the type of nematocysts present (Cutress, 1955). A quest to "map" the nematocyst distribution in organisms of a single genus or family would present immense problems but be of great value.

The traditional functions ascribed to nematocysts have been those of adhering, entangling, penetrating and, more recently, defending (at least in holotrichs of hydras) (Lenhoff and Loomis, 1961). Today it is not possible to assign a definite function to a type of nematocyst. An exception is the desmoneme or volvent nematocyst, which is pear-shaped and whose tube is short and thick; when discharged, the tube forms tight coils used to entangle prey. The functions ascribed to other nematocysts must be viewed with skepticism. While holotrichous and atrichous isorhizas (both with uniform tube diameter and an entirely armatured tube, and without armature, respectively) have been thought of as being glutanants, Zick, in 1929, showed the penetrating action of holotrichous isorhizas (Chapman and Tilney, 1959), and Barrington (1967) stated that both are probably concerned with injection of a poison. At this point, it is not possible to definitely identify the function of this nematocyst.

Our study reaffirms a number of previous findings. Robson's (1953) description of holotrichous isorhizas taken from *Corynactis* states that upon discharge, the nematocyst appears as follows: 1) a transparent ellipsoidal capsule, slightly tapered at one end (as we found); 2) a slightly tapered shaft of relatively great length (same results); and 3) a shaft bearing three clockwise spirals of barbs equidistant from one another. In observing the tube on the holotrichous nematocyst, I described it as being a tube with a single helix running on it. Upon closer examination, it was seen that there was more than one spiral, but the exact number could not be determined due to the difficulty of resolving these helices. Excellent pictures of nematocysts and tubes similar to the ones found in this study may be seen in papers by Robson (1953) and Picken (1953) using both ocular and electron microscopic plates.

Robson mentions a lack of armature on the tube near the base and at the distal tip. The absence of it near the base was observable, but the condition at the tip was not observable with available facilities, during the present study.

The existence of a continuous layer of protoplasm, which is highly ciliated on the outside of the filament, as reported here, coincides with Yanagita and Wada's (1959) findings on acontia in *Diadumene luciae,* a sea anemone. From this appearance it is doubtful that the nematocysts are ever inserted simply between epithelial cells and are directly exposed to the environment per se, in *Manicina areolata.*

SUMMARY—An objective of this study was to determine the identity of capsules appearing in the mesenterial filaments of the rose coral, *Manicina areolata* (Linneaus). The capsules were found to be two types of nematocysts, holotrichs and microbasic p-mastigophores. In addition to this, the function of extrusion of mesenterial filaments from the coral was postulated as having a possible defense/sacrifice purpose. For both mesentery filaments and nematocysts, observational data was supplemented by a brief literature survey of that topic, concentrating on pertinent points.

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LITERATURE CITED

BARRINGTON, E. J. 1967. Invertebrate Structure and Function. Houghton Mifflin. Boston.

BLANQUET, R. AND H. M. LENHOFF. 1966. A disulfide-linked collagenous protein of nematocyst capsules. Science. 154: 152-153.

CHAPMAN, G. B., AND L. G. TILNEY. 1959. Cytological studies of the nematocysts of hydra. I. Desmonemes, isorhizas, onidocils and supporting structures. J. Biophysic. Biochem. Cytol. 5: 69-78.

CUTRESS, C. 1955. An interpretation of the structure and distribution of cnidae in the Anthozoa. Systematic Zool. 4: 120-137.

DUERDEN, J. E. 1902. West Indian Madreporarian polyps. Mem. Nat. Acad. Sci. (U.S.A.) 8: 398-648.

HEGNER, R. W., AND J. G. ENGEMANN. 1968. Invertebrate Zoology. 2nd Ed. Macmillan. New York.

LENHOFF, H. M., AND W. F. LOOMIS. 1961. The Biology of the Hydra and Some Other Coelenterates. University of Miami Press. Coral Gables, Florida.

PICKEN, L. E. R. 1953. A note on the nematocysts of *Corynactis viridis.* Quart. J. Micros. Sci. 94: 203-227.

PRATT, H. S. 1935. Manual of the Common Invertebrate Animals. McGraw Hill Book Co., Inc. New York.

ROBSON, E. A. 1953. Nematocysts of *Corynactis*: the activity of the filament during discharge. Quart. J. Micros. Sci. 94: 229-235.

STRAUGHAN, R. P. L. 1970. The Salt Water Aquarium in the Home. 2nd Ed. A. S. Barnes and Co. New York.

VAUGHAN, T. W., AND J. W. WELLS. 1943. Revision of the suborders families and genera of the scleractina. Geol. Soc. Amer. Spec. Pap. pp. 42-44.

YANAGITA, T. M., AND T. WADA. 1959. Physiological mechanisms of nematocyst responses in sea-anemone VI. A note on the microscopical structure of acontium, with special reference to the situation of cnidae within its surface. Cytologia. 24: 81-97.

YONGE, C. M. 1930. Feeding mechanisms and food. Great Barrier Reef Exped. 1928-29, Sci. Rpt. 1:30 + 53-55; Assimilation and excretion. loc. cit. 1:90.

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EGG-BEARING IN THE TROGLOBITIC CRAYFISH, *PROCAMBARUS PALLIDUS* (HOBBS)

KENNETH RELYEA AND BRUCE SUTTON

Department of Biology, Jacksonville University, Jacksonville, Florida 32211

ABSTRACT: *Approximately 130 ca. 2 mm white eggs were encased in glair which cleared within 24 hr revealing egg attachment to the pleopods. Egg-bearing cave-dwelling crayfish have not been previously observed in Florida.*

EGG-BEARING has never been recorded in the literature for Florida troglobitic crayfishes, to the best of our knowledge. We report here on a female *Procambarus pallidus*, collected in November 1971 from Squirrel Chimney, Alachua County, Florida, which bore eggs after nearly 4 months of aquarium existence (Fig. 1).

Eggs were released on 2 March 1972, or late 1 March 1972. The eggs were white, approximately 2 mm in diam, and, as in epigean members of the family, were initially encased in a single gelatinous mass, "glair", which degenerated within 24 hours. At first the female kept the abdomen tightly curled around the egg mass.

After degeneration of the glair, it was apparent that the eggs were individually attached to the pleopods. Attempts were then made to count the eggs without disturbing the female. The first pleopods bore about 5 eggs each. These were very difficult to see due to their position. The second and fifth pleopods bore about 10 eggs each, and the third and fourth approximately 20 eggs each—a total clutch of approximately 130 eggs. Most of the egg mass was aborted on 7 March 1972, and the crayfish was preserved, (Jacksonville University, catalogue no. 11-C). Thirty eggs were recovered from the aquarium, and 40 remained attached to the pleopods of the female by slender stalks. Because we failed to recover more eggs from the aquarium, we believe that the original estimate of 130 eggs may be slightly high.

Throughout our observations we suspected that the eggs were not fertile (which appears to have been the case), but could not overlook the possibility of sperm retention for extended periods in the troglobitic crayfishes. In this case, the period of sperm retention would have been nearly 4 months. We considered this unlikely, but nothing is known about the reproductive cycle of this species, or of any other troglobitic member of this genus.

The large number of eggs was surprising to us. Most troglobites tend to produce fewer eggs than epigean forms (Poulson and White, 1969). Jegla (1969) reported an average of 45 eggs for 4 females *Orconectes inermis* from Indiana. The number that we observed is not necessarily indicative of natural conditions, since the female was well fed in the aquarium. A lesser number

Fig. 1. Procambrus pallidus, ovigerous female.

might, therefore, be expected in nature, although the original habitat probably represents a subterranean ecosystem with considerable energy input from the surface.

We suspect that the late winter and early spring months may encompass the time of maximum egg-laying and hatching of young for Florida cavernicolous crayfishes, but ovigerous females might occur at any time of the year as in *Orconectes inermis* (Jegla, 1966). Although no ovigerous females are recorded in the literature, our field studies suggest that the young abandon the mother during January through May or perhaps June. This coincides with periods of rising water and high water in Florida subterranean systems, and would afford a maximum opportunity for the dispersal of the young. We have also noted a high rate of copulatory activity (in an aquarium) for an undescribed Florida troglobitic *Procambarus* during late winter and early spring.

Observations on *Orconectes inermis* by Jegla (1966;1969) and Jegla and Poulson (1970) from caves in Indiana and Kentucky are similar to our less extensive observations for *Procambarus pallidus*. The time of egg laying and carrying for *Orconectes inermis* appears to be slightly later in spring and summer months with eggs being hatched during summer and fall (Jegla, 1966). Indications are that *Orconectes* carries the eggs for 2 to 3 months (Jegla and Poulson, 1970). The period of egg carrying in *Procambarus pallidus* may be considerably shortened by higher water temperatures in the Florida subterranean aquatic systems, such as in Squirrel Chimney, which are constantly 21°-22° C as compared to 12°-13° C for Shiloh Cave, Indiana (Jegla, 1966). Our suggestion that egg bearing and release of young in *P. pallidus* may coincide with periods of high water is similar to that of Jegla

(1966) and Jegla and Poulson (1970). The observation by Jegla (1966) that not all adult female *Orconectes* lay eggs each season probably applies to Florida troglobitic crayfishes and deserves further study with respect to energy availability and population densities.

We extend our appreciation for many helpful suggestions and a review of this manuscript to Dr. Horton H. Hobbs, Jr., USNM.

LITERATURE CITED

JEGLA, T. C. 1966. Reproductive and molting cycles in cave crayfish. Biol. Bull. 130:345-358.

———. 1969. Cave crayfish: annual periods of molting and reproduction. Proc. 4th (1965) Internat. Congr. Speleol. Yugoslavia 4-5:135-137.

———, AND T. L. POULSON. 1970. Circannian rhythms—I. reproduction in the cave crayfish *Orconectes pellucidus inermis*. Comp. Biochem. Physiol. 33:347-355.

POULSON, T. L. AND W. B. WHITE. 1969. The cave environment. Science 165:971-981.

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Biological Sciences

A NEW SPECIES OF BRITTLE STAR FROM FLORIDA

ROBERT L. SINGLETARY

Biology Department, University of Bridgeport, Bridgeport, Connecticut 06602

ABSTRACT: Ophiactis rubropoda, *sp. nov., is distinguished by having six arms, one pair of oral papillae, 4-5 arm spines, transversely ellipsoid arm plates, disk spinelets in some specimens, and a red pigment in the water vascular system.*

IN 1968 Dr. Lowell Thomas introduced the author to a population of brittle stars that inhabited the pilings of the dock at the University of Miami's Rosenstiel School of Marine and Atmospheric Science. The brittle stars are unlike any previously reported in the western Atlantic. Their most distinctive feature is the red color of their tube feet. The color is imparted by a pigment in the water vascular system, which has yet to be analyzed. The brittle stars belong to the genus *Ophiactis,* family Ophiactidae and represent a new species.

The author wishes to thank Dr. Lowell Thomas of the Rosenstiel School of Marine and Atmospheric Science, Maureen Downey of the U.S. National Museum, and Ailsa Clark of the British Museum (Natural History).

Ophiactis rubropoda, new species, Fig. 1-4.

MATERIAL STUDIED—*Holotype*:-1 spec., disk diameter 5mm: Virginia Key, Florida; May 4, 1968; USNM E-11422. *Paratypes*:- 94 spec., Virginia Key, Florida; May 4, 1968; USNM E-11423. - 26 spec., Virginia Key, Florida; March 3, 1970; UMML 41.235.

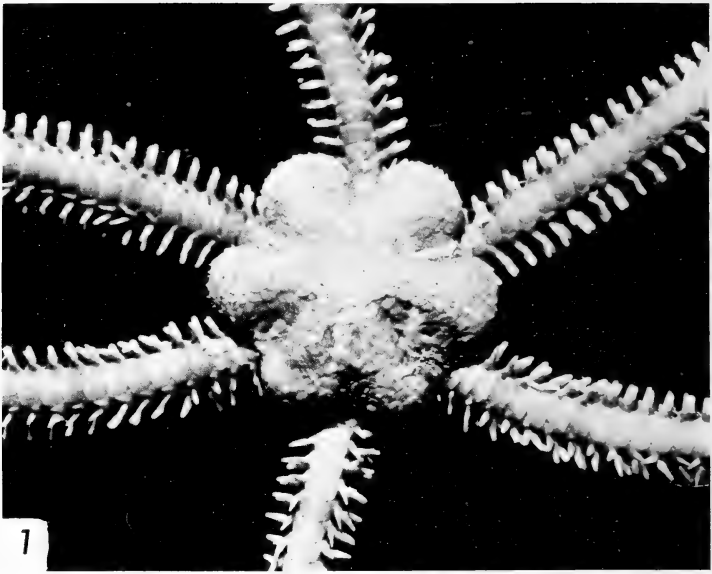


Fig. 1. *Ophiactis rubropoda,* Holotype. Aboral surface, disk diam 5 mm.

DIAGNOSIS—Six arms; one pair of oral papillae; arm spines four or five; upper arm plates transversely ellipsoid; disk spinelets, when present, in interbrachial areas and below, but not on the dorsal surface; tube feet of living specimens contain a red fluid.

DESCRIPTION—The aboral disk covering consists of oval or circular overlapping scales. The radial shields are small, being only slightly larger than the largest disk scales. The two radial shields of each pair are separated from each other by a single row of disk scales. The interbrachial scales on the underside are small, and lacking towards the mouth in sexually mature specimens. Scales along the edge and underside of the disk may have spinelets.

There are six short slender arms. The upper arm plates have evenly rounded margins and adjoining plates are in broad contact. Distal plates are much smaller and triangular with the proximal side having a truncated point.

Arm spines are five proximally in large specimens and four proximally in small specimens, declining in number in the distal segments. The uppermost spine is the smallest, the second from the top and the bottom spines are slightly larger, and the remaining two spines are the largest, equalling about half the width of the arm. The spines are short and blunt with swollen bases.

Underarm plates are octagonal, with the proximal and lateral sides being somewhat concave and the distal side being somewhat convex. The tentacle scales are single, large, and oval.

Oral shields are variable. In some specimens they are diamond shaped, wider than long; in others they are rounded proximally, pointed distally, and longer than wide. The adoral plates of adults are large, barely touching interradially and touching or even imbricate radially. In juveniles, the plates barely touch if at all, both radially and interradially. Each jaw bears a single pair of papillae which are longer than wide.

Color is gray-green, with the small specimens tending toward green and larger specimens toward gray. The arms have alternating light and dark transverse bands. In specimens with regenerating parts, the new portions tend to be much lighter in color than the older portions. In living specimens, the coelomic fluid in the tube feet has a red pigment which is visible in all but the smallest specimens.

Distribution: Biscayne Bay, Florida.

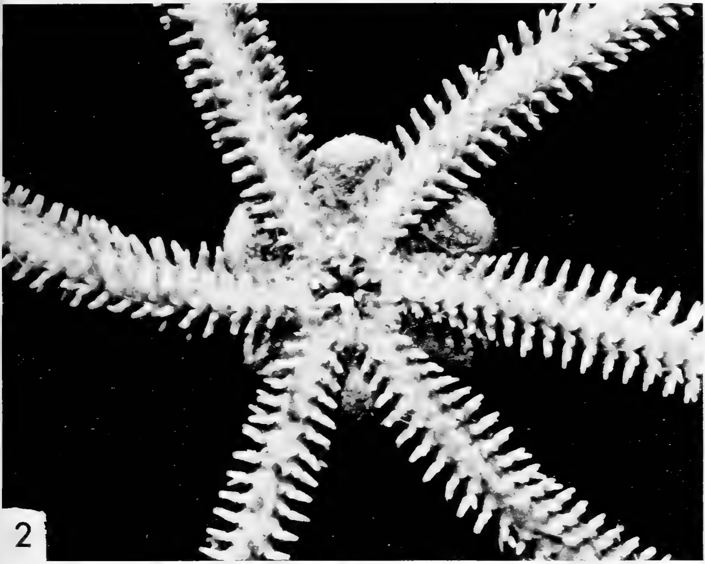
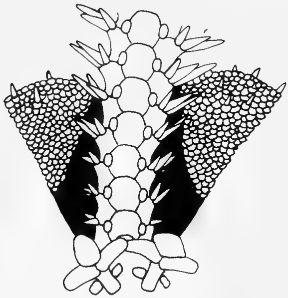


Fig. 2. *Ophiactis rubropoda*, Holotype. Oral surface.

DISCUSSION—Only two other species of *Ophiactis* are reported to have a red pigment in the coelomic fluid, *O. virens* and *O. arenosa*, but *O. rubropoda* does not closely resemble either of these. Foettinger (1880) reported that coelomocytes of *O. virens* contained hemoglobin. However, Preyer (Winterstein, 1921) questioned this observation. MacGinitie and MacGinitie (1968) report a bright red pigment in *O. arenosa* but do not know if it is dissolved in the fluid or found in coelomocytes.

Ophiactis rubropoda most nearly resembles *O. mulleri* Lütken, 1856, and *O. luetkeni* Marktanner-Turneretscher, 1887. It differs from the former by having one instead of two oral papillae on each side of the jaw, much smaller disk scales, and disk spinelets on some specimens; *O. mulleri* is not reported to have any disk spinelets; *O. papillosa* differs from *O. luetkeni* by having six instead of five arms, short pointed disk spinelets rather than long, blunted spinelets, and oral shields of variable shape instead of only diamond shaped shields which are wider than long. Fragmentation is very common in *O. rubropoda*; 131 out of 135 specimens examined were in the process of regenerating new arms and portions of the disk. All but one of the regenerating



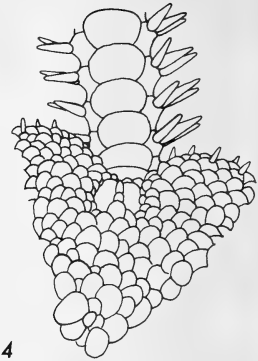


Fig. 3-4. *Ophiactis rubropoda*, part of the disk and the base of the arm—3. oral view; 4. aboral view.

specimens had six arms; it had five arms. Clark (1955) reports that of 129 specimens of *O. luetkeni* she examined, only one was regenerating and it had five arms. Except for *O. mulleri, O. rubropoda* bears little similarity to other west Atlantic species. It appears to be most closely related to those species such as *O. luetkeni, O. lymani,* and *O. notabilis* which have only one oral papilla on each side of the jaw.

LITERATURE CITED

Clark, A. M. 1955. Echinodermata of the Gold Coast. J. West African Sci. Assoc. 1: 16-56.

Foettinger, A. 1880. Sur l'existence de l'hémoglobine chez les échinodermes. Archs. Biol. Paris. 1: 405-415.

Lutken, C. F. 1856. Oversigt over de Vestindiske Ophiurer. Vidensk. Meddel. Dansk. Naturh. Foren Kjøbenharn 8: 1-26.

MacGinitie, G. E., and N. MacGinitie. 1968. Natural History of Marine Animals. 2nd ed. McGraw-Hill, New York.

Marktanner-Turneretscher, G. 1887. Beschreibung neuer Ophiuriden und Bemerkungen zu bekannten. Ann. naturh. (Mus.) Hofmus. Wien. 2: 291-316.

Winterstein, H. 1921. Handbuch der Vergleichenden Physiologie. Vol. 1, Pt. 2. G. Fischer. Jena.

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OCHLOCKONEE RIVER FISHES: SALINITY-TEMPERATURE EFFECTS[1]

Patrick R. Parrish and Ralph W. Yerger
Bionomics Marine Laboratory, Route 6, Box 1002, Pensacola, Florida 32507

Abstract: *In 1968, 38 marine and freshwater fishes were taken over several months under different conditions of salinity and temperature. The degree of influence of these factors depended upon the species and constancy of salinity and temperature.*

Research relating the effects of salinity and temperature to the occurrence and distribution of fishes is relatively new. Many records of fish collections from estuarine areas along the Atlantic and Gulf coasts are available, but usually only the more recent include hydrographic data. At the time of this study, no ichthyological work from the lower Ochlockonee River had been published, although Joseph and Yerger (1956) compiled a list of the fishes of Alligator Harbor, a more saline body of water a few km southeast of the study area (Fig. 1). Joseph and Yerger reported monthly average salinities and temperatures, but did not relate them to the occurrence of specific fishes.

This study was conducted to relate the seasonal occurrence of marine and freshwater fishes to salinity and temperature in the lower Ochlockonee River, Florida. The stretch of river studied is part of an estuarine zone, as defined by Smith (1966). We recognize that such areas are vitally important to the young of numerous marine fishes as nursery grounds. Therefore a secondary purpose of the study was to provide data to aid in future evaluations of the effects of natural and man-made changes in the river.

The Ochlockonee River originates in southwestern Georgia near Albany, and terminates its winding, marsh-enclosed lower course about 56 km south-southwest of Tallahassee, Florida, where it flows into shallow Apalachee Bay, in the northern Gulf of Mexico. The gradient of the river is gradual from the Lake Talquin dam, 60 km inland, to the mouth (Haley, 1956). As a result, tidal influence extends more than 14 km upstream. The influx of tidal waters causes salinity stratification; "wedges" of denser salt water underlie less dense, fresher water. Salinity stratification is a common occurrence in lower reaches of rivers (Bailey, Winn, and Smith, 1954; Tagatz, 1968). In the Ochlockonee, this condition is most distinct when both ebb and flood tides are comparatively high.

The section of river studied is from 150 to 300 m wide and 0.3 to 10 m deep. The current is usually sluggish, becoming moderate during strong tides. The water is turbid, generally light brown, and bottom visibility is usually less than 1 m. Marsh vegetation grows to the edge of the river and is partially

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[1]This paper is based on a thesis submitted by the senior author to the Department of Biological Science, FSU, in partial fulfillment of the requirement for the degree of Master of Science.

flooded during high tides. Except for a few patches of filamentous green algae in deep channels, the river is free of living vegetation. Shoals opposite the main channel have soft mud bottoms and are usually shallow. Deeper channels have a hard bottom which is often covered with woody debris.

The surrounding marsh is typical of that found along the Gulf side of the northern half of Florida. Plant zonation is distinct in these northwest Florida

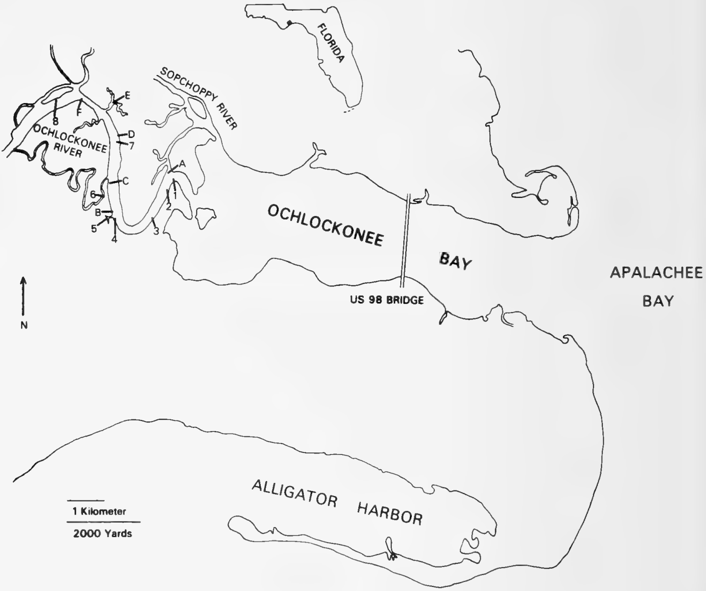

Fig. 1. Study area in the lower Ochlockonee River. Stations 1-8 were sampled by trawl; stations A-F, by seine.

marshes (Kurz and Wagner, 1957). *Juncus* sp. and *Spartina* sp. are prevalent where salt water flooding is common, but in the surrounding low flatwoods above the action of tidal waters, slash-pine, saw-palmetto, wax-myrtle, and wire-grass are dominant.

The river and marsh support a varied fauna other than fishes. Certain invertebrates and vertebrates are among the most conspicuous elements in this area. The bivalve, *Rangia cuneata*, was common throughout the soft mudflats. Amphipods, *Corophium tuberculatum* and *Gammarus* sp., were abundant in the river, particularly in late spring and early summer. Representatives of seven species of decapods were collected: *Penaeus aztecus, P. setiferus, Palaemonetes* sp., *Callinectes sapidus, Rhithropanopeus harrisii, Uca* *minax*, and *U. pugnax*. Among the vertebrates, small alligators were observed, as were numerous birds of the orders Anseriformes, Falconiformes, Ciconiiformes, Columbiformes, and Passeriformes. Turtles were common in the river, and *Pseudemys* sp. and *Macrochelys temmincki* were captured by trawl. Raccoons were seen feeding on the mudflats at low tide. Bottlenosed dolphins were fairly common as far upstream as station F.

METHODS—Twenty-three collections were made at 14 stations from January through October 1968. Sampling was biweekly, at random hours and tidal stages. Eight stations, 2 to 10 m deep, were sampled by trawl, and six stations from 0.3 to 2 m deep were sampled by seines (Fig. 1). Three different habitat types were included in the sampling—deep channels, tidal sloughs, and mudflats. A 12-ft bottom trawl of 3/4-in square mesh was used regularly. Three seines were used at different times: 10×4-ft minnow seine, 3/16-in square mesh; 30×5-ft bag seine, 3/8-in square mesh; and 100×10-ft haul seine, 5/8-in square mesh.

We preserved, stored and measured specimens as described by Hubbs and Lagler (1958). Measurements were made with dividers and a measuring board. Standard lengths are given in mm for all fishes except *Dasyatis sabina*, for which disc width is given. Representative samples of fishes collected are deposited in the Florida State University Fish Collection, Tallahassee, Florida.

Water samples for salinity determinations were taken from the bottom with a Van Dorn water sampler and from the surface with a hand-held bottle. Salinities (parts per thousand, ‰) were determined by means of Greiner hydrometers corrected for temperature. Accuracy of the hydrometers was checked by titrating water samples with silver nitrate. Both low and midrange hydrometers were correct to within 0.1% of the titrated value. The lower limit of the hydrographic tables used was 1.8‰, and in a few instances, minimum salinity was less than 1.8‰. Temperatures were taken with a mercury thermometer graduated in whole degrees Celsius (°C).

RESULTS—Fishes of 38 species from 33 genera and 23 families were collected or sighted. The following list is a taxonomic grouping of these fishes and includes stations at which each was taken, ranges in salinity (Sal), temperature when collected, month taken, number of specimens, and range of lengths. (Salinities less than 1.8‰ are designated by an asterisk.) The nomenclature for fishes follows that of Bailey et al. (1970).

Family DASYATIDAE

Dasyatis sabina (Lesueur), Atlantic stingray. Sta: 1, 3, 4, 7, 8, C, F. Sal 2.5-14.0‰, temp 26.0-30.5C. Spec: *May* 4, 175-247mm; *June* 1, 245mm; *July* 1, 180mm; *Aug.* 3, 230-310 mm; *Sep.* 1, 248mm. [Note: read "*May* 4" to mean "in *May*, 4 specimens were taken," etc.]

Family LEPISOSTEIDAE

Lepisosteus osseus (Linnaeus), longnose gar. Sta: 1, 4, C. Sal 1.9-17.8‰, temp 12.5-30.8C. Spec: *Feb.* 1, 343mm; *May* 5, 549-827mm; *June* 2, 692-1018mm; *Aug.* 3, 420-512mm.

Family ELOPIDAE

Megalops atlantica Valenciennes, tarpon. None captured, but one sighted *25 July* at Station 1.

Family Clupeidae

Brevoortia patronus Goode, Gulf menhaden. Sta: 2, 3, 5, A, B, C, F. Sal 2.5-15.5‰, temp 13.2-30.5C. Spec: *Feb.* 3, 25-26mm; *Apr.* 79, 21-31mm; *May* 67, 27-33mm; *June* 144, 28-46mm.

Dorosoma petenense (Günther), threadfin shad. Sta: F. Spec: *June* 1, 50mm.

Family Engraulidae

Anchoa mitchilli (Valenciennes), bay anchovy. Sta: A, E, F. Sal 2.2-15.5‰, temp 27.5-30.5C. Spec: *May* 26, 22-55mm; *June* 2, 44-51mm; *July* 56, 20-29mm.

Family Synodontidae

Synodus foetens (Linnaeus), inshore lizardfish. Sta: A, C. Sal 11.2-15.5‰, temp 27.5-28.0C. Spec: *May* 9, 48-51mm.

Family Ictaluridae

Ictalurus catus (Linnaeus), white catfish. Sta: 1, 2, 3, 4, 6, 8. Sal 1.9-8.2‰, temp 12.5-30.4C. Spec: *Feb.* 29, 71-170mm; *Mar.* 9, 98-204mm; *Apr.* 10, 100-200mm; *July* 1, 155mm; *Aug.* 1, 128mm; *Sep.* 1, 125mm; *Oct.* 1, 147mm.

Ictalurus punctatus (Rafinesque), channel catfish. Sta: 7, 8. Sal 1.8-3.1‰, temp 25.3-30.0C. Spec: *July* 3, 126-233mm; *Aug.* 3, 127-204mm; *Oct.* 1, 235mm.

Family Ariidae

Arius felis (Linnaeus), sea catfish. Sta: 2, 3, 4, 7, 8, C. Sal 2.3-18.7‰, temp 22.9-30.1C. Spec: *Apr.* 1, 137mm; *May* 4, 153-288mm; *June* 1, 181mm; *Aug.* 2, 243-290mm; *Sep.* 1, 234mm.

Bagre marinus (Mitchill), gafftopsail catfish. Sta: 3. Sal 6.5‰, temp 29.4C. Spec: *Aug.* 1, 337mm.

Family Belonidae

Strongylura marina (Walbaum), Atlantic needlefish. None captured, but commonly sighted *May* through *September*.

Family Cyprinodontidae

Fundulus grandis Baird & Girard, Gulf killifish. Sta: A. Sal 15.5‰, temp 27.5C. Spec: *May* 1, 25mm.

Family Poeciliidae

Gambusia affinis (Baird & Girard), mosquitofish. Sta: 5. Sal 3.6‰, temp 24.6C. Spec: *Apr.* 2, 16-29mm.

Family Atherinidae

Menidia beryllina (Cope), tidewater silverside. Sta: A, C, D, E, F. Sal 2.2-15.5‰, temp 27.5-30.5C. Spec: *May* 51, 27-78mm; *June* 88, 26-83mm; *July* 10, 43-75mm.

Family Syngnathidae

Syngnathus scovelli (Evermann & Kendall), Gulf pipefish. Sta: 4, E. Sal 2.2-7.8‰, temp 13.2-24.8C. Spec: *Mar.* 2, 78-121mm; *July* 5, 75-107mm; *Oct.* 2, 74-95mm.

Family Centrarchidae

Lepomis auritus (Linnaeus), redbreast sunfish. Sta: 4, 6, 8. Sal 2.3-7.5‰, temp 13.2-29.0C. Spec: *Feb.* 2, 113-117mm; *May* 2, 122-137mm; *Sep.* 2, 83-102mm.

Lepomis macrochirus Rafinesque, bluegill. Sta: 4, 5. Sal 3.6-7.4‰, temp 13.2-24.6C. Spec: *Feb.* 2, 113-117mm; *Apr.* 1, 103mm.

Lepomis microlophus (Günther), redear sunfish. Sta: 4, 5. Sal 1.8-3.6‰, temp 11.2-24.6C. Spec: *Jan.* 4, 139-223mm; *Apr.* 1, 148mm.

Lepomis punctatus (Valenciennes), spotted sunfish. Sta: 4, 6. Sal 1.8°-2.2‰, temp 11.2-20.8C. Spec: *Jan.* 3, 93-134mm; *Mar.* 1, 90mm.

Micropterus salmoides (Lacépède), largemouth bass. Sta: 4, 5, 8, D, E. Sal 1.8-3.7‰, temp 11.2-30.5C. Spec: *Jan.* 1, 223mm; *Feb.* 1, 247mm; *June* 1, 58mm; *July* 1, 48mm; *Aug.* 1, 176mm.

Family Pomadasyidae

Orthopristis chrysoptera (Linnaeus), pigfish. Sta: A. Sal 15.5‰, temp 27.5C. Spec: *May* 3, 26-34mm.

Family Sparidae

Lagodon rhomboides (Linnaeus), pinfish. Sta: 1, 2, 4, A, C, D, E, F. Sal 2.2-15.5‰, temp 23.5-30.5C. Spec: *May* 18, 26-51; *June* 10, 41-69mm; *July* 6, 23-54mm; *Aug.* 1, 85mm; *Oct.* 3, 95-108mm.

Family Sciaenidae

Bairdiella chrysura (Lacépède), silver perch. Sta: 1, 2, 3, 4, 6, A. Sal 1.9-21.9‰, temp 12.5-31.1C. Spec: *Feb.* 3, 126-139mm; *Mar.* 1, 140mm; *Apr.* 10, 99-145mm; *May* 31, 26-158mm; *June* 9, 105-143mm; *Aug.* 6, 36-148mm; *Sep.* 3, 143-153mm; *Oct.* 1, 110mm.

Cynoscion arenarius Ginsburg, sand seatrout. Sta: 3. Sal 11.0-12.6‰, temp 28.8-31.1C. Spec: *June* 2, 50-58mm; *Aug.* 1, 65mm.

Leiostomus xanthurus Lacépède, spot. Sta: 1, 2, 3, 4, 5, 6, 7, 8, A, B, C, E, F. Sal 1.9-21.9‰, temp

12.0-30.5C. Spec: *Feb.* 7, 19-113mm; *Mar.* 4, 100-107mm; *Apr.* 13, 17-47mm; *May* 93, 25-168mm; *June* 64, 38-156mm; *July* 3, 58-61mm; *Aug.* 4, 94-111mm; *Sep.* 4, 87-150mm; *Oct.* 14, 88-107mm.

Menticirrhus americanus (Linnaeus), southern kingfish. Sta: 4. Sal 13.4‰, temp 25.2C. Spec: *Aug.* 1, 57mm.

Micropogon undulatus (Linnaeus), Atlantic croaker. Sta: 1, 3, 4, 6. Sal 1.9-21.9‰, temp 12.5-29.8C. Spec: *Feb.* 2, 157-177mm; *Mar.* 11, 18-171mm; *May* 7, 31-202mm; *June* 2, 127-170mm; *July* 5, 106-183mm; *Aug.* 2, 133-203mm; *Sep.* 2, 152-157mm.

Sciaenops ocellata (Linnaeus), red drum. Sta: 2, A, C, F. Sal 2.2-15.5‰, temp 22.9-30.5C. Spec: *Apr.* 1, 109mm; *May* 4, 127-160mm; *June* 1, 216mm.

Family Ephippidae

Chaetodipterus faber (Broussonet), Atlantic spadefish. Sta: 1. Sal 14.8‰, temp 24.8C. Spec: *Aug.* 2, 48-60mm.

Family Mugilidae

Mugil cephalus Linnaeus, striped mullet. Sta: C. Sal 11.2‰, temp 28.0C. Spec: *May* 3, 54-59mm. (Commonly sighted at all stations.)

Family Gobiidae

Gobiosoma bosci (Lacépède), naked goby. Sta: 4, 8, B, D. Sal 2.9-10.4‰, temp 13.2-30.9C. Spec: *Feb.* 2, 24-25mm; *May* 1, 25mm; *June* 2, 30-43mm; *July* 13, 19-30mm.

Microgobius gulosus (Girard), clown goby. Sta: A, C, F. Sal 2.5-15.5‰, temp 27.5-30.5C. Spec: *May* 14, 38-54mm.

Family Bothidae

Citharichthys spilopterus Günther, bay whiff. Sta: C. Sal 11.2‰, temp 28.0C. Spec: *May* 4, 64-75mm.

Paralichthys albigutta Jordan & Gilbert, Gulf flounder. Sta: 1, 3. Sal 12.2-18.7‰, temp 23.9-30.1C. Spec: *May* 5, 71-92mm; *June* 1, 85mm.

Paralichthys lethostigma Jordan & Gilbert, southern flounder. Sta: 1, 2, 3, 4, 5, 6, 8, C. Sal 1.9-20.9‰, temp 12.8-30.3C. Spec: *Feb.* 10, 119-192mm; *Mar.* 6, 134-184mm; *Apr.* 9, 54-189mm; *May* 12, 92-200mm; *June* 7, 101-209mm; *July* 2, 108-123mm; *Aug.* 2, 71-110mm; *Oct.* 2, 92-108mm.

Family Soleidae

Trinectes maculatus (Bloch & Schneider), hogchoker. Sta: 2, 3, 4, 5, 6, A, B, C, D, E, F. Sal 1.9-15.5‰, temp 13.0-30.5C. Spec: *Feb.* 2, 15-35mm; *Mar.* 2, 57-90mm; *Apr.* 3, 35-63mm; *May* 4, 28-53mm; *June* 6, 18-37mm; *July* 6, 11-61mm; *Oct.* 1, 54mm.

Family Cynoglossidae

Symphurus plagiusa (Linnaeus), blackcheek tonguefish. Sta: C, F. Sal 2.5-11.2‰, temp 28.0-30.5C. Spec: *May* 4, 41-53mm; *June* 1, 36mm.

Discussion—The fishes, with one exception, were collected within previously recorded salinity ranges. The majority (74%) of species represented are considered marine; they normally spawn in salt water. None of these marine fishes was collected at salinities outside previously recorded ranges. One freshwater fish, *Lepomis auritus*, was taken at salinities up to 7.5‰, which is considerably higher than the 1.0‰ reported by Keup and Bayless (1964).

Variations in salinity were closely related to the amount of rainfall in the area (Fig. 2). For example, bottom salinity at station 1 decreased from 20.9 to 3.7‰ between 13 June and 14 July, due to 8.1 inches of rainfall from the 3rd to the 7th of July (recorded at Sanborn Tower, 19 km northeast of the study area). study area).

The study was conducted during a period when rainfall was below average. This is not an atypical condition for the area, since cyclic wet and dry seasons occur (Fig. 3). A similar study conducted in the same area during a year of high rainfall (like 1964) might reveal a fish fauna with a higher ratio of freshwater species to euryhaline marine species.

Twenty-six of the 28 species of marine fishes collected are considered euryhaline, i.e., under natural conditions they move from seawater (35‰) to

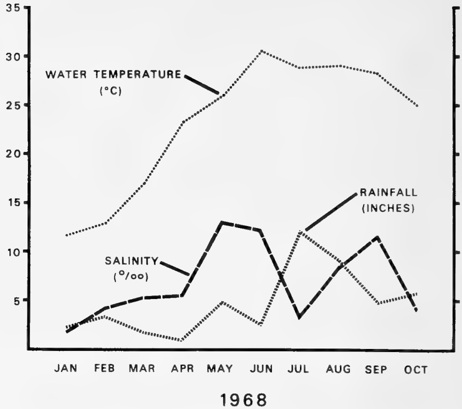

Fig. 2. Water temperature, and relationship of salinity to rainfall in the study area, January through October 1968. Rainfall was recorded at Sanborn Tower, a weather station 19 km northeast of the study area. Salinity is the average of bottom salinities at all stations. Temperature is the average of surface and bottom temperatures at all stations. Air temperature was always within ±2.5°C that of water, usually within ±1°C.

freshwater (< 1‰) or the reverse. Consequently, salinity fluctuations did not prevent their occurrence in the river. The distribution of the other marine fishes collected, *Menticirrhus americanus* and *Paralichthys albigutta,* was influenced by salinity fluctuations, since these fishes are not euryhaline.

Seven of the 10 species of freshwater fishes collected are stenohaline, i.e., they are unable to tolerate wide variations in salinity. Two fishes, *Dorosoma petenense* and *Gambusia affinis,* are euryhaline. The other freshwater fish, *Lepisosteus osseus,* tolerates a wide variation in salinity, but is not euryhaline. Except for *Dorosoma petenense* and *Gambusia affinis,* therefore, the distribution of all freshwater fishes collected was determined by salinity.

Rapid salinity changes apparently affected the distribution of certain euryhaline marine fishes and stenohaline freshwater fishes. For example, the marine fishes *Lagodon rhomboides, Bairdiella chrysura,* and *Leiostomus xanthurus* were not collected during the two periods when salinity decreased sharply (Fig. 2). They were collected, however, before, between, and after these periods. The freshwater fish *Ictalurus catus* was collected at downstream stations when river salinity was low (February, March, April). It was collected at upstream stations when river salinity was high (August), but was also collected at downstream stations during periods of rapid salinity decrease (July, late September). This stenohaline fish apparently moved up and down the river inversely to salinity.

Temperature determined the time of appearance of some fishes in the river. The following marine fishes were present when water temperatures were less than 20°C (January, February, March): *Brevoortia patronus, Syng-*

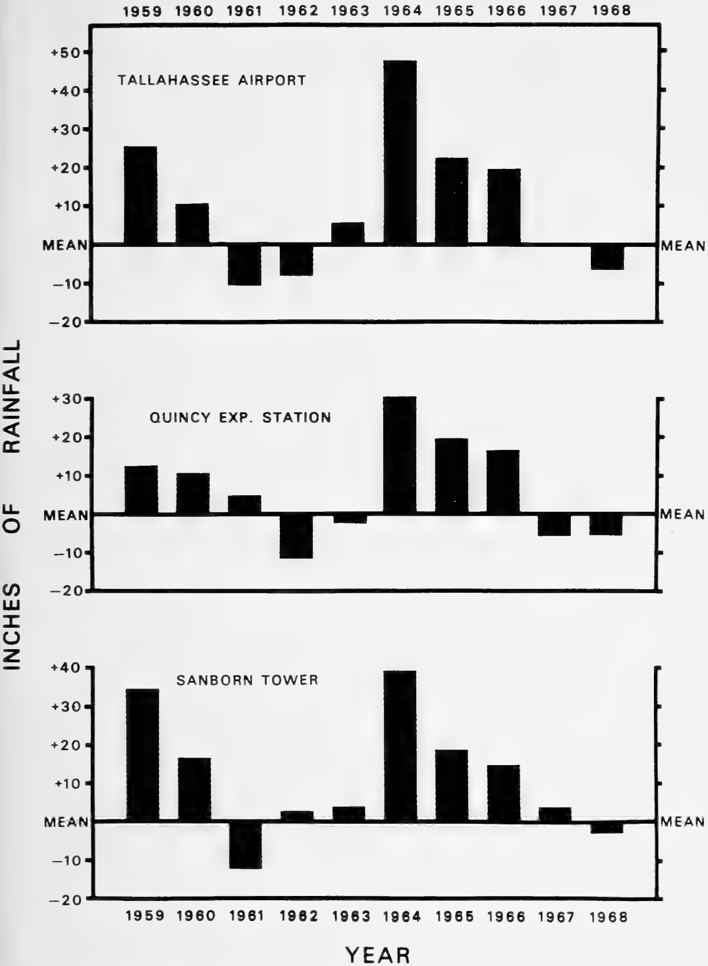

Fig. 3. Deviation from mean annual rainfall at three U. S. Weather Stations in the Ochlockonee River drainage area, 1959-1968. (Source: U. S. Weather Bureau)

nathus scovelli, Bairdiella chrysura, Leiostomus xanthurus, Micropogon undulatus, Gobiosoma bosci, Paralichthys lethostigma, and *Trinectes maculatus.* Other fishes such as *Dasyatis sabina, Megalops atlantica, Arius felis, Bagre marinus,* and *Lagodon rhomboides* were not present in the river until water temperatures had reached the mid-twenties (April). The freshwater fishes, other than *Dorosoma petenense, Gambusia affinis,* and possibly *Lepisosteus osseus,* remain in the river year-round and tolerate seasonal temperature fluctuations.

The lower Ochlockonee River is a valuable nursery area. Juveniles of 24 of the 28 marine fishes were collected. *Brevoortia patronus, Micropogon undulatus,* and *Sciaenops ocellata* are examples of valuable commercial and sport fishes which inhabit this protected area during their early growth period prior to moving into the Gulf to complete their life cycle.

SUMMARY—This study describes the lower Ochlockonee River, Florida, and surrounding area as conditions existed in 1968, and provides salinity tolerance data for 38 marine and freshwater fishes collected in the river. It shows that salinity and temperature affect the occurrence and distribution of certain marine and freshwater fishes in the lower Ochlockonee River. The degree of influence depends on the species of fish and the constancy of salinity and temperature conditions.

ACKNOWLEDGMENTS—We are grateful to the following for aid in this study: Mr. and Mrs. Al Willis provided dock space near the study area; F. Wm. Vockell, J. Wolfe, J. Wiese and C. E. Parrish helped on collecting trips; Dr. W. Heard, L. Abele and E. W. Cake identified invertebrates; T. Cosper titrated salinity samples; Dr. Camm C. Swift helped greatly in collecting and identifying invertebrates and fishes; and the Tall Timbers Research Station helped defray field expenses through a Gerald Beadel Scholarship Grant to Dr. R. W. Yerger.

LITERATURE CITED

BAILEY, R. M., J. E. FITCH, E. S. HERALD, E. A. LACHNER, C. C. LINDSEY, C. R. ROBINS, AND W. B. SCOTT. 1970. A list of common and scientific names of fishes from the United States and Canada. 3rd Ed. Am. Fish. Soc. Spec. Publ. 6:1-150.

———, H. E. WINN, AND C. L. SMITH. 1954. Fishes from the Escambia River, Alabama and Florida, with ecological and taxonomic notes. Proc. Acad. Nat. Sci. Phila. 106:109-164.

HALEY, P. C. 1956. An analysis of the channel sediments of the Ochlockonee River. Master's thesis, Florida St. Univ. Tallahassee.

HUBBS, C. L., AND K. F. LAGLER. 1958. Fishes of the Great Lakes region. Cranbrook Inst. Sci. Bull. 26:213 pp.

JOSEPH, E. B., AND R. W. YERGER. 1956. The fishes of Alligator Harbor, Florida, with notes on their natural history. Florida St. Univ. Stud. 22 (Pap. Oceanog. Inst. 2):111-156.

KEUP, L. AND J. BAYLESS. 1964. Fish distribution at varying salinities in Neuse River Basin, North Carolina. Chesapeake Sci. 5:119-123.

KURZ, H., AND K. WAGNER. 1957. Tidal marshes of the Gulf and Atlantic coasts of northern Florida and Charleston, South Carolina. Florida St. Univ. Stud. 24:168 pp.

SMITH, R. F. 1966. A symposium on estuarine fisheries. Amer. Fish. Soc. Spec. Publ. 3:154 pp.

TAGATZ, M. E. 1968. Fishes of the St. Johns River, Florida. Quart. J. Florida Acad. Sci. 30:25-50.

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OBSERVATIONS ON A FEMALE OARFISH (*REGALECUS GLESNE*)[1]

Carl H. Saloman, Martin A. Moe, Jr. and John L. Taylor

National Marine Fisheries Service, Biological Laboratory, Panama City, Florida 32401;
2048 Ardly Court, Juno Isles, North Palm Beach, Florida 33408;
801 Delaware Ave., Lynn Haven, Florida 32444

Abstract: A live, but injured, gravid female ca. 3 m long had ovaries 77 cm × 7.7 cm containing ca. 139,000 eggs averaging 2.57 mm diam.

Specimens of the oarfish, *Regalecus glesne* (Ascanius), have been found periodically since 1920 between March and June stranded or floundering nearshore along the west coast of Florida (Taylor and Saloman, 1968). Most of the fish have been males, but recently, a female was collected injured but alive off St. Petersburg Beach (March 28, 1968), and another was found in the final stages of decomposition on a mangrove island near the entrance of Tampa Bay (February 23, 1970). Both fishes were longer than 3 m, but an exact measurement could not be made because each lacked an undetermined portion of the posterior body region. The specimen collected in 1968 was deposited with the Marine Research Laboratory of the Florida Department of Natural Resources in St. Petersburg (FSBC 6413), and the other oarfish is in the reference collection of the National Marine Fisheries Service Biological Laboratory on St. Petersburg Beach, Florida.

Fig. 1. Anterior section of a female *R. glesne* with dissected ovary.

The 1968 specimen is of special interest because it is one of the few gravid oarfishes ever collected alive. Previous information on oarfish eggs was limited to a report by Walters (1959) that compared egg size to that of gun pellets; articles by Sanzo (1925) and Sparta (1933) who found *R. glesne* eggs of 2.48 mm diameter among plankton; a paper by Serventy (1966) who ex-

[1]Contribution no. 176 (Moe), Florida Department of Natural Resources, Marine Research Laboratory, P. O. Drawer F, St. Petersburg, Florida.

truded eggs of about 6 mm in diameter from a ripe oarfish in western Australia; and a note, but no measurements, on eggs with well-developed embryos by Welsh (1920).

Ovaries of the specimen collected in 1968 were 77 cm long and had a maximum diam of 7.7 cm (Fig. 1). They had a combined weight of 1,350 g and contained approximately 139,043 eggs. Based on samples of 15 eggs from each of five 15 mm sections of ovary, the average egg diam proved to be 2.57 mm (measured by ocular micrometer) and average egg weight was 0.009 g. These were ovulated eggs, thus their size is probably very close to that of the spawned egg. A few small and immature eggs (0.34 mm in diam) were noted in the anterior ends of ovaries. In general, larger eggs were found in posterior portions of the ovaries (Table 1).

TABLE 1. Mean egg size from each 15 cm section of ovary.

Ovary Section	Mean egg size (mm)
A (anterior)	2.50
B	2.52
C	2.49
D	2.68
E (posterior)	2.67

Histological preparations (Harris' hematoxylin and eosin sectioned in paraffin at 6 μ) showed that all eggs were normally developed except those adjacent to ovarian walls (Fig. 2). These appeared pycnotic, a condition

Fig. 2. Ovigerous tissue of the medial gonad wall showing oocytes in various stages of degeneration.

probably caused by postmortem histolysis and post ovulation degeneration of unreleased eggs. The mature eggs throughout the ovaries were free of any ovarian tissues (connective or ovigerous), indicating that ovulation had occurred and that spawning was imminent at the time of injury. Most eggs matured at the same time, which indicates a single spawning occurrence per season. No evidence of male tissue was found during gross or histological examination.

LITERATURE CITED

SANZO, L. 1925. Uova e larve di *Regalecus glesne* Asc. R. Comitato Talassografico Italiano. Mem. 118:1-8.

SERVENTY, V. 1966. Strange creature of the sea. Pacific Discovery 19:12-15.

SPARTA, DI A. 1933. Trachypteridae e Regalecidae. *In* Faune e Flora del Golfo di Napoli: Uova, larve e stadi grovanili di Teleostei. Stazione Zool. Napoli Monogr. 38:266-279.

TAYLOR, J. L., AND C. H. SALOMAN. 1968. The oarfish, *Regalecus glesne*: a new occurrence and previous records from the Gulf of Mexico. Copeia 1968:404-405.

WALTERS, V. 1959. The sea serpent that is a fish. Sea Frontiers 5:102-104.

WELSH, W. W. 1920. Recent records of ribbon-fishes from Florida. Copeia 86:79-81.

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Biological Sciences

SPIDERS IN THE SUMMER DIET OF CATTLE EGRETS

MICHAEL J. FOGARTY AND HOWARD K. WALLACE

Wildlife Research Projects, 4005 S. Main Street, Gainesville, Florida 32601;
Department of Zoology, University of Florida, Gainesville, Florida 32601

ABSTRACT: *In summer, 1969, contents of 410 egret stomachs were studied. Spiders, especially wolf spiders, were found to be widely present in the diet.*

IN A STUDY by the Florida Game and Fresh Water Fish Commission to determine the summer diet of cattle egrets (*Bubulcus ibis*) in northern Florida, spiders, mainly wolf spiders, were found to comprise a significant part of the foods identified from a sample of 410 egret stomachs. The purpose of this paper is to identify these spiders by families, except the Lycosidae, which are identified to species.

METHODS—The egrets were shot in the late afternoon at four roosts in Alachua and Marion Counties, Florida between 19 June and 16 July 1969. The stomachs were removed soon after death and preserved in a buffered 10% formalin solution. The stomachs were later opened individually and the spiders were removed and pooled for the whole sample. After each of the 410 stomachs was examined, the spiders were identified. Members of each family and species were counted and measured volumetrically.

RESULTS AND DISCUSSION—Although orthopterous insects were found in 96.8 percent of the sample and comprise 80.5 percent of the diet by vol, spiders ranked second by occurrence and vol. Arachnids were present in

TABLE 1. Spiders in 410 cattle egret stomachs.

Family and Species	Number	Volume (ml)
LYCOSIDAE	2,398	472.5
Sosippus floridanus	2	0.5
Pirata sedentarius	1	Tr.[1]
Pardosa milvina	92	1.5
Pardosa saxatilis	2	Tr.
Pardosa longispinata	48	0.5
Pardosa georgii	9	Tr.
Geolycosa fatifera	2	0.5
Arctosa littoralis	1	Tr.
Schizocosa crassipes	1	Tr.
Schizocosa episima	9	0.5
Schizocosa ocreata	2	Tr.
Lycosa carolinensis	127	72.0
Lycosa punctulata	6	0.5
Lycosa rabida	333	56.5
Lycosa helluo	1,283	150.0
Lycosa hentzi	5	1.5
Lycosa lenta	452	143.0
Lycosa angusta	1	Tr.
Lycosa huberti	1	Tr.
GEOLYCOSIDAE	1	Tr.
Unidentifiable		
PARDOSA	20	Tr.
Unidentifiable		
LYCOSIDAE	Unknown	45.0
Unidentifiable		
CLUBIONIDAE	1	Tr.
THOMISIDAE	27	1.5
SALTICIDAE	40	2.5
PISAURIDAE	23	2.5
Dolomedes triton	19	2.5
Pelopatis undulata	4	Tr.
OXYOPIDAE	45	1.5
Peucetia abboti	45	1.5
THERIDIIDAE	10	0.5
Latrodectus mactans	10	0.5
ARANEIDAE	229	8.0
Nephila clavipes	3	0.5
Argiope aurantia	190	6.5
Acanthepeira sp.	1	0.5
Neoscona sp.	1	0.5
Araneus sp.	1	Tr.
ARANEIDAE	33	Tr.
Unidentifiable		
TETRAGNATHIDAE	23	Tr.
Tetragnatha sp.	23	Tr.
UNIDENTIFIABLE SPIDERS	7	0.5
TOTAL	2,803	489.5

[1]Tr. = less than 0.5 ml.

85.1 percent of the stomachs, amounting to 4.7 percent of the diet by vol. The stomachs contained an average of 1.19 cc of spiders. Nine genera of spiders were identified (Table 1).

It is well known that cattle egrets eat spiders, but families, genera, or species usually are not listed. Burns and Chapin (1969) examined 74 cattle egrets collected in Louisiana from June to October and found spiders totaled 10 percent of the foods. Heubeck (1967) examined 165 stomachs collected in Florida from May through January and found spiders in 7.2 percent of the sample. Ikeda (1956) identified the families Heteropodidae, Salticidae, Thomicidae, and Agelenidae from the stomachs of 21 egrets (*B. i. cormandus*) collected from rice fields and river banks in Japan. He noted that spiders comprised 26.1 percent of the diet by vol. Seaman (1955) examined one cattle egret taken at St. Croix, Virgin Islands, in February and found spiders made up 6.0 percent of the stomach contents. Seigfried (1966) noted that spiders made up 4.1 percent of the total vol of 15 nestling cattle egret regurgitates taken from a colony in South Africa. Snoddy (1966) reported that spiders comprised 4.0 percent of the contents of 20 egrets taken in Georgia from August through October. Kadry (1942), Kirkpatrick (1925), Lowe-McConnel (1967), Biaggi (in Palmer, 1962), Reilly (1968), Skead (1956), Ticehurst (1931), and Valverde (1958) reported spiders in the diet of the cattle egret but present no data on the species or frequency.

The Wolf Spiders. Emerton (1902) stated that the Lycosidae were the commonest spider family. Although many are nocturnal (Kaston, 1953), their frequent appearance in the stomach contents indicates that they are active in the day or are made available to the egret when disturbed by grazing livestock or farm machinery, both of which the egret attentively follow when feeding. Four species (*Lycosa helluo, L. lenta, L. rabida,* and *L. carolinensis*) comprised 78.3 percent of the spiders identified, amounting to 85.9 percent by vol of the entire spider diet.

Acknowledgements—Special thanks are due to Mrs. L. A. Hetrick who separated the spiders from the other food items in many of the stomachs. Wildlife Biologists Larry L. Martin, Lovett E. Williams, Jr., and Game Managers Robert W. Phillips and Harry Koon, Florida Game and Fresh Water Fish Commission, assisted with the egret collection. Lovett E. Williams, Jr., made helpful suggestions about the manuscript. This is a contribution of the Federal Aid to Wildlife Restoration Program, Florida Pittman-Robertson Project W-41.

LITERATURE CITED

Burns, E. C. and J. B. Chapin. 1969. Arthropods in the diet of the cattle egret, (*Bubulcus ibis*) in southern Louisiana. J. Econ. Entomol. 62:736-738.

Emerton, J. H. 1902. Repr. 1961. The common spiders of the United States. Dover Pub. New York.

Heubeck, E. K. 1967. A survey of the parasites of the cattle egret (*Bubulcus ibis*) in Florida. Unpublished M.S. thesis. Univ. Florida. Gainesville.

Ikeda, S. 1956. On the food habits of the Indian cattle egret *Bubulcus ibis cormandus* (Boddaert). Jap. J. Appl. Zool. 21: 83-86.

KADRY, I. 1942. The economic importance of the buff-backed egret (*Ardea ibis L.*) to Egyptian agriculture. Zool. Soc. Egypt Bull. 4: 20-26.
KASTON, B. J. 1953. How to Know the Spiders. W. C. Brown Co. Dubuque, Iowa.
KIRKPATRICK, T. W. 1925. The buff-backed egret (*Ardea ibis*, L. Arabic *Abu Qerdan*) as a factor in Egyptian agriculture. Tech. Sci. Service Egypt Bull. 56: 1-6.
LOWE-MCCONNEL, R. H. 1967. Biology of the immigrant cattle egret *Ardeola ibis* in Guyana, South America. Ibis 109: 168-179.
PALMER, R. S. 1962. Handbook of North American Birds. Vol. 1. Yale Univ. Press. New Haven.
REILLY, E. J., JR. 1968. The Audubon Illustrated Handbook of American Birds. McGraw-Hill Book Co. New York.
SEAMAN, G. A. 1955. Cattle egret in Virgin Islands. Wilson Bull. 67: 304-305.
SEIGFRIED, W. R. 1966. On the food of nestling cattle egrets. Ostrich 37: 219-220.
SKEAD, C. J. 1956. The cattle egret in South Africa. Audubon Mag. 58: 202-209; 224-225.
SNODDY, E. L. 1969. On the behavior and food habits of the cattle egret, *Bubulcus ibis* (L.). J. Georgia Entomol. Soc. 4: 156-158.
TICEHURST, C. B. 1931. Notes on Egyptian birds. Ibis 73: 575-578.
VALVERDE, J. A. 1958. An ecological sketch of the Coto Donana. Brit. Birds 51: 1-23.

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Biological Sciences

POLYCHAETE FAUNA ASSOCIATED WITH GULF OF MEXICO SPONGES

DANIEL M. DAUER

Department of Biology, University of South Florida, Tampa, Florida 33620

ABSTRACT: *From 1-17 polychaete worms were found in association with each of 14 sponges distributed among 8 genera.*

THIRTY-FOUR species of polychaetous annelids have been found associated with eight common sponges from the Gulf of Mexico. The sponges studied were: 1 *Adocia neens* (Todsent); 2 *Geodia gibberos* Lamarck; 3 *Ircinia campana* (Lamarck); 1 *Ircinia ramosa* (Keller); 2 *Spheciospongia vesparia* (Lamarck); 1 *Tedania ignis* (Duchassaing and Michelotti); 3 *Xytopsene sigmatum* de Laubenfels; and 1 unidentified Demospongea. From 1-17 species of polychaetes were found with any one sponge. Generalizations concerning diversity of polychaetes associated with sponges are presented.

MATERIALS AND METHODS—Sponges were collected from 9 to 11 m depths west and northwest of Tarpon Springs, Florida, on May 29-31, 1970, and from 2 m depth west of Hudson, Florida, on April 17, 1971. All sponges were collected by scuba diving, placed individually in plastic bags, narcotized with 0.015% prophylene phenoxytol, fixed with 10% formalin in seawater, and transferred after 24-48 hr to 70% isopropyl alcohol for storage. The contents of each plastic bag were sieved with a 0.5 mm sieve to obtain the polychaetes associated with the sponge cortex. The sponges were dissected to find the polychaetes living within the body of the sponge.

RESULTS AND DISCUSSION—Thirty-four species of polychaetes representing 15 families were identified. Only ten of the species, *Aglaurides fulgida* Savigny, *Branchiosyllis oculata* Ehlers, *Eunice rubra* Grube, *Exogone dispar* (Webster), *Lepidonotus variabilis* Webster, *Nereiphylla fragilis* (Webster), *Nereis succinea* Frey and Leuckart, *Podarke obscura* Verrill, *Polydora colonia* Moore, and *Syllis spongicola* Grube, have been previously reported associated with sponges (Augener, 1906; Blake, 1971; Fauvel, 1923; Hartman, 1945,

TABLE 1. Occurrence of polychaete species in Gulf of Mexico sponges. Abundance of polychaetes in each sponge expressed as high (H), medium (M), or low (L) as explained in the text.

POLYCHAETE SPECIES	SPONGE REFERENCE NUMBER[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Aglaurides fulgida						L	L							
Branchiosyllis oculata								H	H					
Branchiosyllis sp.									H					
Ceratonereis irritablis			L	L	L	L								
Ceratonereis mirablis						L								
Chone infundibuliformis					L	L								
Dorvillea sociabilis					L									
Eulalia myriacyclum														L
Eunice rubra		L											L	
Eunice sp.				L		L								
Exogone dispar														L
Goniadella sp.						L								
Laeonereis culveri		L			L									
Lepidametria commensalis					L									
Lepidonotus variablis				L	L	L								
Loima medusa				L										
Lumbrineris coccinea			L	L	L	L							L	
Lysidice ninetta						L								
Marphysa regalis		L											L	
Megalomma lobiferum						L								
Megalomma sp.						L	L							
Nereiphylla fragilis					L									
Nereis succinea				L	L									
Notomastus latericeus						L								
Paramarphysa longula		L				L							L	
Pherusa sp.						L								
Pista palmata														L
Podarke obscura			L			L								
Polydora colonia										H				
Polydora socialis				L	L		L						L	
Protoariciella sp.														L
Syllis spongicola	H	H	H	L	L	L	H				H	H	H	H
Terebella rubra							M						M	
Typosyllis variegata				L	L	L								

[1]Identifications for Reference Numbers are: 1 *Adocia neens;* 2-3 *Geodia gibberos;* 4-5-6 *Ircinia campana;* 7 *Ircinia ramosa;* 8-9 *Spheciospongia vesparia;* 10 *Tedania ignis;* 11-12-13 *Xytopsene sigmatum;* 14 Unidentified Demospongea.

1951, 1968; Pearse, 1934; Pettibone, 1963). The results presented in Table 1 show with which sponge a particular polychaete species was found.

The diversity of polychaetes associated with any one sponge was highly variable. Five of the sponges (*Adocia neens, Spheciospongia vesparia, Tedania ignis,* and two *Xytopsene sigmatum*) contained only a single species of polychaete, while the remaining sponges examined averaged approximately seven species of polychaetes. One species, *Syllis spongicola,* was present in 11 of the 14 sponges. Fifteen of the 34 total polychaete species occurred in only one sponge. Twenty-seven (79.5%) of all polychaete species occurred twice or less.

Absolute numbers of polychaetes were not recorded (due to the difficulty in comparing numbers of polychaetes between sponges of different volumes and surface areas). Instead, relative abundance was recorded as high ($>$ 50 individuals per species per sponge), low ($<$ 5 individuals per species per sponge), and medium ($<$ 50 and $>$ 5 individuals per species per sponge). Four species were rated as abundantly high (*Branchiosyllis oculata, Branchiosyllis* sp., *Polydora colonia,* and *Syllis spongicola*). One species, *Terebella rubra* (Verrill), was rated as medium. All other polychaete species were rated as low in relative abundance.

Three species of polychaetes were found living within the tissue of the sponge, *Branchiosyllis* sp., *Dorvillea sociabilis* (Webster), and *Syllis spongicola.* The remainder of the polychaetes were found in the canals of the sponge (e.g. *Branchiosyllis oculata*), occupying tubes within the canals of the sponge (e.g. *Polydora colonia*), found in fissures provided at the point of attachment of the sponge (e.g. *Lepidonotus variabilis*), or in the sediment which accumulated upon the sponge (e.g., *Notomastus latericeus* Sars).

Syllis spongicola, the most abundant species of polychaete (in occurrences and relative abundance) exhibited varying color patterns depending upon the sponge harboring it. Three external color forms, pale, orange and brown, were found. The pale form (pale to flesh color when preserved) was previously reported by Hartman, 1951. The *Syllis spongicola* found in *Geodia gibberos, Ircinia campana, I. ramosa, Spheciospongia vesparia,* and in two *Xytopsene sigmatum* exhibited the pale form. The orange form was found in a single *Xytopsene sigmatum* with the other two forms absent. This form was similar to the pale form in coloration, but possessed a bright orange pharynx. The brown form was found only in *Adocia neens* with the other two forms absent. In addition to color patterns, the three forms exhibited differences in body width, eye size, and pharyngeal and proventricular length (Table 2).

Examination of the occurrence and the relative abundance data in Table 1 shows that *Syllis spongicola* is the dominant polychaete in both relative abundance in any one sponge and total number of occurrences in different sponges. The only times it was rated low in relative abundance was in *Ircinia campana* which is the sponge with the largest totals of polychaete species. *Branchiosyllis oculata, Branchiosyllis* sp., and *Polydora colonia* occur in high relative abundance, but appear rarely in different sponges. In all cases, *Syllis* *spongicola* was absent when any of these three species were present. All other species of polychaetes occur in medium or low relative abundance and rarely occurred in more than one sponge.

TABLE 2. Mean (± standard deviation) measurements of morphological characters found in three color forms of *Syllis spongicola* Grube. All specimens were in the 5-11 mm total length range. (N = 15 for each color form.)

CHARACTERS	PALE	ORANGE	BROWN
Last pharyngeal segment	6.3 ± 0.7	7.2 ± 0.8	7.3 ± 0.5
Last proventricular segment	12.9 ± 1.5	14.9 ± 0.8	12.1 ± 0.3
Width of anterior pair of eyes (microns)	18.8 ± 3.1	17.5 ± 2.7	13.0 ± 1.0
Width of posterior pair of eyes (microns)	14.2 ± 3.1	13.6 ± 2.9	10.0 ± 0.2
Maximum width of body (mm)	0.6	0.6	0.4

When polychaetes were highly abundant, only an average of 3 species were present. With medium or low polychaete abundance, an average of 9 polychaete species were present. Since 29 (85%) of the polychaete species were always low in relative abundance, and 27 (79.5%) of these occurred in two or less sponges, it appears that the association of most polychaete species found with sponges is a random occurrence, and probably determined primarily by the shape of the sponge, i.e., by the amount of sediment allowed to accumulate, and by the area provided for refuge and attachment. This conclusion is supported by the fact that the greatest polychaete diversity was found with the common vase sponge, *Ircinia campana,* which due to its shape accumulates the greatest amount of sediment. In addition, those sponges with the least surface area and/or contour (e.g. *Spheciospongia vesparia* and *Xytopsene sigmatum*) generally had only one or two species found with them.

SUMMARY—1) The polychaete fauna associated with sponges is dominated in total numbers and in relative abundance by *Syllis spongicola* Grube; 2) a few polychaetes (*Branchiosyllis oculata* Ehlers, *Branchiosyllis* sp., and *Polydora colonia* Moore) were found with high relative abundances and rare occurrences in different sponges; 3) approximately 80% of the polychaetes found associated with sponges occur in relatively low abundances, and rarely in a large number of sponge species; and 4) the majority of polychaetes found with sponges occur randomly—their appearance is determined primarily by the external morphology of the sponge rather than by the species.

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LITERATURE CITED

AUGENER, H. 1906. Westindische Polychaeten. Bull. Mus. Comp. Zool. 43:91-196.

BLAKE, J. A. 1971. Revision of the Genus *Polydora* from the east coast of North America (Polychaeta: Spionidae). Smithsonian Contr. Zool. 75:1-32.

FAUVEL, P. 1923. Polychetes errantes. Faune de France. 5:1-488.
HARTMAN, O. 1945. The marine annelids of North Carolina. Bull. Duke Univ. Marine Sta. 2:1-51.
__________. 1951. The littoral marine annelids of the Gulf of Mexico. Publ. Inst. Marine Sci. 2:7-124.
__________. 1968. Atlas of the Errantiate Polychaetous Annelids from California. Allan Hancock Foundation. Los Angeles.
PEARSE, A. S. 1934. Inhabitants of certain sponges at Dry Tortugas. Pap. Tortugas Lab. Carnegie Inst. 28:117-121.
PETTIBONE, M. H. 1963. Marine polychaete worms of the New England region. Families Aphroditidae through Trochochaetidae. U.S. Nat. Mus. Bull. 227: 1-356.

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Biological Sciences

AN UNUSUAL ESTUARINE RECORD OF OCEANIC SQUID, *CRANCHIA SCABRA*

ELDON J. LEVI

National Marine Fisheries Service, Gulf Breeze, Florida 32561

ABSTRACT: *A live male was collected about a mile inside the Pensacola Bay Entrance.*

An oceanic squid, *Cranchia scabra* Leach, was taken alive in Pensacola Bay, Florida, on March 16, 1970. The male squid, mantle 6.4 cm long and fourth tentacle 3.4 cm, was captured in shallow water, 1 mile inside the entrance. Soon after transfer into a bucket the tentacles retracted and the squid contracted into a ball. After 20 min the tentacles were extended and swimming was resumed.

Cranchia scabra is a widely distributed species (Clarke, 1966), has been reported from all temperate and tropical seas (Voss, 1956a, 1956b) and is not usually found near shore. The northernmost record in the Gulf of Mexico was from lat. 29°16′ N. and long. 87°40′ W. (R/V *Oregon*, Station 516) or about 75 miles south of Pensacola Entrance. The genus is easily identified by the barrel-shaped mantle covered with star tubercles, the gladius and eyes visible through the mantle, and two small rounded terminal fins. Clarke (1966) listed the maximum mantle length of males and females as 8.2 cm. Rees and Maul (1956) reported an unusually large individual, sex unknown, 11.0 cm long.

Museum reference AN-1888, U.S. Environmental Protection Agency, Gulf Breeze, Florida.

LITERATURE CITED

CLARKE, M. R. 1966. A review of the systematics and ecology of oceanic squids. Adv. Marine Biology 4:91-327.
REES, W. J., AND G. E. MAUL. 1956. The Cephalopoda of Madeira. Bull. Brit. Mus. Nat. Hist. 3:257-281.

Voss, G. L. 1956a. A checklist of the Cephalopoda of Florida. Quart. J. Florida Acad. Sci. 19:274-282.

———. 1956b. A review of the cephalopods of the Gulf of Mexico. Bull. Mar. Sci. Gulf Carib. 6:86-178.

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Biological Sciences

ANISEIA MARTINICENSIS: AN ADVENTIVE IN FLORIDA[1]

Daniel F. Austin

Department of Biological Sciences, Florida Atlantic University, Boca Raton, Florida 33432

Convolvulaceae are weedy and many species appear in places where they have not been previously recorded. Dispersal methods for very few species in the family have been studied, and consequently little is known about how they are transported. Certain species such as *Ipomoea alba, Ipomoea pes-capre, Ipomoea macrantha* (=*I. tuba*), and *Merremia tuberosa* were recorded by Guppy (1917) as being dispersed by the ocean. Other species are carried from place to place by man: *Ipomoea cairica, Ipomoea tricolor,* and *Turbina corymbosa* are undoubtedly transported by man's activities.

In 1967 George Avery (Fairchild Tropical Garden) found an unfamiliar morning glory growing at a dump in Coral Gables, Florida. Avery, an astute naturalist, realized that the plant was not part of the usual southern Florida flora. Collections of the vine were determined by Avery with Leon & Alain's (1957) flora of Cuba as *Aniseia martinicensis,* a genus previously known no closer to the United States than Cuba, the Isle of Pines and Jamaica. Shortly after I arrived in Florida (1970) Avery mentioned this plant collection to me and I confirmed his determination.

Aniseia martinicensis is widely distributed in Central and South America, but not commonly encountered on most of the Antilles Islands. Its spotty distribution in the islands indicates either a lack of collecting, or more probably, an uncommon occurrence. The plants at the dump in Florida strongly suggest an introduction by man.

Early in March of 1971 Avery and I visited the area where the plant grew in Coral Gables. Since the plant was originally collected, the mounds of soil upon which the *Aniseia* grew had been leveled. Although the area was searched at length for the *Aniseia,* none was found. It appears likely that *Aniseia* is no longer extant in the location where it was originally collected. This does not necessarily mean that the species no longer grows in the Miami area. Its inclusion in Long & Lakela (1971) seems to be based on Avery's collections.

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Since there has been only one report of the reproductive biology of this species (Schlising, 1970), more data are desirable. Schlising reported insect visitors on *Aniseia* in Costa Rica, but made few comments on the plants. Specimens from Panama cultivated at the Missouri Botanical Garden (St. Louis) produced flowers and fruits regularly for about two years. Flowers were produced without any apparent preference for season. Self-fertility and autogamy is present in the population based on experiments with the Missouri grown plants. All seeds grown produced seedlings which grew with vigor. The available data indicate that the taxon is a polyploid with $2n = 60$ (Lewis & Oliver, 1969). The plants prefer marshy areas throughout their range, and produce flowers for only a short period in early morning. The flowers open a single day and close between 10:00 and 12:00 a.m.

Aniseia martinicensis (Jacq.) Choisy. Mem. Soc. Phys. Genéve 8: 144. 1838.

FLORIDA: DADE CO.: dump at Shoal Point, Coral Gables, 2 Jan. 1967, *Avery 249* (FLAS, FSU, FTG). Same locality, fruiting specimen, 15 Feb. 1967, *Avery s.n.* (FLAS).

LITERATURE CITED

GUPPY, H. B. 1917. Plants, Seeds, and Currents in the West Indies and Azores. Williams & Norgate. London.

LEON, BRO. AND BRO. ALAIN. 1957. Convolvulaceae *In* Flora de Cuba. 5:218-248.

LEWIS, W. H. AND R. L. OLIVER. 1969. Chromosome counts. Ann. Missouri Bot. Gard. 56:473.

LONG, R. W. AND O. LAKELA. 1971. A Flora of Tropical Florida. University of Miami Press. Coral Gables.

SCHLISING, R. A. 1970. Sequence and timing of bee foraging in flowers of *Ipomoea* and *Aniseia* (Convolvulaceae). Ecology 51:1061-1067.

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Biological Sciences

THE SPOTTED TURTLE IN FLORIDA AND SOUTHERN GEORGIA

JAMES F. BERRY AND CULVER S. GIDDEN

Department of Biology, University of Utah, Salt Lake City, Utah 84112;
Bureau of Sport Fisheries and Wildlife, St. Marks National Wildlife Refuge,
P. O. Box 68, St. Marks, Florida 32355

ABSTRACT: *Four new records from Florida and two from Georgia confirm an expanded range for* Clemmys guttata.

CARR (1940) reported the first Florida record of *Clemmys guttata* (Schneider) from Lake Weir, Marion County. Neill (1954) reported additional records from Lake Weir and from near Winter Haven, Polk County, but dismissed all Florida records as probable introductions. Grobman (1954) reported another Florida specimen from the Steinhatchee Wildlife Management Area in Lafayette County, but Ernst (1972) considered all Florida records "questionable".

The Florida State Museum contains four unreported *Clemmys guttata* from Florida: (1) UF-14650 a skeletal specimen from 1 mile northeast of Wellborn, Suwannee County, collected by L. Geiger on November 23, 1956; (2) UF-14447 from Windsor, Alachua County, collected in the Spring of 1962 by C. Ray; (3) UF-29559 from 2 miles south of the Jacksonville toll bridge, Duval County, collected in June, 1964; and (4) UF-29558 from the vicinity of Gainesville, Alachua County, collected in 1970.

Since 1965, four adult *Clemmys guttata* have been collected in the St. Marks National Wildlife Refuge in Wakulla County, Florida. The first of these (FSUM-238) was found DOR on Florida Road S-59, 3.8 miles south of Newport, April 8, 1965, by the junior author; CSG-351 was collected by the junior author on Stoney Bayou Dike Road on March 22, 1967; another spotted turtle was collected, photographed and released on Florida Road S-59 between East River Pool and Stoney Bayou Pool on April 3, 1972, by a field class from Cortland College, Cortland, New York; the fourth (TTRS-588) was collected DOR by the junior author on Florida Road S-59, on April 16, 1972.

The number of specimens collected, length of time between collections, and distance between collecting sites (five air miles between extremes) indicate that this secretive species is established on the St. Marks Wildlife Refuge. The Refuge has many shallow ponds and meandering sloughs similar to areas inhabited by the spotted turtle to the north. The new records suggest that Neill (1957) was correct in his assumption that Florida populations represent

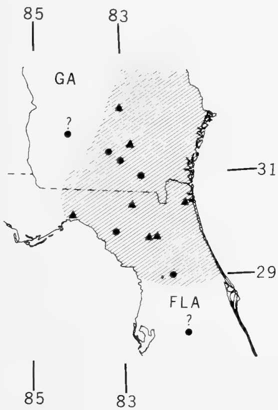

Fig. 1. Range of *Clemmys guttata* (shaded area) in northern Florida and southern Georgia. Triangles represent new records, circles represent old records.

relict colonies of an essentially northern species. In light of the records, it seems reasonable to extend the range of *Clemmys guttata* to northern Florida as far south as Marion County, and west to Wakulla County (Fig. 1).

In southern Georgia, *Clemmys guttata* has been reported from Berrien, Lanier, and Liberty Counties (Knepton, 1956), and from Ware County (Folkerts and Skorepa, 1967). A record from near Albany, Dougherty County (Conant, 1958) is questionable. To these we add new records: (1) an adult from a titi bay on Seventeen-mile Creek, 6 miles east of Douglas, Coffee County, collected by Milton Hopkins, July 30, 1971, (MH-760); and (2) a DOR specimen (TTRS-590) from 6-7 miles northeast of Jacksonville, Telfair County, collected by William Dopson, June 24, 1972. These new records support Ernst's (1972) conception of the western limit of the range of this species in southern Georgia (Fig. 1).

Acknowledgements—We thank D. Bruce Means of the Tall Timbers Research Station, Tallahassee, Florida (TTRS); Dr. Henry M. Stevenson of Florida State University (FSUM); and Dr. Sam R. Telford, Jr., of the University of Florida and the Florida State Museum (UF) for permission to examine specimens in their care. We thank Milton Hopkins of Fitzgerald, Georgia, for permission to cite his specimen. This study was supported by a grant to the senior author from Tall Timbers Research Station.

LITERATURE CITED

Carr, A. 1940. A contribution to the herpetology of Florida. Univ. Florida Biol. Sci. Ser. 3:1-118.

Conant, R. 1958. A Field Guide to the Reptiles and Amphibians of the United States and Canada East of the 100th Meridian. Houghton Mifflin Co. Boston.

Ernst, C. H. 1972. *Clemmys guttata*. Cat. Amer. Amphibians and Reptiles, pp. 124.1-124.2.

Folkerts, G. W. and A. C. Skorepa. 1967. A spotted turtle, *Clemmys guttata* (Schneider), from southeastern Georgia. Herpetologica 23:63.

Grobman, A. B. 1954. Report of the Director for 1953-1954. Florida State Museum. Gainesville.

Knepton, J. C., Jr. 1956. County records of Testudinata collected in Georgia. J. Tennessee Acad. Sci. 31:322-324.

Neill, W. T. 1954. Ranges and taxonomic allocations of amphibians and reptiles in the southeastern United States. Publ. Res. Div. Ross Allen's Reptile Inst. 1:75-96.

———. 1957. Historical biogeography of present-day Florida. Bull. Florida State Mus. 2:175-220.

Florida Sci. 36(2-4):198-200. 1973.

PUGHEADEDNESS IN THE FLORIDA LARGEMOUTH BASS *MICROPTERUS SALMOIDES FLORIDANUS* (LESUEUR)

Robert L. Chew

Texas Parks and Wildlife Department, John H. Reagan Building, Austin, Texas 78701

Abstract: *This first report is based upon both a female and male which were examined with subsequent observations on the skull of the more deformed female. Nearly all bones were modified by being thinner and mis-shapen compared to normal.*

Pugheadedness is a widespread anomaly among fishes as indicated by the numerous references compiled by Dawson (1964, 1966). The only previous report of a pugheaded specimen within the Family Centrarchidae was by Herrick in 1885. To my knowledge, this is the first report of this anomaly occurring in *Micropterus salmoides floridanus.* Observations on the sexual maturity of the specimens and on the cleaned skull of the female are also included.

The first pugheaded specimen was captured April 4, 1968, by electroshocker at night in the Oklawaha River at Orange Springs, Marion County, approximately 10 miles upstream from the Rodman Dam. This 302 mm (standard length) female weighed 563 g and had a "K" value of 2.04. The specimen had dehydrated considerably by the time it was obtained by the author and although corrective measures were attempted, the "K" value is thought to be lower than its true condition. Its ovaries were large and turgid (2.7% body weight) indicating that it might have successfully spawned.

The second specimen, a 250 mm (s.l.) male, was captured January 22, 1969, by electroshocker in Lake Weir, Marion County. It weighed 406 g and had a "K" value (2.59) which compares favorably with condition factors of other largemouth bass obtained within Lake Weir. Well developed testes indicated that the specimen might be capable of reproducing.

Bailey and Hubbs (1949) and Buchanan (1968) used as a character index to differentiate *M. s. floridanus* from *M. s. salmoides* the sum of the number of scale rows above and below the lateral line, around the caudal peduncle, on the cheek, and the number of scales along the lateral line. Three counts were made for each of the five scale characters and an average character index was obtained for each specimen. The character index for both the female (137) and the male (136) were within that range (135 to 142) established by Bailey and Hubbs (1949) for *M. s. floridanus.*

Pugheadedness was most pronounced in the female (Fig. 1). Although an increase in size would increase the disfiguration, it is felt that the male was actually pugheaded to a lesser degree. Only the female had the highly pigmented tongue which sometimes accompanies pugheadedness (Herrick, 1885; Mansueti, 1960). It is possible the pigmentation of the tongue may be related to the extent of the anomaly.

Both specimens possessed typical pugheaded features of acutely steep forehead, exophthalmic eyes, pushed in snout, and shortened maxilla. Neither had overly enlarged teeth. Radiographs of both specimens indicated modification of the frontals, parasphenoid, nasals, and vomer.

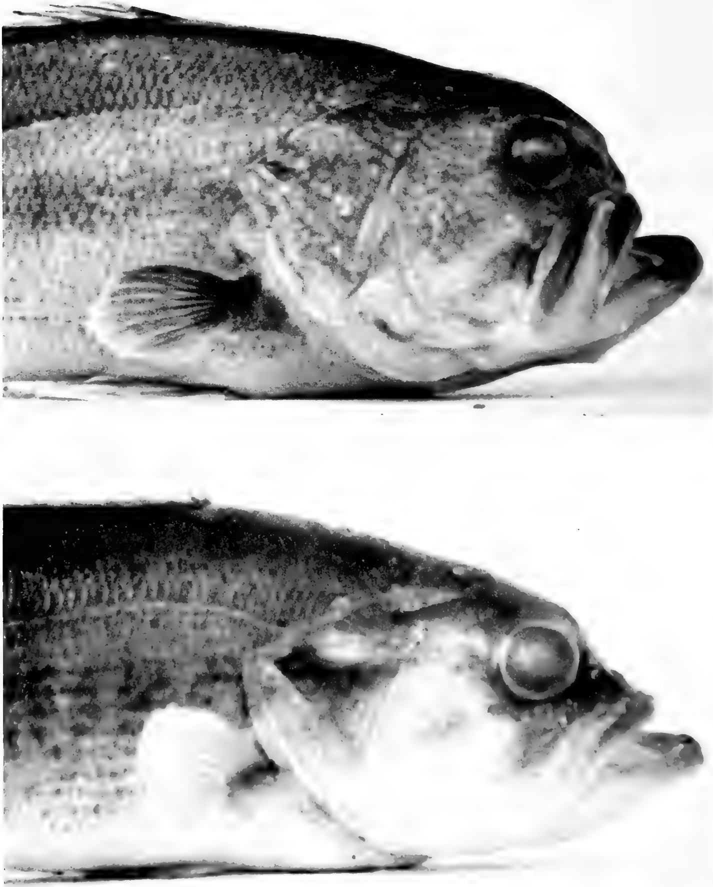

Fig. 1. Florida largemouth bass (*Micropterus salmoides floridanus*). Pugheaded female (top), 302 mm standard length; and male (bottom), 250 mm standard length.

Fig. 2. Skull of pugheaded female (top), and typical Florida largemouth bass specimen (bottom), 302 mm and 305 mm standard length, respectively. Note considerable modification of vomerine tooth patch.

The skull of the female and that of a comparable sized, typical largemouth bass were cleaned and the skeletal elements compared. Although rarely done, this procedure is recommended for skeletal anomalies since it proved most informative. Nearly all the bones of the aberrant skull were modified to some degree (Fig. 2). The frontals were atypical in that they were considerably thinner, humped over the optic capsule and curved ventrally. The prefrontals were also thinner and were considerably modified at their anteroventral ends. The parethmoid, dermethmoid, vomer and parasphenoid deviated most from the typical skull. The dermethmoid, usually lying 45° downward from a horizontal plane, was shortened and almost vertical. The vomer curved posteriorly, was elongated and covered the anteroventral portion of the parasphenoid. The vomerine tooth patch had become oval and was twice as long as wide. The parasphenoid curved dorsally within the vomer and dermethmoid and was shortened to about 50 percent of its typical length. The nasals and lacrimals were smaller, shorter and bent ventrally. The aberrant anterior bones of the skull rounded the optic capsules and certainly contributed to exophthalmia. Even the otic capsules were modified and significantly reduced in size. Foramina perforating the frontals, pre-frontals, and nasals were present but considerably altered.

Neither specimen displayed evidence of mechanical injury, but whether the anomaly was the result of genetic and/or environmental factors was undeterminable. Pugheadedness apparently did not prevent the attainment of sexual maturity for either specimen and leaves open the possibility that it could be passed on.

Acknowledgments—Acknowledgment is made to William Wegener for donation of the female pugheaded specimen. This research was supported by Federal Aid in Fish and Wildlife Restoration Funds, Project F-24-R, and by the State of Florida Game and Fresh Water Fish Commission.

LITERATURE CITED

Bailey, R. M., and C. L. Hubbs. 1949. The black basses (*Micropterus*) of Florida, with a description of a new species. Occ. Pap. Mus. Zool. Univ. Michigan. 516:40 pp.

Buchanan, J. P. 1968. A meristic and morphometric comparison of Arkansas largemouth bass, *Micropterus salmoides salmoides* (Lecepede) and the Florida subspecies, *Micropterus salmoides floridanus* (LeSueur). Unpublished M. S. thesis. Univ. of Arkansas. Fayetteville.

Dawson, C. E. 1964. A bibliography of anomalies of fishes. Gulf Res. Repts. 1:309-399.

__________. 1966. A bibliography of anomalies of fishes—supplement 1. Gulf Res. Repts. 2:169-176.

Herrick, F. H. 1885. An abnormal black bass. Science 6:243-244.

Mansueti, R. J. 1960. An unusually large pugheaded striped bass, *Roccus saxatilis*, from Chesapeake Bay, Maryland. Chesapeake Sci. 1:111-113.

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FRESHWATER ALGAE FROM THE DADE-COLLIER JETPORT

Norman Richardson

Department of Biology, University of Miami, P. O. Box 9118, Coral Gables, Florida 33124
[Presently: Department E.P.O. Biology, Colorado University, Boulder, Colorado 80302]

Abstract: *Samples taken June-August, 1970, yielded 72 Cyanophyta, 46 Chlorophyta, 3 Euglenophyta, 44 Chrysophyta, and 2 Pyrrophyta.*

In conjunction with the initial Jetport Survey conducted during the months of June-August, 1970, a preliminary checklist of freshwater algae was assembled from 27 samples taken from the study area. Preliminary floristic lists for freshwater algal materials occurring in the south Florida area must be assembled before comparative studies can be initiated (Nielsen and Madsen, 1948a, b; Madsen and Nielsen, 1950).

Materials and Methods—Field materials were collected from sediment and water samples and preserved in Carbowax (polyethylene glycol). Both living and preserved materials were examined. Microscopic determination of species composition employed the following taxonomic publications: Smith, 1950; Desikachary, 1959; Bourrelly, 1966, 1968, 1970; Leedale, 1967. No quantitative observations were possible due to the short sampling period and the generic diversity of the samples. Liquid preserved samples are available at the University of Miami for reference.

Discussion—Palmer (1969) has assembled a composite rating of algae tolerating organic pollution, taken from 165 authorities. While certain of the 60 genera listed by Palmer occur in the following checklist, there was an absence at this time of conventional pollution indicators in the Jetport samples.

Although all samples were rich in genera of Cyanophyta, in no sample were they the dominant form. However, the generic diversity of Cyanophyta in these samples could provide the base for marked shifts in composition of populations were conditions in the study altered by natural or artificial causes.

Few living diatoms were seen in the samples, although many frustules and auxospores were present. Many palmelloid forms of Chrysophyta were observed. Both of these observations underscore the potential seasonal variation in composition of populations.

A noteworthy observation on these samples is the apparent restriction of morphological types. The three principal groups found in these samples—the Chlorophyta, Chrysophyta and Cyanophyta—illustrate similar morphological trends. Each group shows elaboration of unicellular, palmelloid and filamentous modes of thallus constructions. In the observed samples, filamentous forms were largely absent in all three groups.

LIST OF SPECIES

CYANOPHYTA

Anabaena sp.
Anabaena ambigua Rao
Anabaena variabilis Kütz. *ex* Born. & Flah
Anabaena variabilis v. *kashiensis* (Bharadw.) Fritsch
Aphanizomenonflos-aquae (L.) Ralfs
Aphanocapsa koordersi Strom
Aphanocapsa pulchra (Kütz.) Rab.
Aphanothece sp.
Aphanothece microscopica Näg.
Aphanothece clathrata West & West
Arthrospira spirulinoides Ghose
Chroococcus sp.
Chroococcus minutus (Kütz.) Näg.
Chroococcus pallidus Näg.
Chroococcus turgidus (Kütz.) Näg.
Chroococcus varius A. Br.
Closteriospira lemanensis Reverdin
Cylindrospermum michailovskoense Elenkin
Dactylococcopsis raphidioides Hansg.
Glaucocystis sp.
Gloeocapsa calcarea Tilden
Gloeocapsa compacta Kütz.
Gloeocapsa crepidinum Thuret
Gloeocapsa nigrescens Näg.
Gloeocapsa pleurocapsoides Nck.
Gloeocapsa polydermatica Kütz.
Gloeocapsa punctata Näg.
Gloeothece linearis Näg.
Lyngbya sp.
Lyngbya contorta Lemm.
Lyngbya limnetica Lemm.
Lyngbya perelegans Lemm.
Marssoniella elegans Lemm.
Mastigocoleus testarum Lagerh.
Merismopedia marssonii Lemm.
Merismopedia tenuissima Lemm.
Microcoleus vaginatus (Vauch.) Gom.
Microcystis aeruginosa Kütz.
Microcystis elabens (Bréb.) Kütz.
Microcystis protocystis Crow
Microcystis pseudofilamentosa Crow
Microcystis robusta (Clark) Nygaard
Microcystis viridis (A. Br.) Lemm.
Myxosarcina spectabilis Geitler
Nodularia spumigena Mert.
Nostoc calcicola Bréb.
Nostoc carneum Ag.
Nostochopsis sp.
Nostochopsis hansgirgi Schmidle
Oocystis crassa Wittr.
Oscillatoria amonea Gom.
Oscillatoria limosa Ag.
Oscillatoria pernornata f. *attenuata* Skuja
Oscillatoria splendida Grev.
Phormidium muscosum Rao
Phormidium purpurascens (Kütz.) Gom.
Rhizoclonium hieroglyphieum (Ag.) Kütz
Rivularia sp.
Schizothrix lacustris A. Br.
Schizothrix vaginata (Näg.) Gom.
Scytonema subtile Moeb.
Spirulina sp.
Spirulina major Kütz.
Spirulina princeps G. S. West
Spongiococcum alabamense Deason
Stichosiphon regularis Geitler
Stigeoclonium tenue Kütz.
Symploca cartilaginea (Mont.) Gom.
Symploca muscorum (Ag.) Gom.
Synechococcus aeruginosus Näg.
Tolypothrix tenuis Kütz
Xenococcus Schousboei Hansg.

CHLOROPHYTA

Actinotaenium elongatum (Racib.) Teil.
Ankistrodesmus falcatus (Corda) Ralfs.
Ankistrodesmus falcatus v. *radiatus* (Chod.) Lemm.
Ankistrodesmus gelifactum (Chod.) Bourr.
Chlorallanthus ablongus Pascher
Chlorococcum wimmeri Rabenh.
Chlorolobion obtusum Korch.
Chlorosarcina stigmatea Deason
Cladophora sp.
Cladophora glomerata (L.) Kütz
Closteriopsis longissimum v. tenuissimum G. M. Smith
Closterium acerosum (Schrank) Ehr.
Closterium biclavatum Börg.
Closterium braunii Reinsch
Closterium setaceum v. *vittatum* Gronbl.
Cosmarium binum Nordst.
Cosmarium botrytis Menegh.
Cosmarium circulare Reinsch
Euastrum didelta (Turp.) Ralfs.
Euastrum turgidum Wall.
Hydrodictyon sp.
Hydranium gracile Korch.
Kirchneriella elongata G. M. Smith
Micrasterias foliacea v. *ornata* Nordst.
Planctonema lauterbornii Schmidle
Pleurotaenium minutum v. *excavatum* Scott
Pleurotaeneum trabecula (Ehrg.) Näg.
Podohedra longipes Düringer
Schroederia setigera Lemm.
Sphaerobotrys fluviatilis Butch.
Spondylosium planum (Wolle) W. & W.
Spongiochloris spongiosa (Vischer) Starr
Staurastrum elongatum Barker
Staurastrum leptocladum v. cornutum Wille
Staurastrum sebaldi
Staurastrum subcruciatum Cook & Wille

Cosmarium nastum f. *granulatum* Nordst.
Cymbella lanceolata (Ehr.) Brun.
Dactylococcopsis sp.
Dactylococcopsis raphidioides Hansg.
Euastrum bidentatum Näg.
Staurastrum teliferum v. *lagoense* Wille
Stauroneis sp.
Stauroneis anceps Ehr.
Tetmemorus brebissonii (Menegh.) Ralfs.
Tomaculum catenatum White

EUGLENOPHYTA
Euglena deses Ehr.
Phacus sp.
Trachelomonas sp.

CHRYSOPHYTA
Achnanthes coarctata (Bréb.) Grun.
Achnanthes lanceolata (Bréb.) Grun.
Actinella sp.
Actinotaenium subglobulosum (Nordst.) Teil.
Amphicampa eruca Ehr.
Amphipleura sp.
Amphipleura pellucida Kütz.
Amphora ovalis Kütz.
Asterionella formosa Hass.
Brebissonia Boeckii (Ehr.) Grun.
Caloneis silicula (Ehr.) Cleve.
Chrysocapsa planctonica (W. & G. S. West) Pascher
Closterium sp.
Closteriospira lemanensis Reverdin
Cocconeis pediculus Ehr.
Cocconeis placentula v. *lineata* (Ehr.) Cleve.
Coscinodiscus lacustris Grun.
Cosmarium regnellii Wille
Denticula sp.
Diatoma vulgare Bory
Diatomella sp.
Epithemia zebra (Ehr.) Kütz.
Eunotia sp.
Eunotia pectinalis (Kütz.) Rab.
Fragilaria sp.
Fragilaria crotonensis v. *praelonga* Grun.
Frustulia rhomboides (Ehr.) DeToni
Gomphonema vibrio Ehr.
Gyrosigma acuminatum (Kütz.) Cleve.
Hantzschia sp.
Hantzschia amphioxys (Ehr.) Grun.
Mestogloia Danseii Thw.
Navicula gracilis Ehr.
Pinnularia viridis (Nitzsch) Ehr.
Pleurosigma sp.
Pleurosigma delicatulum W. Smith
Rhopalodia gibba (Ehr.) Müller
Stauroneis anceps Ehr.
Synedra splendens Kütz.
Synura splendens Kütz.
Synura uvella Ehr.
Tabellaria fenestrata (Lyngb.) Kütz.
Tabellaria fenestrata v. *asterionelloides* Grun.
Tetracyclus rupestris (A. Br.) Grun.

PYRROPHYTA
Glenodinium uliginosum Schilling
Hypnodinium sphaericum Klebs

The exceedingly short collection period of the present study makes these observations little more than cursory at the present time. It is imperative that floristic studies be completed over a 12-month period in order that seasonal variation, a well recognized character of freshwater algal populations, be observed. These studies are currently in progress.

ACKNOWLEDGMENTS—This research was supported by grant B7360R from the Dade County Port Authority.

LITERATURE CITED

BOURRELLY, P. 1966. Les algues d'eau douce. Tome I. Les algues vertes. Editions N. Boubée et Cie. Paris.

__________. 1968. Les algues d'eau douce. Tome II. Les algues jaunes et brunes: Crysophycées, Pheophycées, Xanthophycées et Diatomées. Editions N. Boubée et Cie. Paris.

__________. 1970. Les algues d'eau douce. Tome III. Les algues bleues et rouges, les Eugléniens, Peridiniens et Cryptomonadines. Editions N. Boubée et Cie. Paris.

DESIKACHARY, T. V. 1959. Cyanophyta. Academic Press and Indian Council of Agr. Res., New Delhi.

LEEDALE, G. F. 1967. Euglenoid flagellates. Prentice Hall. Englewood Cliffs, New Jersey.

MADSEN, G. C. AND C. S. NIELSEN. 1950. Check list of the algae of northern Florida. II. Quart. J. Florida Acad. Sci. 13:3-21.

NIELSEN, C. S. AND G. C. MADSEN. 1948a. Check list of the algae of northern Florida. I. Quart. J. Florida Acad. Sci. 11:63-66.

———, AND ———. 1948b. Preliminary check list of the algae of the Tallahassee area. Quart. J. Florida Acad. Sci. 11:111-117.

PALMER, M. 1969. A composite rating of algae tolerating organic pollution. J. Phycol. 5:78-82.

SMITH, G. M. 1950. The Fresh Water Algae of the United States. McGraw-Hill. New York.

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Biological Sciences

RANGE EXTENSION OF *PENAEUS SETIFERUS* (LINNAEUS) TO TAMPA BAY, FLORIDA

CARL H. SALOMAN

National Marine Fishery Service, Panama City Laboratory,
P. O. Box 4218, Panama City, Florida 32401

ABSTRACT: *The large male taken measures 34.6 mm carapace length and 161 mm total.*

A LARGE MALE white shrimp (*Penaeus setiferus*) in excellent condition was presented to me by Carl Razor (Fishery Reporting Specialist, National Marine Fisheries Service) in Tampa, Florida, for identification. He was given the specimen by a shrimp boat captain who caught it while shrimping in the vicinity of Gadsden Point, Tampa Bay, on March 23, 1972. The shrimp measures 34.6 mm carapace length and 161 mm total length. This marks the first occurrence of *P. setiferus* in the Tampa Bay area.

The distribution and taxonomic status of the commercial penaeid shrimps of the genus *Penaeus* were recently summarized by Farfante (1969). The published range of the species is from Fire Island, New York, to Campeche, Mexico, and in Florida, south on the east coast to St. Lucie and from Apalachicola Bay westward.

In the Gadsden Point area of Tampa Bay, the range of mean annual salinity is 22.8 to 24.3 ppt (Taylor and Saloman, 1967) and turbidity is relatively high because the area borders Hillsborough Bay, which is the most turbid part of Tampa Bay (Taylor and Saloman, 1970). The bottom substrate in this area consists mostly of silt and clay and has a high organic content (Taylor and Saloman, 1969) due to high levels of domestic and industrial wastes, upland drainage, and stream discharge into Hillsborough Bay (Taylor, Hall, and Saloman, 1970). The species occurs elsewhere in this type of habitat (Farfante, 1969).

LITERATURE CITED

FARFANTE, I. P. 1969. Western Atlantic shrimps of the genus *Penaeus*. U. S. Fish Wild. Serv. Fish. Bull. 67:461-591.

TAYLOR, J. L., J. R. HALL, AND C. H. SALOMAN. 1970. Mollusks and benthic environments in Hillsborough Bay, Florida. U. S. Fish Wildl. Serv. Fish. Bull. 68:191-202.

———, AND C. H. SALOMAN. 1967. Benthic project. *In* Report of the Bur. of Comm. Fisheries Biol. Lab., St. Petersburg Beach, Florida, 1966, p. 4-8. U. S. Fish Wildl. Serv. Circ. 257.

———, AND ———. 1969. Sediments, oceanographic observations, and floristic data from Tampa Bay, Florida, and adjacent waters, 1961-65. U. S. Fish Wild. Serv. Data Rep. 34. 562 pages in 9 microfiche.

———, AND ———. 1970. Benthic project. *In* Report of the Bureau of Commercial Fisheries Biological Laboratory, St. Petersburg Beach, Florida, 1969. U. S. Fish Wildl. Serv. Circ. 342:3-10.

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Biological Sciences

RANGE EXTENSIONS FOR THE SCORPIONFISH *SCORPAENA ISTHMENSIS*

JOHN D. MCEACHRAN AND WILLIAM N. ESCHMEYER

Virginia Institute of Marine Science, Gloucester Point, Virginia 23062
[Now: Department of Wildlife and Fisheries Sciences,
Texas A. & M. University, College Station, Texas 77843];
California Academy of Sciences, San Francisco, California 94118

ABSTRACT: *New localities are cited off Honduras, Yucatán, Florida and North Carolina for this species which is best known from southern tropical Atlantic coastal waters.*

THE SCORPIONFISH *Scorpaena isthmensis* Meek and Hildebrand was previously reported from the Atlantic coast of Panama to Rio de Janeiro, Brazil, and considered a rarity from Panama to Columbia (Eschmeyer, 1965, 1969). On November 13, 1969, a specimen of *S. isthmensis* was captured off the coast of North Carolina (34°25.5′ N, 76°19′W) in 15 fms (27.4 m). Examination of scorpaenids housed at the Tropical Atlantic Biological Laboratory (TABL) and the University of Miami Marine Laboratory (UMML) reveals that unreported specimens of *S. isthmensis* have been captured at four additional localities north of Panama (Fig. 1). It is likely that the species regularly occurs along certain portions of the east coasts of Central America and the southeastern United States.

Locality data for the new records are as follows: TABL 106085 (1, 130 mm SL) 15°45′N, 83°32′W, 18-20 fms, (off Honduras) UNDAUNTED STA. 6703, 60 ft trawl, 9 April 1967; TABL 107580 (4, 113-152 mm SL) 29°44′N, 80°26.5′W, 20 fms, (off Florida) SILVER BAY STA. 5587, otter trawl, 12 March 1964; TABL 107581 (1, 118 mm SL) 29°45.5′N, 80°28′W, 19 fms, (off Florida) SILVER BAY STA. 5495, 27 February 1964; UMML 27020 (1, 79 mm SL) 21°13′N, 86°25′W, 30-90 fms, (off Yucatán Peninsula, Mexico) PILLSBURY STA. 588, 10 ft trawl, 14 March 1967; VIMS (Virginia Institute of Marine Science) 990 (1, 116 mm SL) 34°25.5′N, 76°19′W, 15 fms, (off North Carolina) EASTWARD STA. 13307, try net, 13 November 1969.

Fig. 1. Distribution (in part) of the Scorpionfish *Scorpaena isthmensis*. Solid circles from Eschmeyer (1969), specimens from Rio de Janeiro not shown. Stars represent new records.

Scorpaena isthmensis resembles *Scorpaena bergi* Evermann and Marsh, particularly in having a dark blotch on the spinous dorsal fin, but can be distinguished from the latter by the pectoral fin ray count, length of the second anal spine in relation to the third anal spine, coloration, and nature of the suborbital ridge (Eschmeyer, 1965). The northern specimens of *S. isthmensis* differ only slightly from the southern specimens reported by Eschmeyer (1965). Fin ray counts, scale counts and coloration are the same. All eight new specimens have a dorsal ray count of XII, 9-1/2; anal fin rays III, 5-1/2; and pectoral rays 18. The southern specimens have a gill raker formula of 4 - 5+9 - 10 (Eschmeyer, 1965), whereas the northern specimens have a formula of 4 - 5+9 - 11. Measurements are similar (Table 1). The slight differences in some of the ranges of body parts as a percentage of standard length (SL) are probably not populational differences but are caused by the larger size of the northern specimens. The 152 mm SL specimen reported here is the largest known.

Scorpaena isthmensis appears to be a "continental" species, as no specimens have been reported from the Bahamas or the eastern Caribbean Sea. It occurs with *S. calcarata* and other scorpionfishes in many areas but is unknown from the west coast of Florida or in the northern and western Gulf of Mexico. Depths of captures for *S. isthmensis* range from 8 to 55 fms, except one taken from 5 ft of water at Curacao (Eschmeyer, 1965). *S. calcarata* inhabits coastal waters from the southeastern United States, around Florida, the northern Gulf of Mexico, the western and southern Caribbean Sea, and south to Brazil (Eschmeyer, 1965, 1969). *S. isthmensis* sometimes occurs with the more widely ranging species, *S. brasiliensis,* and occasionally has been captured with the offshore "continental" species, *S. agassizii.* Its habitat is similar to that of the less frequently collected *S. dispar. S. agassizii, S. dispar,* and *S. brasiliensis* have distributions similar to that of *S. calcarata. S. isthmensis* should be looked for at Tortugas shrimp grounds off Florida and in the northern and western Gulf of Mexico, but it may be excluded from these areas by subtle habitat differences or competition with other fishes.

Smooth cheek scorpionfish, in reference to the lack of spines on the suborbital ridge, is proposed as the vernacular name for *S. isthmensis* since this species will be an addition to the American Fisheries Society list of common names checklist.

The North Carolina specimen of *S. isthmensis* was collected by J. A. Musick of VIMS on the *R/V Eastward* through the cooperation of the Duke University Marine Laboratory and the Cooperative Program of Biological Oceanography, National Science Foundation Grant GB—8189. George C. Miller and Phillip C. Heemstra (TABL), C. Richard Robins (UMML), and Katherine Smith and Maurice Giles (California Academy of Sciences) assisted in the preparation of this note; Contribution No. 647, VIMS.

TABLE 1. Range and proportional measurements observed in northern and southern specimens of *Scorpaena isthmensis* expressed as percentage of standard length.

	Northern Specimens	Southern Specimens[a]
Number of specimens	8	°[b]
Range in standard length	74-152 mm	2[b]
Head Length	39-47	41-48
Jaw Length	21-25	20-24
Orbit Diameter	10-13	10-14
Snout Length	11-13	9-13
Length of Third Dorsal Spine	14-17	15-18
Pectoral Fin Length	28-36	30-36
Predorsal Fin Length	32-38	33-39
Interorbital Width	4-5	4-6
Body Depth	34-41	31-38
Caudal Fin Length	27-32	29-34
Orbit Diameter/Snout Length	0.8-1.1	0.9-1.5

[a]Eschmeyer, 1965.
[b]See Eschmeyer, 1965, pp. 104, 148-156.

LITERATURE CITED

ESCHMEYER, W. N. 1965. Western Atlantic scorpionfishes of the genus *Scorpaena,* including four new species. Bull. Mar. Sci. 15:84-164.

————. 1969. A systematic review of the scorpionfishes of the Atlantic Ocean (Pisces: *Scorpaenidae*). Occ. Pap. Calif. Acad. Sci. 79:1-143.

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DISCOVERY OF THE GASTROPOD SNAIL *MELANOIDES (THIARA) TUBERCULATA* (MULLER) IN FLORIDA

THOMAS N. RUSSO

U. S. Geological Survey, Miami, Florida 33130

ABSTRACT: *The first known colonies of the oriental snail* Melanoides tuberculata *were collected in South Florida in 1971. The snails were found in both fresh and brackish canal waters.* Melanoides *is also known to be an intermediate host of a human parasite* Philohthalmus *sp. Both the snail and the parasite are prevalent in the Orient and have been reported in San Antonio, Texas. The potential for human infestation does exist in Florida with the presence of the intermediate host but is probably unlikely.*

I COLLECTED *Melanoides* in south Florida from the Pompano and Middle River Canals in 1971. Subsequent identification of the snails as *Melanoides (Thiara) tuberculata* was made by Dr. Fred Thompson, malacologist at the University of Florida. This identification was later confirmed by Drs. Henry van der Schalie and Gary Pace at the University of Michigan. At this time, these appear to be the only known colonies found in Florida.

The populations of *M. tuberculata* at the two canal sites in south Florida are well established as indicated by their abundance (Table 1) and the presence of juvenile and adult animals. The average numbers of snails, collected with an Ekman dredge, were 130 per sq m at the Pompano Canal and 216 per sq m at the Middle River Canal.

TABLE 1. *Population of* M. TUBERCULATA *collected on March 28, 1972 with an Ekman dredge in south Florida.*

Site	Depth in feet	Substrate	Number of samples	Average no. per sq meter	Range no. per sq meter
Pompano Canal	0-2	Sand	4	211	177-222
Pompano Canal	3-6	Algae*	4	133	88-177
Pompano Canal	0-6	Sand and algae*	8	172	88-222
Middle River Canal	0-3	Sand and rock	8	205	133-266

**Cladophora sp.*

Melanoides tuberculata tolerates a relatively wide range of salinity conditions in south Florida. The Pompano Canal site is a fresh water habitat with an average chloride of 40 mg/l, while the Middle River site is estuarine with chloride concentrations ranging between 230 to 2,200 mg/l, (0.4-4.3°/₀₀ sea water). Because of this tolerance and the interconnecting canal system, *M. tuberculata* can be expected to spread, if it has not already done so, throughout south Florida.

The genus *Thiara* is well known as an intermediate host of several trematode parasites of man such as the oriental lung fluke *Paragonimus* sp. and *Philophthalmus* sp. (Abbott, 1952). Human infestation by *Philophthalmus* sp. has only been reported on two occasions in Belgrade, 1939 and Ceylon, 1958. However in San Antonio, Texas the rediae (free living larval stages) of the trematode *Philophthalmus* sp., have been isolated from *M. tuberculata* and the adult parasite from the eyes of ducks (Murray and Haines, 1966).

The cercariae (larval stages) of *Philophthalmus* sp. have also been reported in the fresh water snails *Goniobasis* sp. in Indiana (West and Fisher, 1959) and *Tarebia granifera mauiensis* in Hawaii (Alicatta, 1962). In addition, *Philophthalmus hegeneri* also utilizes the marine snail *Batillaria minima* as an intermediate host along the Gulf coast of Florida (Penner and Fried, 1963).

The fact that metacercariae encyst on hard objects and would have to be ingested raw by man suggests that unless we change our food habits drastically, these worms pose little threat to human health (F. J. Vane Vusse, personal communication, 1973).

The likelihood of human infestation from this parasite in south Florida is probably small. However, the potential for human infestation does exist there as elsewhere in the United States where the potential host, *M. tuberculata* is present.

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LITERATURE CITED

ABBOTT, R. T. 1952. A study of the intermediate snail host (*Thiara granifera*) of the oriental lung fluke (*Paragonimus*). Proc. U. S. Nat. Mus. 102:71-116.

ALICATA, J. E. 1962. Life cycle and developmental stages of *Philophthalmus gralli* in the intermediate and final hosts. J. Parisit. 48:47-54.

MURRAY, H. D. AND D. HAINES. 1966. *Philophthalmus* sp. (Trematode) in *Tarebia granifera* and *Melanoides tuberculatus* in south Texas. Ann. Rpt. Amer. Malacol. Union, p. 44-45.

PENNER, L. R. AND B. FRIED. 1963. *Philophthalmus hegeneri* sp. n., an ocular trematode from birds: J Parisit. 49: 974-977.

WEST, A. F. AND F. M. FISHER. 1959. The life history of a species of *Philophthalmus* (Trematoda: Philophthalmidae). J. Parisit. 45 (suppl.): 60.

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RANGE EXTENSION OF *CENTROPRISTIS STRIATA MELANA*

William N. Lindall, Jr., William A. Fable, Jr., and L. Alan Collins

NMFS Biological Laboratory, St. Petersburg Beach, Florida 33706

Abstract: *The known range of the fish is extended about 100 miles southward.*

Two juveniles of *Centropristis striata melana* Ginsburg were collected in the Gulf of Mexico off the mouth of the Harney River, Everglades National Park, Florida (25°25′N; 81°11′W) on November 3, 1971. The specimens measured 144 and 149 mm total length and were taken at ebb tide in water 1.2 m deep with a 4.8 m otter trawl that had a 6.3 mm mesh inner liner. When the fishes were netted, water temperature was 26.7°C, salinity was 27.2°/$_{00}$, and dissolved oxygen measured 4.6 ml/1.

This collection extends the known range of *C. s. melana* some 100 miles south of its previously reported southern limit in Charlotte Harbor, Florida (Miller, 1959; Wang and Raney, 1971). Its known northern range limit is Pensacola, Florida (Miller, 1959), and the fish occurs in greatest numbers between Apalachee Bay and lower Tampa Bay (Godcharles, 1970).

At present there is still some controversy concerning the proper taxonomic position of the specimens collected. Ginsburg (1952) separated the Gulf coast and Atlantic coast populations into two species, *Centropristes melanus* and *C. striatus*, respectively. Miller (1959) questioned this differentiation at the species level and provided the subspecific classifications of *Centropristes striatus melanus* and *C. s. striatus* for fishes of the two populations. Briggs (1960) corrected Ginsburg's spelling to *Centropristis melana* and *C. striata.* Godcharles (1970) used the subspecific designation and spelling of Miller (1959), and Wang and Raney (1971) used both the subspecific classification and the revised spelling. Taxonomic characters of the two specimens in our collection corresponded to those selected by Miller for *C. s. melanus,* and we used the revised spelling of Briggs to arrive at the name, *Centropristis striata melana.* Dr. Ronald Baird, Marine Science Institute, University of South Florida, St. Petersburg, Florida, confirmed our identification.

Further collections are needed in the area where the two specimens were taken to determine if there is overlap of the Atlantic and Gulf coast populations, or if they are truly allopatric as Ginsburg (1952) suggested.

LITERATURE CITED

Briggs, J. C. 1960. The nomenclature of *Centropristis*, Cuvier, 1829. Copeia 1960(4):358.

GINSBURG, I. 1952. Eight new fishes from the Gulf coast of the United States, with two new genera, and notes on geographic distribution. J. Wash. Acad. Sci. 42:84-101.

GODCHARLES, M. F. 1970. Exploratory fishing for southern sea bass, *Centropristes striatus melanus*, in the northeastern Gulf of Mexico. Florida Dept. Nat. Res. Tech. Ser. 63:1-26.

MILLER, R. J. 1959. A review of the sea basses of the genus *Centropristes* (Serranidae). Tulane Stud. Zool. 7:35-68.

WANG, J. C. S., AND E. C. RANEY. 1971. Distribution and fluctuations in the fish fauna of the Charlotte Harbor estuary, Florida. Charlotte Harbor Estuarine Stud., Mote Marine Lab. 56 pp. + appendices.

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Biological Sciences

MELANISM IN FLORIDA BOBCATS

JOHN PARADISO

U. S. Fish and Wildlife Service, Office of Endangered Species, Washington, D.C. 20240

ABSTRACT: *A nearly black female bobcat was collected in Polk County, Florida, in October, 1970. Melanistic bobcats have been reported only 4 times previously, with all reports from southern Florida.*

MELANISM appears to be quite rare in the North American bobcat (*Lynx rufus*), as only four melanistic specimens have been recorded in the literature. Hamilton reported on a pair trapped between Clewiston and Belle Glade, Palm Beach County, Florida, in February 1940. He described the coloration of these animals as being dark brown, shading to black on the back and speckled with white hairs. The spots were visible when the skin was held at an angle. Ulmer reported on two melanistic specimens taken in Martin County, Florida, about 14 miles above the mouth of the Loxahatchee River. One was trapped on 18 April 1939, and ultimately deposited as a study skin in the collection of the Academy of Natural Sciences of Philadelphia; the other was trapped in January 1940, and was kept on exhibition in the Bronx Park Zoo. Ulmer described the Academy specimen as being far from black. He said the most heavily pigmented portions were on the crown and dorsal area. In most lights these areas appeared black, but at certain angles the dorsal stripes had a decidedly mahogany tint. The mahogany coloring became lighter and richer on the sides, and he described the underparts as being lightest, almost ferruginous in color. The chin, throat and cheeks were a dark chocolate brown, but the facial stripes were clearly visible on the sides, underparts and limbs. Ulmer stated that the Bronx Park animal appeared darker and the spots were not visible, although the poor light in the quarantine room may have been the reason.

Recently another melanistic bobcat was called to my attention. On 23 November 1970, Mr. George Tregembo of Tote-Em-In Zoo in Wilmington, North Carolina, wrote me that he had obtained a live female specimen of *Lynx rufus* that was coal black in coloration. Tregembo stated that the cat was taken in a cage trap in the latter part of October 1970, in the town of Loughman, Polk County, Florida, where it had been reported to be feeding on the poultry raised locally. I visited Mr. Tregembo at the Tote-Em-In Zoo on 5 February 1971, and examined the live animal closely in good light (Fig. 1). At a distance of 2-1/2 ft or more, it does appear to be entirely black, but at closer range it can be seen that the belly and legs are actually mahogany in coloration. Also, at close range a few white hairs are visible, scattered over the entire body. When viewed at certain angles, a trace of spotting on the sides and banding on the legs is faintly evident. Tregembo and I feel that the cat can be no more than two and a half years old as the teeth are in very good and sharp condition. The body size is that of an average female Florida cat of that age; the weight was 20 lbs. when I examined the animal, but Tregembo tells me that when captured it appeared to weigh less. The length of the tail is 4-1/2 inches.

Fig. 1. Melanistic female bobcat from Loughman, Polk County, Florida. Photograph courtesy of George Tregembo, Tote-Em-In Zoo, Wilmington, North Carolina.

It is of interest to note that the latest specimen of a melanistic bobcat is also from southern Florida; nowhere in the literature is there a report of melanism in this species from elsewhere in North America. As Ulmer noted, melanism in the Felidae is extremely rare outside the tropics and subtropics. Perhaps the Florida race of the bobcat would have a greater tendency toward melanism than other subspecies of *Lynx rufus* since in its common color phase it is the darkest known form of the species.

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MOSQUITO FLIGHT AND NIGHT RELATIVE HUMIDITY IN FLORIDA

Maurice W. Provost

Florida Medical Entomology Laboratory, State Division of Health,
P. O. Box 520, Vero Beach, Florida 32960

Abstract: *Trapping of mosquitoes during the May-October breeding season revealed that flight patterns of mosquitoes had strong correlation with RH 90 percent or more during evening twilight. In Florida the likelihood of high nighttime RH varies seasonally and geographically, but these differences are obscured when only mean RH values are considered. Humidity may be more important than temperature as a flight factor in tropical and subtropical areas, and could cause geographic differences in the flight behavior of the same insect.*

In 1963 an examination of the then 8-year record of this research center's New Jersey mosquito light trap, operated nightly throughout the year, revealed that peak numbers of *Culex nigripalpus* females coincided remarkably with rainfall recorded 100 ft away, on a day-to-day basis (Provost, 1969). This prompted a statistical analysis of the data for 1959, a year of good production for this mosquito, vector of St. Louis Encephalitis (Dow, et al., 1964), and a year for which we had an excellent record of both rainfall and relative humidity (RH) at the light-trap site. In the 153 nights of the main *C. nigripalpus* breeding season, June through October, overnight collections of females several times reached into the hundreds, but a 90 percent RH 1 hr after sunset seemed to be about the lower threshold for large collections. A chi-square analysis quickly proved that collections of 10 or more females were highly correlated ($X^2 = 46.1781$ or sig. $< .001$) with RH 1 hr after sunset equal to or greater than 90 percent. Relating such collections to rainfall of 1 mm or more between noon and 2000 hr demonstrated, not surprisingly, a high order of correlation also ($X^2 = 14.7875$ or sig. $< .001$). To satisfy myself that this was not a response peculiar to *C. nigripalpus*, I performed the same 90 percent threshold analysis with two even more common mosquitoes breeding continuously in this area from May through October and therefore each furnishing 184 nights of data. Using a threshold of 20 females per night for *Anopheles crucians*, I found again a very high correlation ($X^2 = 22.1589$ or sig. $< .001$), and using a threshold of 75 females per night for *Deinocerites cancer*, a slightly less but still good correlation was established ($X^2 = 9.6863$ or sig. $< .01$). It should be pointed out that because of the great influence of moon phase on light-trap collections of mosquitoes (Bidlingmayer, 1964; Provost, 1959), sequential daily corrections were applied to the collection data in accordance with the best ratios of new moon to full moon bias I could obtain with the advice of W. L. Bidlingmayer (cf. also Bidlingmayer, 1967), viz. 3:1 for *C. nigripalpus*, 4:1 for *A.*

crucians, and 6:1 for *D. cancer.* Although more study of the mosquito response to humidity is indicated, the existence of the response is beyond doubt (Dow and Gerrish, 1970). Muirhead-Thomson (1938) in studying daytime avoidance of very high RH by *Culex fatigans* also learned that these reactions "disappeared altogether after sundown." In the same report he demonstrated that mosquitoes responded to RH and not to saturation deficiency. It is evident from the many researches cited by Clements (1963) that different mosquito species have their own moisture preferenda for various activities and that these are related to the weather in which they must be performed. These same laboratory researches have frequently revealed preferenda near or above 90 percent RH, so that our putative 90 percent threshold for *Culex nigripalpus* is by no means out of line.

Gross Geographic Differences—Realizing that night RH were going to need examination on a geographic basis, I obtained U. S. Weather Bureau data for 1968 from ten airports in Florida where RH were taken by psychrometer. Since so many of Florida's nocturnal mosquitoes put on a great burst of flying activity within the first 2 or 3 hr after sunset and since the RH at 2200 hr is both within this period and a fair indicator of the entire night's humidity regime, that particular time's RH was selected as the best to analyze. It was found (Table 1) that the year's nights with relative humidities at 2200 hr 90 percent or higher varied from 7 percent at West Palm Beach to 40 percent at Tallahassee. A geographical involvement was further evident from the fact that the five east coast stations averaged 10.7 percent compared to 22.4 percent for the three west coast stations and 33.9 percent for the two interior stations. It was also significant (Table 1) that four or more such nights in a row occurred once a year per station on the east coast while occurring almost three times per year on the west coast and over six times at the interior stations. A spot or random check with 1969 data showed that these findings for 1968 were not just peculiar for the year but very likely represented a typical year. So there was, clearly, a geographical aspect to this matter of evening RH so important to mosquito activity in Florida.

Since evening RH depend to a considerable degree on afternoon rains, which was easily demonstrated, a more precise geographical picture can be obtained by analyzing the more abundant rainfall data. Using the 3 yr, 1948-1951, when the U. S. Weather Bureau published *hourly* rainfall for a number of Florida stations, I was able to analyze 26 stations, well distributed from Pensacola to Key West. What is plotted in Fig. 1 for each station is the 3-yr avg percent of hr between 1200 and 1600 hr (white part of bar) and between 1600 and 2000 hr (black part of bar), and on a monthly basis, when more than .04 in of rain fell. With 365 days a yr and 3 yr and 4 hr per period, a large sample is involved here; for a 30-day month, the white and black portions of a bar each represent the percentage of 360 possible hr when heavy rain (arbitrarily .05 in or more) fell. The picture emerging from Fig. 1 is now very clear.

In all of Florida, heavy rains between noon and 2000 hr are more frequent from May through October (the broad bars in Fig. 1) than from November

TABLE 1. Occurrence of 2200 hr RH readings 90% or higher, by psychrometer, at ten Florida airports in 1968. (Calculated from ESSA-EDS "Local Climatological Data.")

	Consecutive days with 2200 hr RH 90% or higher											
	1	2	3	4	5	6	7	8	9	10	d./yr	%
1. Pensacola	35	9	3			1				1	78	21
2. Tampa	35	7	3	1							62	17
3. Ft. Myers	26	11	9	1	1	2			1		105	29
4. Tallahassee	23	19	14	5	1		1			1	145	40
5. Orlando	31	8	9	3	2						96	26
6. Jacksonville	33	13	1								62	17
7. Daytona	19	4	5								42	12
8. W. Palm Beach	10	5		1							24	7
9. Miami	18	2	2	2							36	10
10. Key West	14	2	3	1							31	8
					(per station)							
West Coast (1-3)	32	9	5	1	<1	1			<1	<1	82	22.4
Interior (4-5)	27	14	12	4	2		<1			<1	124	33.9
East Coast (6-10)	19	5	2	1							39	10.7
STATE (1-10)	24	8	5	1	<1	<1	<1		<1	<1	68	18.6

through April, as might be expected. But real geographical differences appear within the months May through October, the important mosquito-breeding season in Florida. There are three patterns, which I would designate in the following manner: (1) WEST FLORIDA. Only one month at one station exceeded 10 percent of possible hours between noon and 2000 hr with heavy rains. May was low at all stations. Heavy rains occurred consistently more often between noon and 1600 hr than between 1600 and 2000 hr. (2) TROPICAL FLORIDA. The two Florida Keys stations revealed astoundingly low numbers of heavy rains between noon and 2000 hr, the hr with such rains rarely exceeding 4 percent of total possible. As in the West Florida pattern, there is little difference among the months, although here heavy rains seems evenly distributed between the two afternoon periods. This tropical pattern, only partially accounted for by low rainfall in general, is gradually extenuated through Florida's subtropical region along the east coast northward to Brevard County. It is interesting that the two interior stations well below Lake Okeechobee, North New River Canal #2 and Tamiami Trail Forty-mile Bend (numbers 21 and 23 in Fig. 1), show patterns with stronger affinities to the Tropical. (3) CENTRAL FLORIDA. Throughout this largest block of the state, including the west coast, the interior, Lake Okeechobee and northward, and northeast Florida, there appears a consistent pattern. A large percentage of possible hours between noon and 2000 hr receives heavy rains, especially in the four summer months June through September, but never exceeding 20 percent in any one month. There is also a well shaped bell curve, reaching a peak in July or August. At nearly all stations there is a pretty even distribution of heavy rains between the two halves of the afternoon.

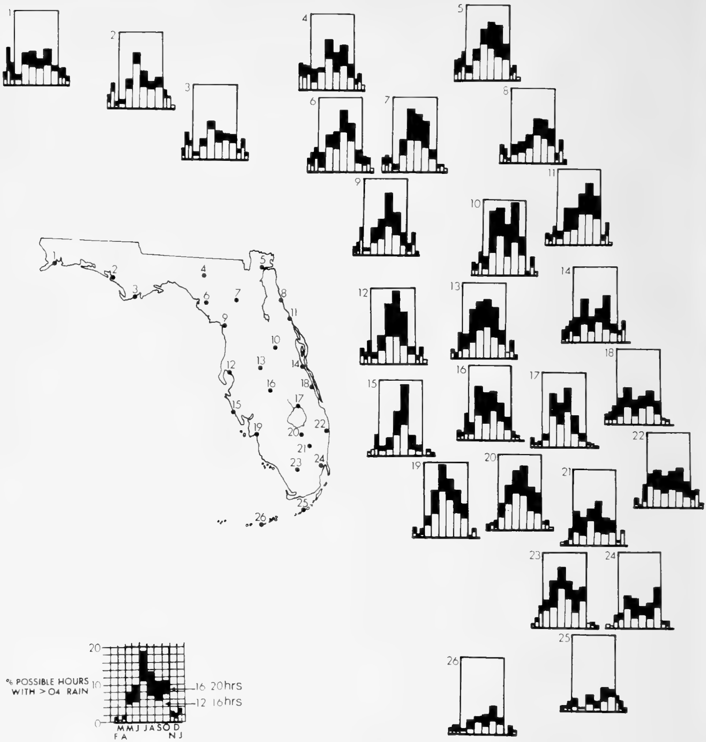

Fig. 1. Annual patterns for afternoon rains at 26 Florida stations, based on 3 years (1948-1951) of hourly data from U. S. Weather Bureau. Stations are: 1 Pensacola, 2 Panama City, 3 Apalachicola, 4 Dowling Park, 5 Jacksonville, 6 Cross City, 7 Gainesville, 8 Marineland, 9 Inglis, 10 Orlando, 11 Daytona Beach, 12 Tampa, 13 Lake Alfred, 14 Melbourne, 15 Venice, 16 Avon Park, 17 Okeechobee, 18 Vero Beach, 19 Fort Myers, 20 N. New River Canal #1, 21 N. New River Canal #2, 22 West Palm Beach, 23 Tamiami Trail 40-mile Bend, 24 Miami, 25 Lignumvitae Key, 26 Key West.

What all this adds up to is that there are considerably fewer evenings with high RH in the Florida Keys, on the lower East Coast, and in the West Florida panhandle than in the rest of Florida. This is especially pronounced in the middle of the mosquito-breeding season. In order to probe deeper into this geographical difference, I made a special study of the most extreme situations, Key West, which is also the most insular station, and Orlando, which is one of the most "interior" stations and quite representative of the peninsula's non-coastal central region, topographically and otherwise. For this purpose I used nighttime readings from U. S. Weather Bureau psychrometer data for 1968, taken every 3 hr, viz. 2200, 0100, 0400, and 0700 hr, when humidities are usually at their highest. Wind velocities and directions were taken simultaneously with these RH readings. "High" humidities were those 90 percent or above, in accordance with our findings on *C. nigripalpus* behavior, as was also, in some analyses, the 2200 hr readings as most indicative of the night's RH regime and occurring within the peak of *C. nigripalpus* flying activities.

KEY WEST AND ORLANDO CONTRASTED—Temperatures figure so prominently in the RH equation that a word about them should be interjected here. In the winter, Orlando, of course, is much cooler than Key West, the three winter months averaging 61.1° F vs. 71.0° at Key West. But the difference in the four summer-month average is much less, 81.7° vs. 83.5°. [Why winter has 3 months and summer 4 in Florida is demonstrated in a paper in preparation.] Winter contrasts show more in the statistic that 45.5 percent of winter nights drop to below 50° F at Orlando, compared to 0.7 percent at Key West. And reflecting the far greater stability in temperatures in the tropics is the more revealing fact that over the same 28 yr above averaged for Orlando, 8.0 percent of summer days exceeded 95°, while the 28-year record at Key West revealed only 0.06 percent (2 days actually).

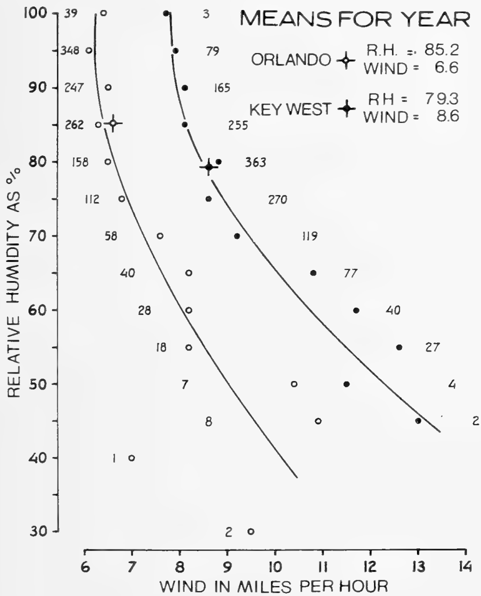

Fig. 2. Relationship of night (2200, 0100, 0400, 0700 hr) RH to wind velocities at Orlando and Key West. Computed from U. S. Weather Bureau data (1968).

Conditions of both RH and wind are more stable at Key West, as might be expected of an insular site. Night humidities average out lower at Key West. The night winds at Key West are definitely stronger than those at Orlando. The Key West night winds are strongly east, veering toward north in fall and winter, and toward south in summer. At Orlando the night winds are more variable and average northeasterly swinging toward north and even northwest in fall and winter, and toward southeast in summer. Neither site is subject to onshore and offshore daily shifts, as is the case with all coastal sites backed by a lot of mainland—a further reason for selecting Key West to compare with Orlando. The coordinates of the two sites are 28.32 N and 81.23 W for Orlando, and 24.33 N and 82.06 W for Key West. These place Key West well within the trade-wind region while Orlando is more appropriately in the horse-latitude belt and much more under the influence of the westerlies prevailing to the north.

Night RH certainly decrease with increasing winds (Fig. 2), regardless of location. If 90 percent relative humidity is the approximate lower threshold for mosquito activity, it is clear that winds in excess of 9 miles per hr must

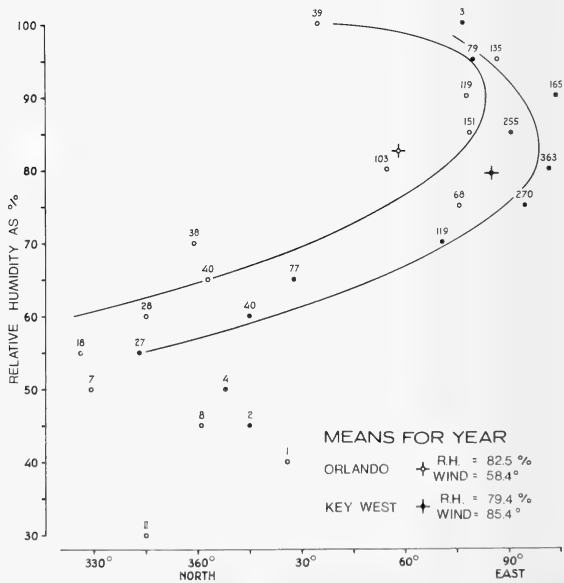

Fig. 3. Relationship of night (2200, 0100, 0400, 0700 hr) RH to wind directions at Orlando and Key West. Computed from U. S. Weather Bureau data (1968).

seriously hamper mosquito flight, unless it is of the migratory kind (cf. Provost, 1953). At both sites, the highest night wind velocities were from the north, so it is not surprising that, with very few exceptions, the highest night RH accompanied easterly winds (Fig. 3). (The differences in mean RH at the same station in figures 2 and 3 are due to different numbers of nights available for the combination of parameters.) With the Atlantic to the east of Florida, one might inquire what sort of humidity the winds sweeping over it might show. The record for April to October at Key West, when the winds were most directly and consistently out of the east, indicates that night winds over the ocean stay close to 80 percent RH in this latitude, barring showers.

If high humidities are considered those 90 percent or higher, the contrast in night conditions between Key West and Orlando becomes more striking than what appears from a comparison of mean RH. Thus such high RH readings at Orlando were four times more numerous than at Key West (Table 2), and the difference between the two sites was greatest in the three worst mosquito-breeding months, July through September. The percentage of relative humidities 90 percent or higher rises during the night, but the increase from 1900 hr to 0700 hr is 11 to 63 percent (6×) at Orlando but only 5 to 14 percent (3×) at Key West. The same examination of 1968 data revealed that this increase in RH during the night was greatest in the summer at Orlando and in the winter at Key West.

Using the 2200 hr reading as a criterion for evening humidity, we find Orlando's RH averaging 80 percent for the year and Key West 78 percent. However, in terms of readings equalling or exceeding 90 percent, Orlando

TABLE 2. RH 90% or higher at night (2200, 0100, 0400, 0700 hr) at Orlando and Key West. Computed from U. S. Weather Bureau data (1968).

% night R.H. 90% or higher	Months from January (1) to December (12)											
	1	2	3	4	5	6	7	8	9	10	11	12
Orlando	52	29	40	40	39	55	58	48	61	42	53	41
Key West	14	13	4	2	13	20	5	7	6	10	26	29
Difference	38	16	36	38	26	35	53	41	55	32	27	12

averaged 25 percent of nights compared to Key West's 9 percent. And, as an excellent indicator of contrasts in stability, the rise in RH from 1300 hr to 2200 hr averaged 26 percentage points for the year in Orlando and only 8 at Key West. This rise, on the RH scale, exceeded 10 percent on 330 days in Orlando and 96 days in Key West; it exceeded 30 percent on 110 days at Orlando and never at Key West.

CONCLUSIONS AND SUMMARY—Night ocean air of 80 percent RH appears to characterize the winds entering the Florida peninsula from the Atlantic. The more exposed to such influence a site is, Key West being the extreme example, the nearer to this humidity nighttime readings will remain and as a consequence the fewer will be very high readings, such as 90 percent and above. In the interior of the peninsula, e.g. Orlando, lesser winds at greater distances from the ocean permit higher nighttime RH as a result of evapotranspiration from the all-surrounding vegetated land and the inevitable temperature inversions, which intensify through the night. Gulf coast sites have nighttime RH intermediate between the two examined stations, but always closer to Orlando than Key West. The assumed causes are the moderating influence of oceanside locations, Gulf of Mexico air probably approximating the 80 percent nighttime RH of Atlantic Ocean air in this latitude, and the moist air frequently reaching that coast from overland to the east.

But the most revealing conclusion of this study is the deceiving nature of mean figures in relating meteorological factors to biological phenomena, many other examples of which can be developed. In this instance, evening RH at Orlando and Key West did not differ much as means, yet Orlando had three times as many 2200 hr readings at or above 90 percent as Key West, and the average rise from 1300 hr to 2200 hr was likewise three times as great.

It is well established that mosquito flight activity is greatly influenced by temperature (cf. references in Clements, 1963), but during the main mosquito season in Florida, temperatures never get low enough to have any appreciable influence on flight and RH apparently becomes a dominant regulating factor, along with, as always, light intensity and wind. This study has revealed pronounced geographical differences, within Florida, in nighttime RH. Whether or not mosquitoes have become adjusted to these drastic differences from place to place in the state by appropriate threshold differences we cannot yet tell. But if they have not, it is certainly to be expected that evening behavior of the same species will vary with location.

Although this study has applied itself strictly to mosquitoes, the supplantation of temperature by humidity as a dominant flight factor may apply to many other nocturnal insects in the subtropics and tropics. It is clear that in this country, only Florida and possibly southernmost Texas, would exhibit this phenomenon of summer nights. Everywhere else nighttime temperatures get into low enough ranges at night to be a dominant factor all year.

Acknowledgments—Financial support for part of this study came from the National Institute of Arthritis and Infectious Diseases (grant no. AI—06587). I wish also to acknowledge the assistance of the late Willem Janse, whose mathematical and analytical work was most helpful. The U. S. Weather Bureau has been most helpful in providing needed climatological data described in the text.

LITERATURE CITED

Bidlingmayer, W. L. 1964. The effect of moonlight on the flight activity of mosquitoes. Ecology 45:87-94.

———. 1967. A comparison of trapping methods for adult mosquitoes: species response and environmental influences. J. Med. Entomol. 4:200-220.

CLEMENTS, A. N. 1963. The Physiology of Mosquitoes. Pergamon Press. New York. 393 p.

DOW, R. P., P. H. COLEMAN, K. E. MEADOWS, AND T. H. WORK. 1964. Isolation of St. Louis Encephalitis viruses from mosquitoes in the Tampa Bay area of Florida during the epidemic of 1962. Amer. J. Trop. Med. & Hyg. 13:462-468.

——— AND G. M. GERRISH. 1970. Day-to-day changes in relative humidity and the activity of *Culex nigripalpus* (Diptera: Culicidae). Ann. Entomol. Soc. Amer. 63:975-999.

MUIRHEAD-THOMSON, R. C. 1938. The reaction of mosquitoes to temperature and humidity. Bull. Entomol. Res. 29:125-140.

PROVOST, M. W. 1953. Motives behind mosquito flights. Mosquito News 13:106-109.

———. 1959. The influence of moonlight on light-trap catches of mosquitoes. Ann. Entomol. Soc. Amer. 52:261-271.

———. 1969. The natural history of *Culex nigripalpus. In* "St. Louis Encephalitis in Florida." Florida St. Bd. Health Monogr. 12:46-62.

———. 1972. An Environment for Life: Florida's Weather. Fla. St. Div. Health Monog. (in preparation).

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A BACTERIAL DISEASE OF HATCHLING LOGGERHEAD SEA TURTLES

Ross Witham

Florida Department of Natural Resources,
Marine Research Laboratory, St. Petersburg, Florida 33701

Abstract: *Necrotic, spreading, nonwalled skin lesions developed in 140 pen-reared hatchling loggerhead sea turtles and most died within a week of the first appearance of the disease. Treatment with mixed penicillin and streptomycin was begun after 131 had died, and before pathogenic determination had been completed.* Bacteroides *sp.* Pseudomonas aeruginosa *and* Staphlococcus epidermis *were found in lesion pus cultures.* Bacteroides *sp., common in the feces of warm-blooded animals, was considered the primary pathogen.*

The Florida Department of Natural Resources has been involved in sea turtle research for a number of years (Ingle and Smith, 1949; Carr and Ingle, 1959; Schmidt and Witham, 1961; Routa, 1968). Efforts to breed green turtles, *Chelonia mydas,* appear promising, and this species can apparently adapt to its natural environment after being hatched and raised in captivity for as long as one year (Witham and Carr, 1968; Carr and Sweat, 1969; Witham, 1971).

Disease is an ever-present threat to any mariculture operation and sea turtles being raised in captivity have often died with no specific cause determined. Superficial skin lesions, probably fungal (Anon., 1971) occasionally developed on our turtles and these were effectively treated with 5-10 percent gentian violet.

During July and August 1970, Ralph Estabrooks hatched 140 loggerheads, *Caretta caretta,* at the House of Refuge Museum, Hutchinson Island, near Stuart, Florida. These were kept in a large partitioned tank with a number of older green and loggerhead turtles. The concrete block partition permitted water circulation but maintained separation of large and small animals. Seawater of 30.50 to 35.50‰ salinity was pumped from shallow wells into the section containing small turtles and discharged from the other section.

Necrotic, spreading skin lesions which did not respond to gentian violet treatment began appearing on some hatchlings in September, 1970, and death followed within three to seven days. All hatchlings were not infected simultaneously, but within three months each had developed the symptoms. None of the older turtles became diseased.

Swabs of the characteristic pus exudate from lesions on tongues, cloacas, heads, flippers, and ventral body areas near the plastron were collected with "Culturettes." Leon W. Powell, Jr., M.D., Department of Pathology, Martin Memorial Hospital (personal communication), found *Bacteroides* sp., *Pseu-*

Contribution No. 227, Florida Department of Natural Resources Marine Research Laboratory.

domonas aeruginosa, and *Staphylococcus epidermis* in the samples. His findings were confirmed by the Bio-Assay Laboratory, Dallas, Texas, and by the Florida Department of Pollution Control, Tallahassee (personal communication, Noel F. White, Microbiologist). Lesions were necrotic, spreading, and not walled off (Rosebury and Sonnenwirth, 1958), and thus *Bacteroides* sp. was considered the primary pathogen.

Since the lesions did not respond to fungal treatments, a bacterial infection was indicated prior to actual verification and identification. Consequently, a broad spectrum antibiotic combination was injected subcutaneously in the nine surviving turtles (131 hatchlings had already died). Dosage per turtle (50-100 g ea) was 0.1 ml of a solution of 25,000 USP units/ml potassium penicillin and 250 mg/ml streptomycin sulfate. Five of those being treated were apparently weakened by disease and died during cold weather, while one died following treatment. The remaining three received six injections each during a 3-month period to treat recurring lesions and are still alive after 18 months. While high dosages of penicillin/streptomycin mixture appear to have been effective in treating these animals, chloramphenicol is considered the drug of choice against *Bacteroides* and should be tested in future outbreaks (Goodman, 1971).

Bacteroides was first reported as a disease-causing organism in man during 1878-1879 when it was isolated from brain abscesses, lung gangrene, and peritonitis (Morton, 1965). It has been reported that pure cultures of *Bacteroides* caused disease in test animals, and that the pathogenic activity was increased when mixed with other bacteria (Rosebury and Sonnenwirth, 1958; Burrows, 1963). These anaerobic, Gram-negative, nonmotile rods are found in feces of warm-blooded animals, and Goodman (1971) reports that they comprise 95 percent of human intestinal flora and about 20 percent of the feces weight.

Janssen (1968) reported evidence of fish (white perch, *Roccus americanus*) being infected by human pathogens, and Krantz and Heist (1970) made similar findings for brook and brown trout. However, these authors did not find evidence of *Bacteroides* infection. No literature references to such infections in reptiles were found.

LITERATURE CITED

ANONYMOUS. 1971. Question: how do corneal ulcers spread? J. Amer. Med. Assoc. 217: 1035-1036.

BURROWS, W. J. 1963. Textbook of microbiology. W. B. Saunders Co. Philadelphia.

CARR, A. AND R. M. INGLE. 1959. The green turtle (*Chelonia mydas mydas*) in Florida. Bull. Mar. Sci. Gulf Carib. 9: 315-320.

_______, AND D. E. SWEAT. 1969. Long-range recovery of a tagged *Chelonia* on the east coast of North America. Biol. Conserv. 1 p. unnumbered.

GOODMAN, J. S. 1971. *Bacteroides sepsis*: diagnosis and therapy. Hosp. Pract. January: 121-128.

INGLE, R. M. AND F. G. W. SMITH. 1949. Sea turtles and the turtle industry of the West Indies, Florida and the Gulf of Mexico, with annotated bibliography. Mar. Lab. Univ. Miami Spec. Publ.: 6-107.

JANSSEN, W. A. AND C. D. MEYERS. 1968. Fish: serologic evidence of infection with human pathogens. Science 159: 547-548.

KRANTZ, G. E. AND C. E. HEIST. 1970. Prevalence of naturally acquired agglutinating antibodies against *Aeromonas salmonicida* in hatchery trout in central Pennsylvania. J. Fish. Res. Bd. Canada 27: 969-973.

MORTON, H. 1965. *Bacteroides*, pp. 770-774. *In* R. J. Dubos and J. Giffirsch, ed. Bacterial and Mycotic Infections of Man. 4th ed. J. B. Lippincott Co. Philadelphia.

ROSEBURY, T. 1965. Bacteria indigenous to man, pp. 326-355. *In* R. J. Dubos and J. Giffirsch, ed. Bacterial and Mycotic Infections of Man. 4th ed. J. B. Lippincott Co. Philadelphia.

ROUTA, R. A. 1968. Sea turtle nest survey of Hutchinson Island, Florida. Quart. J. Florida Acad. Sci. 30: 287-294.

SCHMIDT, S. AND P. R. WITHAM. 1961. In defense of the turtle. Sea Frontiers 7: 211-219.

WITHAM, R. 1971. Breeding of a pair of pen-reared green turtles. Quart. J. Florida Acad. Sci. 33: 288-290.

———, AND A. CARR. 1968. Returns of tagged pen-reared green turtles. Quart. J. Florida Acad. Sci. 31: 49-50.

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Biological Sciences

GROWTH OF HYDRILLA IN SOLUTION CULTURE AT VARIOUS NUTRIENT LEVELS[1]

KERRY K. STEWARD AND R. A. ELLISTON

Agricultural Research Service, U. S. Department of Agriculture, Fort Lauderdale, Florida 33314

ABSTRACT: *Hydrilla* (Hydrilla verticillata *Royle) was cultured in modified Hoagland's nutrient solutions having various concentrations of mineral elements. Maximum increase in dry wt occurred at 10% of basic Hoagland's concentrations of all elements with added sodium bicarbonate. Tissue contents of P and Ca were directly related to solution levels of these mineral elements; K accumulation appeared independent of solution concentration. Addition of* $NaHCO_3$ *reduced P accumulation, but had no effect on Ca or K accumulation. Hydrilla appeared to utilize bicarbonate as a carbon source for photosynthesis.*

INCREASED levels of nitrogen and phosphorus resulting from pollution of natural waters have been implicated as causal factors in nuisance growths of higher aquatic plants (Anon., 1965; Boyd, 1970; Edmondson, 1969; Lind and Cottam, 1969; Mackenthun and Ingram, 1967). A reduction in the supply of these normally growth limiting nutrient elements would help to prevent excessive growth of aquatic weeds (Anon., 1965, 1968, 1969; Boyd, 1970; Steward, 1970). If realistic water quality criteria are to be developed in terms of allowable concentrations of nutrients which will prevent uncontrolled growth of aquatic weeds, the basic nutritional requirements of these plants must be understood (Anon., 1965). The requirements need to be determined for individual plant species as it has been shown that the requirements vary among species (Gerloff and Krombholz, 1966).

The submersed aquatic plant hydrilla (*Hydrilla verticillata* Royle) appears to be highly adaptable to a wide range of water quality. Since its introduction in

[1]Cooperative Investigations of the U. S. Department of Agriculture, Agricultural Research Service, Southern Region, Florida/Antilles Area, and the Central and Southern Florida Flood Control District.

1960, this plant has spread throughout the freshwaters in the state of Florida and has become established in southern Georgia and Alabama (Steward, 1969). We have observed hydrilla growing in tannin stained waters of highly eutrophied drainage canals as well as in clear oligotrophic spring waters. The mineral nutrient requirements of hydrilla are unknown.

The primary objective of this study was to establish a defined mineral nutrient solution which would provide hydrilla plants with optimum levels of required nutrients. Once these optimum levels have been established, the concentrations of individual mineral nutrient elements can be manipulated to provide additional information on the requirements for individual nutrient elements. A secondary objective was to relate growth of hydrilla at various nutrient levels to uptake or accumulation of selected nutrient elements.

METHODS AND MATERIALS—A modified Hoagland's nutrient solution (Hoagland and Arnon, 1950) was used as the basic medium for growing test plants (Table 1). In experiment 1, plants were grown in 100, 50, 10, or 1 percent concentrations of the macronutrients specified for Hoagland's solution. In these solutions, the micronutrients required were included at 100 percent concentration. In experiment 2, plants were grown in 10 or 1 percent concentrations of the macronutrients and 100, 50, or 10 percent concentrations of the micronutrients. Sodium bicarbonate ($NaHCO_3$) was added at a concentration of 0.2 mM to one half of the nutrient treatments in both experiments to determine the utility of bicarbonate as a carbon source. All solutions were prepared in distilled, demineralized water and changed every 7 days.

TABLE 1. Modified Hoagland's nutrient solution used for the culture of hydrilla (100 percent concentration).

MACRONUTRIENT SALT	ml of Molar Stock Solution per l Nutrient Solution	Element in Final Solution (ppmw)	
$Ca(NO_3)_2$	5	Ca	200
KNO_3	5	N	210
$MgSO_4 \cdot 7H_2O$	2	K	273
KH_2PO_4	1	Mg	48
K_2HPO_4	0.5	S	64
		P	46
MICRONUTRIENT SALT	Stock Solution[1]		
H_3BO_3	45 mM	B	0.49
$MnCl_2 \cdot 4H_2O$	9 mM	Mn	0.55
$CuCl_2 \cdot 2H_2O$	0.3 mM	Cl	1.14
MoO_3	0.1 mM	Cu	0.019
$Zn(C_2H_3O_2)_2 \cdot 2H_2O$	0.75 mM	Mo	0.009
		Zn	0.049
Fe chelate	0.1% iron	Fe	1.0

[1]One ml added per liter of final solution.

In experiment 1, algal growth increased rapidly between solution changes. It was necessary in experiment 2 to grow plants in algae-free cultures to eliminate algal competition for nutrients. These cultures were obtained by surface-sterilizing vegetative propagules for 15 seconds in 0.1 percent solutions of mercuric chloride ($HgCl_2$). The sterilized propagules, after germinating in the dark, were transferred to sterile (autoclaved) nutrient solutions. Sodium bicarbonate was added after autoclaving.

Plant Material. The material for experiment 1 consisted of unbranched apical stem cuttings 50 mm long from plants collected in local canals. The propagules used in experiment 2 were subterranean turions (Steward, 1970) collected from the hydrosoil of outdoor pools in which hydrilla had been previously cultured.

Each treatment consisted of two replicates of five plants each. The plants were grown for 42 days in experiment 1 and for 28 days in experiment 2. The initial dry weights of the plants in experiment 2 were estimated from fresh weights and were based on the average moisture content of 20 similar sized plants. Dry matter yields were determined on harvested plants after oven-drying at 65 to 70°C for 48 hr. Dried samples were ground in a Wiley mill to pass a 40-mesh screen, and stored in glass vials until analyzed.

The experiments were conducted in growth chambers at a day temperature of 27°C and a night temperature of 20°C. Light was supplied at 5400 lux (500 ft-c) on a 12-hr photoperiod by fluorescent tubes and supplemented with incandescent bulbs.

Analytical Procedures. Plant tissues were analyzed for total phosphorus, potassium, and calcium following wet-ashing of the tissue in a nitric-perchloric acid mixture. Phosphorus determinations were by a phosphomolybdate procedure (Ulrich and Johnson, 1959). Calcium and potassium were determined by atomic absorption spectrophotometry.

TABLE 2. Change with time in fresh weight of hydrilla apical cuttings grown at different nutrient levels and bicarbonate concentrations.

Nutrient Conc. (%)	HCO_3[1]	Growth in days						
		0	7	14	21	28	35	42
100	+	0.97[2]	0.97	0.68	0.18	0.10	0.02	0.00
	–	1.06	1.06	0.56	0.38	0.10	0.03	0.00
50	+	1.20	1.20	0.93	0.43	0.23	0.14	0.03
	–	1.14	1.14	0.83	0.67	0.22	0.13	0.02
10	+	1.20	1.20	1.40	1.62	1.92	1.98	2.26
	–	1.26	1.26	1.16	0.65	0.54	0.32	0.18
1	+	0.98	0.98	1.51	1.97	2.37	2.50	2.61
	–	0.97	0.97	1.00	0.92	0.62	0.38	0.24
0	+	1.07	1.07	0.84	0.84	0.82	0.83	0.62
	–	1.04	1.04	0.96	0.78	0.92	0.71	0.66

[1]0.2 mM $NaHCO_3$.
[2]Average total wt in g of two 5-plant replicates.

RESULTS AND DISCUSSION—The effects of various levels of Hoagland's nutrient solution on the growth of stem cuttings are shown in Table 2. The salient points of this experiment are that growth declined at 100 and at 50 percent nutrient solution concentrations, with or without added sodium bicarbonate; and growth increased steadily at 10 and 1 percent concentrations with added sodium bicarbonate. Growth decreased at the 10 and 1 percent concentrations in the absence of sodium bicarbonate. Growth also began to decrease in treatments containing no added nutrients after 7 days, indicating that tissue reserves of nutrients had been depleted.

The results of this experiment indicate that the higher nutrient solution concentrations provided unsatisfactory growth conditions. The 10 and 1 percent concentrations appeared to provide adequate levels of nutrients in the presence of $NaHCO_3$. There was a definite enhancement of growth in these treatments with the addition of sodium bicarbonate.

The second experiment was conducted to confirm the findings of the first experiment as well as to further define optimum and threshold nutrient concentrations. In this experiment, plants were grown in solutions in which microelement as well as macroelement concentrations were varied. The influence of the various concentrations of mineral elements on the growth of hydrilla is shown in Table 3. The addition of bicarbonate significantly increased growth at the 10 percent macro and microelement levels and at the 100 and 50 percent microelement levels within the 1 percent macroelement level.

TABLE 3. Change in dry wt (mg) of hydrilla after 28 days growth in solutions of different nutrient and bicarbonate concentrations.

	Macronutrient Concentration (percent)					
	10			1		
	Micronutrient Concentration (percent)					
$NaHCO_3$[1]	100	50	10	100	50	10
+	57ef[2]	61ef	80f	52def	56ef	22bcd
—	37cde	30cde	—11a	7abc	9abc	—8ab

[1]0.2 mM $NaHCO_3$.
[2]Means of 2 replications followed by the same letter or letters are not significantly different at the 5 percent level as determined by Duncan's Multiple range test.

Within the treatments receiving bicarbonate additions, the only significant response to microelement levels occurred at the 1 percent macro and 10 percent microelement level. A greater than 50 percent reduction in dry weight at these levels indicates that concentrations of one or more microelements may have been growth limiting.

There was a tendency for growth to decrease with increasing microelement levels within the 10 percent macroelement level in the presence of bicarbonate. This may indicate that one or more microelements were present at toxic concentrations at these higher levels.

Phosphorus accumulation in plant tissue was directly related to concentration of phosphorus in nutrient solutions (Table 4). Accumulation was greatest within the 10 percent macroelement level and varied inversely with microelement levels in the presence of bicarbonate. In the absence of bicarbonate, microelement concentration did not influence phosphorus accumulation. Accumulation was reduced in the presence of bicarbonate at the 100 and at the 50 percent microelement level. Neither bicarbonate nor microelement concentration influenced phosphorus accumulation within the 1 percent macroelement level.

TABLE 4. Total calcium, phosphorus, and potassium content of hydrilla plants cultured in solutions of different nutrient and bicarbonate concentrations for 28 days.

		Macronutrient Concentration (percent) 10			1		
Nutrient Element (%)[1]	$NaHCO_3$[2]	Micronutrient Concentration (percent) 100	50	10	100	50	10
Phosphorus	+	1.2b[3]	1.7c	2.1d	0.6a	0.6a	0.5a
	—	1.8cd	2.0d	2.1d	0.7a	0.6a	0.6a
Calcium	+	2.4bc	3.5d	4.1e	1.1a	1.4a	1.1a
	—	3.1cd	3.9de	4.3e	1.1a	1.1a	1.9ab
Potassium	+	3.9a	4.6a	3.8a	4.9a	4.0a	4.1a
	—	4.4a	4.9a	3.5a	4.3a	4.3a	4.2a

[1]Avg. percent of oven dry wt, 2 replicates.
[2]0.2 mM per liter.
[3]Means for individual elements followed by the same letter or letters are not significantly different at the 5 percent level as determined by Duncan's Multiple range test.

Phosphorus concentration in tissue varied between 12,000 to 21,000 ppmw at the 10 percent macroelement level. This is a 2600 to 4500 fold increase over the 4.6 ppmw concentration in the media. A ten-fold reduction in media concentration to 0.46 ppmw produced two to four-fold reductions in tissue levels (5000 to 7000 ppmw phosphorus within the 1 percent macroelement level). The tissue levels of phosphorus, however, were 10,800 to 15,200-fold greater than the 0.46 ppmw media level indicating that accumulation was more efficient at this lower level.

Calcium accumulation in tissue followed a pattern similar to phosphorus accumulation. Calcium content decreased with decreased solution levels. Accumulation of calcium was inhibited by increasing microelement levels in the 10 percent macroelement solutions. Microelement concentrations did not influence calcium accumulation at the 1 percent macroelement level. Bicarbonate additions did not effect calcium accumulation at any nutrient level.

Potassium accumulation was not dependent on solution concentration and was not influenced by added bicarbonate nor by microelement levels. Accumulation was not reduced at the 1 percent macroelement level (2.7 ppmw concentration) indicating that hydrilla may have a low requirement for potassium.

Under the conditions of these experiments, the optimum nutrient level for hydrilla appeared to lie between the 10 and 1 percent macronutrient concentrations and below the 50 percent micronutrient concentration. Dry matter yield was enhanced in the presence of sodium bicarbonate with these levels. The higher micronutrient levels reduced phosphorus and calcium accumulation and tended to inhibit growth.

These findings are in close agreement with those of Gerloff and Krombholz (1966). They found that a 20 percent concentration of a modified Hoagland's solution was adequate for the growth of four of the six species of submersed aquatic plants investigated. The principle effect of bicarbonate additions was on dry matter production rather than nutrient uptake and may have been related to bicarbonate utilization for photosynthesis. Others have shown experimentally that certain aquatic plants are able to utilize bicarbonate (Arens, 1933; Mackenthun and Ingram, 1967). Hydrilla appeared to belong in this group of plants.

LITERATURE CITED

Anonymous. 1965. Restoring the quality of our environment. Rpt. Environmental Pollution Panel, President's Sci. Adv. Comm. Wash., D. C.

__________. 1968. Water quality criteria. Report Nat. Tech. Adv. Comm. to Secretary of the Interior. F.W.P.C.A. Wash., D. C.

__________. 1969. Cleaning Our Environment: The Chemical Basis for Action. Amer. Chem. Soc. Wash., D. C.

Arens, K. 1933. Physiologisch polarisierter Massenanstausch und Photosynthese bei submersen wasserpflanzen I. Planta 20: 621.

Boyd, C. E. 1970. Vascular aquatic plants for mineral nutrient removal from polluted waters. Econ. Bot. 24:95-103.

Edmondson, W. T. 1969. Eutrophication in North America. pp. 124-149. *In* Eutrophication: Causes, Consequences, Correctives. Print. & Publ. Off. National Acad. Sci. Wash., D. C.

Gerloff, G. C. and P. H. Krombholz. 1966. Tissue analysis as a measure of nutrient availability for the growth of angiosperm aquatic plants. Limnol. Ocean. 11:529-537.

Hoagland, D. R. and D. I. Arnon. 1950. The water culture method for growing plants without soil. California Agr. Exp. Sta. Circ. 347 (Revised) Berkley, Calif.

Lind, C. T. and G. Cottam. 1969. The submerged aquatics of University Bay: A Study in Eutrophication. Amer. Midland Nat. 81:353-369.

Mackenthun, K. M. and W. M. Ingram. 1967. Biological associated problems in freshwater environments. Their identification, investigation and control. U. S. Dept. Interior F.W.P.C.A. Wash., D. C.

Steeman-Nielson, E. 1947. Photosynthesis of aquatic plants with special reference to the carbon sources. Dansk Bot. Ark. 12:1-71.

Steward, K. K. 1969. Effects of growth regulators and herbicides on germination of hydrilla turions. Weed Sci. 17: 299-301.

__________. 1970. Nutrient removal potentials of various aquatic plants. Hyacinth Control J. 8:34-35.

Ulrich, A. and C. M. Johnson. 1959. Analytical methods for use in plant analysis. California Agr. Exp. Sta. Bull. 776:25-78.

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ECOLOGICAL DATA FOR A FLORIDA TROGLOBITIC CRAYFISH

Kenneth Relyea and Bruce Sutton

Department of Biology, Jacksonville University, Jacksonville, Florida 32211

Abstract: Procambrus erythrops, *described from Suwannee County, is a detritus feeder inhabiting the higher energy zones of the cave.*

Ecological data, none quantitative, are sparse for Florida troglobitic crayfishes. We present here some basic qualitative observations on a recently described species, *Procambarus erythrops* (Relyea and Sutton, 1974). These observations were made at the type locality, a Suwannee County sink hole known as Sim's Sink to us, which penetrates to the ground water level. The banks of the sink are not especially precipitous. The sink has been partially covered by the original owners of the property with a roof of boards covered with an accumulation of detritus, mosses and ferns. Broken portions of the roof and spaces between boards allow detritus to filter into the sink hole. The water surface is about 4 m below the roof.

The pool of water is elliptical, measuring approximately 3 m × 4 m, and is bounded by a nearly straight shaft of limestone for half of its circumference down to a depth of about 7 m (bottom of pool). There are small ledges and crevices in the limestone wall. The remaining portion of the pool opens to a cave of unknown extent. With lower water levels, the surface area of the pool is greater since part of the cave ceiling is then above water level.

The only other known locality for this species is a vertical sink shaft (chimney type) of about 10 m which leads to a small opening in the aquatic subterranean system.

Procambarus erythrops is found both at the bottom of the sink (including in the cave) and in crevices on the vertical limestone walls of the pool. We have observed and captured individuals from near the water's edge to a depth of about 13 m in the cave. The bottom of the sink is composed of decaying logs and detritus. A fine black silt in the cave may be a preferred substrate. The edge of the pool of water has a floating layer of decaying leaves which may afford cover and, ultimately, food. We suspect that the artificial roof allows the crayfish to use what once was a lighted and less suitable portion of the aquatic system of the sink. It seems likely that *P. erythrops* would retreat into deeper areas if the roof were not there.

The population at Sim's Sink appears to be concentrated in the area near the cave mouth and at the bottom of the pool. Fewer individuals are found at increasing distances from the cave mouth—which probably reflects the energy funnel effect of sink holes such as this. We estimate the Sim's Sink population to consist of 200 to 300 individuals, although juveniles are easily overlooked.

We have observed *P. erythrops* feeding on detritus, and this is undoubtedly the major food resource. However, as is probably true of most troglobitic crayfishes in Florida, *P. erythrops* is an opportunist with respect to obtaining food. We frequently find frogs (*Rana*) and toads (*Bufo*) at the bottom of sinks, and these as well as other animals (rodents, insects) are certainly important sources of organic energy input to the subterranean chambers. However, plant materials, especially leaves from hardwoods, are the main organic input. An assessment of energy flow in a Florida cave system remains to be obtained. No one has made an adequate study of the microfauna of sinks such as Sim's Sink, and this would be a necessary prelude to more sophisticated trophic studies.

The only other large troglobite associated with *P. erythrops* is the crayfish *Troglocambarus maclanei*. The latter is found in greater abundance deeper in the cave system, resulting in minimal overlap with *P. erythrops*. *Troglocambarus maclanei* is a coinhabitant of other Florida caves with *Procambarus pallidus* and *P. lucifugus* (see Hobbs, 1942, for localities). In these situations *T. maclanei* also probably occupies lower energy zones. We have also found the troglobitic isopod, *Crangonyx hobbsi*, in Sim's Sink, but have insufficient data to comment further on it.

Of general interest is that water temperature remained at 22° C throughout January and February of 1972, and probably does not vary much from that temperature at other times of the year. Water levels are low through the winter months into May or June, when, with increasing rain, water level rises. We suspect that juveniles are dropped in conjunction with rising water. This would afford maximum dispersal of young as well as coincide with maximum organic input.

Males seem to patrol a territory while females seek protected areas (based on field and aquarium observations). A tail-curling defensive posture has been observed for females which is not apparent for males. It may be an extension of egg bearing behavior. Copulation has been observed in aquarium maintained individuals, but no gravid females are yet known. It is noteworthy that aquarium individuals copulate frequently, and copulation may last up to 12 hr.

LITERATURE CITED

Hobbs, H. H., Jr. 1942. The crayfishes of Florida. Univ. Florida Publ. Biol. Sci. Ser. 3(2):1-179.

Relyea, K. and B. Sutton. 1974. A new troglobitic crayfish of the genus *Procambarus* from Florida (Decapoda: Astacidae). Tulane Stud. Zool. Bot. (in press).

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T. Quentin Burnson, 222 N.W. 3rd Ave., Gainesville, Fla. 32601
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T. D. Carr, Dept. of Physics, Univ. of Florida, Gainesville, Fla. 32601
Dr. C. A. Carratt, 23 Diamandidou Ave., Psychikon, Athens, Greece
Otis Carroll, Dept. of Natural Sci., Univ. of North Florida, P. O. Box 17074, Jacksonville, Fla. 32216
Chris Clemons Carter, 427 Palm Drive, Mt. Dora, Fla. 32757

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Terry C. Casper, 45 Van Houten Fields, West Nyack, N.Y. 10994
Dr. Alfred B. Chaet, Provost Gamma College, Univ. of West Florida, Pensacola, Fla. 32504
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Dr. J. S. Clegg, Dept. of Biology, Univ. of Miami, Coral Gables, Fla. 33124
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Dr. Glenn M. Cohen, Dept. of Biology, Fla. Inst. of Technology, Melbourne, Fla. 32901
Miss Sylvia E. Coleman, 1408 S.W. 10th Terr., Apt. 38, Gainesville, Fla. 32601
Sneed B. Collard, Faculty of Biology, Univ. of West Florida, Pensacola, Fla. 32504
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David M. Cooper, 362 N.E. Plymouth Circle, Corvallis, Oregon 97330
Mrs. Priscilla C. Cooper, Univ. Center for Pollution Res., Fla. Inst. of Technology, Melbourne, Fla. 32901
Dr. James Corwin, M.D., 323 11th Ave. No., Jacksonville, Fla. 32050
Steve W. Cowan, P.O. Box 551, Miami Springs, Fla. 33166
Dr. Walter R. Courtenay, Jr., Dept. of Biol. Sci., Fla. Atlantic Univ., Boca Raton, Fla. 33432
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Dr. T. J. Cunha, 252 McCarty Hall, Univ. of Florida, Gainesville, Fla. 32611
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Dr. Wm. B. Deichmann, Box 8216, Univ. of Miami, Coral Gables, Fla. 33124
Allen DeKock, Ft. Lauderdale Christian School, 6330 N.W. 31st Ave., Ft. Lauderdale, Fla. 33309
Mrs. Patricia E. Denninghoff, Merritt Island High School, 100 E. Lucas Rd., Merritt Island, Fla. 32952
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John F. Dequine, Southern Fish Culturists, Inc., P.O. Box 251, Leesburg, Fla. 32748
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James Goetz, Dept. of Geology, Univ. of South Florida, Tampa, Fla. 33620
Dr. Alexander Z. Goldweber, P.O. Box 600237, No. Miami Beach, Fla. 33160
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Dianne Grimm, 12050 S.W. 63rd Ave., Miami, Fla. 33156
Robert B. Grimm, Dept. Biol. Sci., Fla. Atlantic Univ., Boca Raton, Fla. 33432
Raymond Grizzle, 1420 Stetson Circle East, Cocoa, Florida 32922
Mr. W. R. Groover, Lake Worth High School, P.O. Box 1409, Lake Worth, Fla. 33460
Frank X. Groselle, 2120 N. 47th Ave., Hollywood, Fla. 33021
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Dr. Louise Jodrey Hagedorn, 1200 S. Ocean Blvd., Apt. 6H, Boca Raton, Fla. 33432
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William Hammond, 5456 Parker Dr., Ft. Myers, Fla. 33901
Paul G. Hansel, 1374 Monterey Blvd., St. Petersburg, Fla. 33704
Keith L. Hansen, Biology Dept., Stetson Univ., Deland, Fla. 32720
Michael J. Hansinger, P.O. Box 14361, University Station, Gainesville, Fla. 32604
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Edwin H. Hebb, 502 Maywood St., Marianna, Fla. 32446

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John Lewis Highsmith, St. Johns River Jr. Coll., Palatka, Fla. 32077
E. Roland Hill, Jr., Rt. 2, Box 535, Maitland, Fla. 32751
William P. Hill, 275 W. Magnolia Ave., Studio 9, Merritt Island, Fla. 32952
J. B. Hilmon, 656 Shawnee Trail, Ashville, N.C. 28805
Dr. Horton H. Hobbs, Jr., U.S. National Museum, Rm. 301, Washington, D.C. 20560
Dr. Nicholas R. Holler, 2820 E. University Ave., Gainesville, Fla. 32601
Dr. Thomas S. Hopkins, Chmn., Fac. of Biology, Univ. of West Florida, Pensacola, Fla. 32504
James G. Houser, Tech. & Research Staff, The Martin Co., P.O. Box 5837, Orlando, Fla. 32805
Fred E. Howard, Jr., 306 Gardner Dr. N.E., Ft. Walton, Fla. 32548
Larry G. Howell, Dept. of Chemistry, Univ. of South Florida, Tampa, Fla. 33620
Prof. Chu Shyen Huang, Chipola Jr. College, Marianna, Fla. 32446
Michael D. Hubbard, Dept. Biol. Sci., Florida State Univ., Tallahassee, Fla. 32306
Dr. David S. Hubbell, 861 6th Ave. S., St. Petersburg, Fla. 33101
Carl L. Hubbs, Scripps Institute, La Jolla, Calif. 92037
Dr. Jay S. Huebner, Nat. Sciences Dept., Univ. of North Florida, Jacksonville, Fla. 33701
Dr. Harold J. Humm, Univ. of South Florida, Marine Sciences Institute, St. Petersburg, Fla. 33701
Edythe M. Humphries, 1390 Milford Terrace, Teaneck, N.J. 07666
Burton P. Hunt, Dept. of Biol., Univ. of Miami, Coral Gables, Fla. 33124
C. P. Idyll, Nat. Oceanic Atmos. Adm., 6010 Executive Blvd., Rockville, Md. 20852
Robert M. Ingle, Consulting Biologist, 2306 Mission Rd., Tallahassee, Fla. 32304
Dr. Dale E. Ingmanson, USAID/BRASILIA/SDS, APO New York, N.Y. 09676
Dr. Russell E. Isaacks, 8965 S.W. 115th Terr., Miami, Fla. 33156
Dr. Marvin L. Ivey, Dept. Nat. Sci., St. Petersburg Jr. College, P.O. Box 13489, St. Petersburg, Fla. 33733
Dr. C. G. Jackson, Jr., Dept. Biol. Sci., Miss. State College (Women), Columbus, Miss. 39701
Mrs. Irma K. Jarvis, 276 Cherry St., Palm Beach Gardens, Fla. 33403
Dr. Minas Joannides, Jr., 500 30th Ave. South, St. Petersburg, Fla. 33705
P. M. Johanson, 5001 St. Johns Ave., Palatka, Fla. 32077
Roman K. C. Johns, 910 N. Riverside Dr., Indialantic, Fla. 32901
Dr. Clifford Johnson, Dept. of Zoology, Univ. of Florida, Gainesville, Fla. 32611
Dr. David W. Johnston, Dept. of Zoology, Univ. of Florida, Gainesville, Fla. 32611
Dr. Ralph C. Johnston, 601 Seaway Dr., Ft. Pierce, Fla. 33450
John W. Jolley, Jr., Bur. of Marine Sci. & Tech., 201 5th St., West Palm Beach, Fla. 33401
Dr. Alice M. Jones, Med. Res. Inst., Fla. Inst. of Tech., Melbourne, Fla. 32901
Bartlett C. Jones, 2204 N.W. 21st Pl., Gainesville, Fla. 32611
Dr. E. Ruffin Jones, Jr., Flint Hall, Univ. of Florida, Gainesville, Fla. 32611
Dr. James I. Jones, Rt. 2, Box 618, Tallahassee, Fla. 32301
Dr. Ronald H. Jones, Med. Res. Inst., Fla. Inst. of Tech., Melbourne, Fla. 32901
Dr. Wm. Denver Jones, Physics Dept., Univ. of South Florida, Tampa, Fla. 33620
Edmund F. Kallina, Jr., Dept. of History, F.T.U., P.O. Box 25000, Orlando, Fla. 32816

Dr. Stanley Kaplan, Med. College of Wisconsin, Dept. of Anatomy, 561 N. 15th St., Milwaukee, Wisc. 53233
Edith E. Katz, R.D. 2, Box 663A, Deland, Fla. 32720
Stanley R. Kaye, 1540 N.E. 191st St., No. Miami Beach, Fla. 33162
Leonard S. Keller, Dept. of Phys. Sci., Fla. International Univ., Tamiami Trail, Miami, Fla. 33144
William M. Keller, 1364 Woodbine St., Clearwater, Fla. 33515
Dr. George G. Kelley, 4606 13th Pl., Vero Beach, Fla. 32960
Jerome Kelly, Dept. of Biol., Univ. of Miami, Coral Gables, Fla. 33124
James M. Keltner, Jr., Gulf Breeze Lab., Gulf Breeze Environ. Prot. Agcy., Gulf Breeze, Fla. 32561
Dr. Rudolph T. Kempton, 924 Shore Drive, St. Augustine, Fla. 32084
Harry W. Kendall, Physics Dept., Univ. of South Florida, Tampa, Fla. 33620
Herbert D. Kerman, Halifax District Hospital, Daytona Beach, Fla. 32015
Dr. John P. Kerr, 4770 Velasquez St., Rt. 4, Pensacola, Fla. 32504
Dr. Jerome P. Keuper, Pres., Fla. Inst. of Technology, P.O. Box 1150, Melbourne, Fla. 32901
Ronald J. Killion, 750 Mooring Line Dr., Naples, Fla. 33940
Dr. W. G. Kirk, Range Cattle Exper. Sta., Ona, Fla. 33865
Dr. Francis M. Knapp, Dept. of Biol., Stetson Univ., Deland, Fla. 32720
Dr. Duane Koenig, Dept. of History, Univ. of Miami, Coral Gables, Fla. 33124
James L. Koevenig, Dept. Biol. Sci., F.T.U., Box 25000, Orlando, Fla. 32816
Prof. John J. Koran, Jr., 178 Norman Hall, Univ. of Florida, Gainesville, Fla. 32611
Georgianna Kay Kraus, 13308 82nd Ave. No., Seminole, Fla. 33542
Richard Kreske, P.O. Box 248855, University Branch, Coral Gables, Fla. 33124
Dr. Henry Kritzler, F.S.U. Marine Lab., Rt. 1, Sopchoppy, Fla. 32358
Jerome O. Krivanek, Dept. of Biology, Univ. of South Florida, Tampa, Fla. 33620
Prof. Robert A. Kromhout, Physics Dept., Fla. State Univ., Tallahassee, Fla. 32306
Jerry E. Kubal, P.O. Box 12464, Univ. Sta., Gainesville, Fla. 32601
Prof. E. A. Kulakowski, Edison Comm. College, College Parkway, Ft. Myers, Fla. 33901
Dr. Frederick W. LaCava, 264 S. Atlantic Ave., Ormond Beach, Fla. 32074
Mrs. Susan F. LaCava, 264 S. Atlantic Ave., Ormond Beach, Fla. 32074
Dr. Burritt S. Lacy, Box 267, Keene, New York 12942
Dr. Albert M. Laessle, 1617 N.W. 45th Avenue, Gainesville, Fla. 32605
Dr. Edward Larson, Dept. of Biol., Univ. of Miami, Coral Gables, Fla. 33124
Albert A. Latina, Dept. of Biol., Univ. of South Florida, Tampa, Fla. 33620
Dr. John M. Lawrence, Dept. of Zoology, Univ. of South Florida, Tampa, Fla. 33620
James M. Layne, Archbold Biol. Sta., Rt. 2, Box 180, Lake Placid, Fla. 33852
Dr. Robert J. Leacock, Astronomy Dept., Univ. of Florida, Gainesville, Fla. 32611
Benjamin B. Leavitt, Dept. of Zoology, Univ. of Florida, Gainesville, Fla. 32611
Mrs. Annette J. Lee, Physics Dept., Florida Keys Jr. College, Key West, Fla. 33040
Prof. Clarence E. Lee, 2833 N.E. 26th Ave., Lighthouse Point, Pompano Beach, Fla. 33064
James B. Lee, 4832 Headlee Dr., Orlando, Fla. 32809
Dr. W. Henry Leigh, Chmn., Dept. of Biology, Univ. of Miami, Coral Gables, Fla. 33124
Dr. Irwin S. Leinbach, 631 6th Ave. S., St. Petersburg, Fla. 33705
Frank P. Leto, Jr., 1591 S. Lane, 132B, Jacksonville, Fla. 32210
Roy R. Lewis III, Hillsborough Comm. College, Box 22127, Tampa, Fla. 33622
Dr. William A. Little, P.O. Box 875, Univ. of Miami, Biscayne Annex, Miami, Fla. 33152
Ben Lynd, P.O. Box 3028, Orlando, Fla. 32811
Dr. Robert W. Long, Dept. Botany & Bacteriology, Univ. of South Florida, Tampa, Fla. 33620
Dr. Albert Lorz, 409 Newell Hall, Univ. of Florida, Gainesville, Fla. 32611
Wm. V. Lovell, Rt. 2, Box 18, Sanford, Fla. 32771
Dr. J. T. Ludwig, P.O. Box 238, Jacksonville, Fla. 32201

Nancy E. Lutz, Box 225, Ft. George Is., Fla. 32226
Gilbert L. Lycon, Stetson Univ., Deland, Fla. 32720
Prof. Robert Macgowan, 1119 S. Johnson Ave., Lakeland, Fla. 33803
Dr. Charles H. Mallery, Dept. of Biol., Univ. of Miami, Coral Gables, Fla. 33124
Samuel Mandlow, 5025 Grace Street, Tampa, Fla. 33607
Tom Mangum, Science Dept., Valencia Comm. College, Orlando, Fla. 32802
Dr. Richard L. Mansell, Dept. of Biology, Univ. of South Florida, Tampa, Fla. 33620
Dr. Richard N. Mariscal, Dept. of Biol. Sci., Florida State Univ., Tallahassee, Fla. 32306
Dr. Meyer B. Marks, 333 Arthur Godfrey Rd., Miami Beach, Fla. 33140
Dr. Alex Marsh, Dept. Biol. Sci., Fla. Atlantic Univ., Boca Raton, Fla. 33432
Dr. James S. Marsh, Physics Dept., Univ. of West Florida, Pensacola, Fla. 32504
Dr. D. F. Martin, Dept. of Chemistry, Univ. of South Florida, Tampa, Fla. 33620
Dwight D. Martin, 5612-B 18th Way, South, St. Petersburg, Fla. 33712
Robert A. Martin, Curator, Ocean Life Park Aquarium, 105 3rd St., Villamar, Isla Verde, San Juan, Puerto Rico
James P. Marum, Dept. of Oceanography, Fla. State Univ., Tallahassee, Fla. 32306
Roger A. Martz, 3994 S.W. 12th Terr., Ft. Lauderdale, Fla. 33315
Dr. Donald Mason, 504 Riverside Dr., Indialantic, Fla. 32901
Mark A. Mastandrea, Ph.D., MSI Corp., 1425 S. Belcher Road, Clearwater, Fla. 33516
Bertha Mather, 2304 S. Colonial Dr., Melbourne, Fla. 32901
Ethelyne L. McBee, 4191 S.W. 97th Ct., Miami, Fla. 33165
Patrick M. McCaffrey, Dept. of Oceanography, Fla. State Univ., Tallahassee, Fla. 32306
Wm. L. McCart, P.O. Box 806, Roma, Texas 78584
D. S. McCorquodale, Jr., 395 N.W. 23rd St., Boca Raton, Fla. 33432
S. E. McFadden, Jr., 813 N.W. 25th Ave., Gainesville, Fla. 32601
M. David McJunkin, Dept. of Geography, Fla. Atlantic Univ., Boca Raton, Fla. 33432
Dr. Doris McKenzie, Dept. of Medicine, Univ. of Miami Med. School, Miami, Fla. 33136
Dr. Ronald B. McKinnis, Automatic Machinery Corp., Box 1888, Winter Haven, Fla. 33880
Gary McKnight, Biol. Dept., Lake City Comm. College, Lake City, Fla. 32055
Mary Ruth McMahan, 4457 38th Ave. N., St. Petersburg, Fla. 33713
James M. McWhorter, Miami-Dade Jr. College, 11380 N.W. 27th Ave., Miami, Fla. 33167
Mervin E. Meck, D.O., 225 N. Causeway, New Smyrna Beach, Fla. 33167
Dr. R. W. Menzel, Oceanographic Inst., Fla. State Univ., Tallahassee, Fla. 32306
E. P. Miles, Director, Computing Center, Fla. State Univ., Tallahassee, Fla. 32306
Dr. Donald R. Miller, Indust. & Systems Engr., Univ. of Florida, Gainesville, Fla. 32611
Dr. E. Morton Miller, 1212 Manati Ave., Coral Gables, Fla. 33146
Dr. Harvey A. Miller, Dept. Biol. Sci., F.T.U., Orlando, Fla. 32816
Alfred P. Mills, Dept. of Chemistry, Univ. of Miami, Coral Gables, Fla. 33124
M. Ronald Milmeo, 4800 Grant St., Hollywood, Fla. 33021
Wallace Minto, 1121 Lewis Ave., Sarasota, Fla. 33577
Martin A. Moe, 2008 Tanglewood Way N.E., St. Petersburg, Fla. 33702
David Molchos, 9400 Martinique Dr., Miami, Fla. 33157
Frances M. Moody, 810 Rollins St., Orlando, Fla. 32803
Harold L. Moody, Game & Freshwater Fish Comm., 545 N. Woodland, Winter Garden, Fla. 32787
David H. Mook, R.F.D. 1, Box 196, Ft. Pierce, Fla. 33450
Dr. Joseph Curtis Moore, Fla. Southern College, Lakeland, Fla. 33802
McDonald Moore, 562 Leamore Ct., Mobile, Ala. 36617
Dr. Robert C. Moore, School of Pharmacy, Univ. of Georgia, Athens, Ga. 30601
William H. Moore, P.O. Box 938, Lehigh Acres, Fla. 33936
Thomas F. Morrison, 1491 Summerland Ave., Winter Park, Fla. 32789
Julia F. Morton, Box 8204, Univ. of Miami, Coral Gables, Fla. 33124
Gerald A. Moshiri, Faculty of Biology, Univ. of West Fla., Pensacola, Fla. 32504

Charles J. Mott, Dept. of Nat. Sci., St. Petersburg Jr. Coll., Clearwater, Fla. 33515
Frank Moya, Dept. of Anesthesiol., Jackson Mem. Hospital, Miami, Fla. 33136
Dr. Robert S. Mullin, Plant Pathology Lab., Univ. of Florida, Gainesville, Fla. 32611
Joseph F. Mulson, Dept. of Physics, Rollins College, Winter Park, Fla. 32789
Mary Ruth Murray, 4520 Santa Maria St., Coral Gables, Fla. 33146
Dr. Margaret Jean Mustard, Univ. of Miami, P.O. Box 9118, Coral Gables, Fla. 33124
Dr. James L. Nation, 208 Newell Hall, Univ. of Florida, Gainesville, Fla. 32611
Rev. Dr. P. Nawrocki, c/o Bendix AES, 6801 Kenilworth Ave., Riverdale, Md. 20840
David Nicol, Box 14376, Univ. Station, Gainesville, Fla. 32611
Dr. Jorma I. Niven, 1803 E. Lakeview Ave., Pensacola, Fla. 32503
Dr. Nancy L. Noble, Dept. of Biochem., Univ. of Miami School of Med., P.O. Box 520875, Miami, Fla. 33152
Jack H. Noon, Physics Dept., F.T.U., Box 25000, Orlando, Fla. 32816
Dr. Frank H. Nordlie, Dept. of Zoology, Univ. of Florida, Gainesville, Fla. 32611
Dr. Timothy O'Keef, Dept. of Communication, F.T.U., Orlando, Fla. 32816
Lewis D. Ober, 1235 N.E. 20th St., No. Miami Beach, Fla. 33162
Larry Ogren, Nat. Marine Fisheries Serv., NNOAA, P.O. Box 4218, Panama City, Fla. 32401
Dr. M. Jack Ohanian, Dept. of Nucl. Engr. Sci., Univ. of Florida, Gainesville, Fla. 32611
Dr. Norman L. Oleson, Dept. of Physics, Univ. of South Florida, Tampa, Fla. 33620
Lawrence A. Olsen, Dept. of Oceanography, Fla. State Univ., Tallahassee, Fla. 32306
Dr. Wallace H. Orgell, 2431 Tigertail Ave., Miami, Fla. 33133
Dr. George Osborn, 487 Little Hall, Univ. of Florida, Gainesville, Fla. 32611
Dr. John A. Osborne, Dept. Biol. Sci., F.T.U., Box 25000, Orlando, Fla. 32816
Dr. Bernard Ostle, College of Nat. Sci., F.T.U., Box 25000, Orlando, Fla. 32816
Dr. Joan Ostrow-Schwebel, 1121 Via Del Mar, Winter Park, Fla. 32789
Dr. Francisco J. Palacio, Univ. of Miami, 10 Rickenbacker Cswy., Miami, Fla. 33149
Dr. Huo-Ping Pan, U.S. Dept. of Interior, 2820 E. University Ave., Gainesville, Fla. 32611
Dr. Mary Cathryne Park, 450 Norwood St., Merritt Is., Fla. 32952
Garald G. Parker, 3303 McFarland Rd., Tampa, Fla. 33618
Dr. Robert H. Patton, 5901 Banyan Terr., Plantation, Fla. 33313
Allen Paul, Dept. of Oceanography, Fla. State Univ., Tallahassee, Fla. 32306
Dr. Lawrence R. Penner, 1rp Biol. Sci. Group U-43, Univ. of Connecticut, Storrs, Conn. 06268
Nathaniel M. Perlmutter, c/o Geraghty & Miller, Inc., 501 W. Hillsborough Ave., Tampa, Fla. 33603
Dr. William L. Peters, P.O. Box 111, Florida A & M Univ., Tallahassee, Fla. 32307
Jeffrey Peterson, P.O. Box 3081, Lantana, Fla. 33460
Dr. Cecil G. Phipps, 1245 E. 8th St., Cookeville, Tenn. 38501
E. C. Pirkle, 2219 N.W. 17th Ave., Gainesville, Fla. 32601
Fred Pitts, 27 Halset Rd., Milton, Fla. 32570
Dr. Hans S. Plendl, Dept. of Physics, Fla. State Univ., Tallahassee, Fla. 32306
Earle K. Plyler, Dept. of Physics, Fla. State Univ., Tallahassee, Fla. 32306
Dr. Adrian W. Poitras, Miami-Dade Jr. College, 11380 N.W. 27th Ave., Miami, Fla. 33167
Dr. Louis J. Polskin, M.D., 1401 S. Florida Ave., Lakeland, Fla. 33803
Frank Z. Pollara, 510 Palm Circle West, Naples, Fla. 33940
Robert Lee Pope, Dept. Biol., Miami-Dade Jr. College, Miami, Fla. 33156
Dr. James G. Potter, Fla. Inst. of Tech., Melbourne, Fla. 32901
Dr. Leon W. Powell, Jr., Martin Mem. Hospital, Stuart, Fla. 33494
Robert W. Powell, Dept. of Psychology, Univ. of South Florida, Tampa, Fla. 33620
Kenneth W. Prest, Jr., 3425 S.W. 2nd Ave., Apt. 218, Gainesville, Fla. 32601
Maurice W. Provost, Ph.D., Director, Fla. Med. Entom. Lab., Div. of Health, P.O. Box 520, Vero Beach, Fla. 32960
Alfred B. Pulin, Dept. of Chem., Univ. of South Florida, Tampa, Fla. 33620

Dr. R. W. Puryear, Florida Mem. College, 5800 N.W. 42nd Ave. & LeJeune Rd., Miami, Fla. 33054
Dr. Hugh Putnam, Dept. Environ. Engrg., Univ. of Florida, Gainesville, Fla. 32611
Dr. Jerzey T. Pytlinski, 1402-15 S.W. 10th Terr., Gainesville, Fla. 32601
Douglas J. Raber, Dept. of Chem., Univ. of South Florida, Tampa, Fla. 33620
Wendell J. Ragan, Geology Dept., Univ. of South Florida, Tampa, Fla. 33620
S. Ramachandran, Ph.D., 3599 University Blvd. So., Jacksonville, Fla. 32216
Anthony F. Randazzo, Dept. of Geology, Univ. of Florida, Gainesville, Fla. 32611
Dr. K. Ranga Rao, Faculty of Biology, Univ. of West Florida, Pensacola, Fla. 32504
Dr. Casper Rappenecker, 1707 N.W. 7th Pl., Gainesville, Fla. 32601
George K. Reid, Eckerd College, St. Petersburg, Fla. 33733
Dr. Roger D. Reid, 6219 Vicksburg Dr., Pensacola, Fla. 32503
Dr. Walter J. Rhein, Dept. Math. Sci., F.T.U., Box 25000, Orlando, Fla. 32816
Richard A. Rhodes II, 205 N.W. Monroe Circle No., St. Petersburg, Fla. 33702
Earl R. Rich, Dept. of Biol., Univ. of Miami, Coral Gables, Fla. 33124
Prof. Henry Rick, 2350 N.W. 182nd Terr., Opa Locka, Fla. 33054
Florence K. Riemer, 9130 S.W. 100th St., Miami, Fla. 33156
Dr. Robert N. Rigby, Physics Dept., Univ. of West Florida, Pensacola, Fla. 32504
Dr. Carl D. Riggs, ADM 226, Univ. of South Florida, Tampa, Fla. 33620
Dr. W. C. Rippy, Jr., 13518 N. Florida Ave., Tampa, Fla. 33612
Bruce J. Ripy, Box 209-A, Rt. 1, Hawthorne, Fla. 32640
Ernest Ray Roberts, Box 1828, Stuart, Fla. 33494
Dr. Leonidas H. Roberts, Dept. of Physics & Astron., Univ. of Florida, Gainesville, Fla. 32611
Lt. Richard E. Roberts, P.O. Box 1246, Hobe Sound, Fla. 33455
Dr. Harry S. Robertson, Dept. of Physics, Univ. of Miami, P.O. Box 248284, Coral Gables, Fla. 33124
Dr. C. Richard Robins, 9190 S.W. 61st Ct., Miami, Fla. 33156
Dr. Earl G. Rodgers, 2183 McCarty Hall, Univ. of Florida, Gainesville, Fla. 32611
Dr. Martin A. Roessler, Trop. Bio. Ind., 8966 S.W. 87th Ct., Miami, Fla. 33156
Dr. David A. Roland, Sr., Poult. Sci. Dept., Univ. of Florida, Gainesville, Fla. 32611
Dr. Joseph Rosenshein, Santa Fe Comm. Coll., Northwest Campus, 3000 N.W. 83rd Street, Gainesville, Fla. 32602
Dr. David Rosner, 1341 S. Hickory St., Melbourne, Fla. 32901
Arnold Ross, Natural History Museum, Balboa Park, Box 1390, San Diego, Calif. 92112
Dr. John S. Ross, Dept. of Physics, Rollins College, Winter Park, Fla. 32789
Dr. Raymond E. Roth, Box 166, Rollins College, Winter Park, Fla. 32789
Wes Rouse, Warner Southern College, Lake Wales, Fla. 33853
Peter A. Saber, 8423 Caracas, Orlando, Fla. 32807
John R. Sabin, Dept. of Physics, Univ. of Florida, Gainesville, Fla. 32611
Walter G. Sall, M.D., 1680 Meridian Ave., Suite 204, Miami Beach, Fla. 33139
Bruce Salmon, 810 Rollins Street, Orlando, Fla. 32803
Dr. Harold K. Salzberg, 3708 Country Club Blvd., Cape Coral, Fla. 33904
Dr. Murray Sanders, M.D., 3009 Spanish Trail, Delray Beach, Fla. 33444
Carl J. Sandstrom, Dept. of Biology, Rollins College, Winter Park, Fla. 32789
Milton S. Saslaw, M.D., 1350 N.W. 14th St., Miami, Fla. 33125
Dr. E. G. Franz Sauer, Zoologisches Forschungs-institut u Museum A Koenig, Adenaurallee 150-164, 53 Bonn, Germany
Earl M. Sawyer, Dept. of Physics, Univ. of Florida, Gainesville, Fla. 32611
Harry J. Schaleman, Jr., 1106 Pass-a-grille Way, St. Petersburg Beach, Fla. 33706
George F. Scherer, M.D., J. H. Miller Health Center, Box 832, Gainesville, Fla. 32611
Jack F. Schindler, St. Petersburg Jr. College, St. Petersburg, Fla. 33733
George H. Schneider, 2292 S.W. 36th Ave., Miami, Fla. 33145

H. N. Schnitzlein, Ph.D., Dept. of Anatomy, Univ. of South Florida, College of Med., Tampa, Fla. 33620
H. W. Schrader, 128 B Williamson Hall, Univ. of Florida, Gainesville, Fla. 32611
Ralph W. Schreiber, Dept. of Zoology, Univ. of South Florida, Tampa, Fla. 33620
Dr. Harry P. Schultz, Dept. of Chem., Univ. of Miami, Coral Gables, Fla. 33124
Herbert H. Schusler, 1121 Lewis Ave., Sarasota, Fla. 33577
Dr. Albert Schwartz, 10000 S.W. 84th St., Miami, Fla. 33143
Guenter Schwarz, Dept. of Physics, Fla. State Univ., Tallahassee, Fla. 32306
Martin D. Schwebel, Orange County Poll. Dept., 2008 E. Michigan Ave., Orlando, Fla. 32806
Charles W. Seal, Biol. Dept., Pensacola Jr. College, Pensacola, Fla. 32504
Dr. Thomas Seale, Dept. of Biol. Sci., Fla. State Univ., Tallahassee, Fla. 32306
Joseph Frank Sedmera, Jr., Science Dept., Lake City Comm. College, Lake City, Fla. 32055
Francisco Sepulveda, 312 S.W. 12th St., Gainesville, Fla. 32601
Dr. Earl J. Serfass, Milton Roy Co., P.O. Box 12169, St. Petersburg, Fla. 33733
Jimmy B. Serna, 220 Rue Max, Pensacola, Fla. 32507
Dr. P. L. Sguros, Dept. Biol. Sci., Fla. Atlantic Univ., Boca Raton, Fla. 33432
Ken Shain, Edison Community College, Ft. Myers, Fla. 33901
Leland Shanor, Dept. of Botany, Univ. of Florida, Gainesville, Fla. 32601
H. B. Sherman, P.O. Box 683, Deland, Fla. 32720
Prof. Joel F. Sherman, Math-Science Div., Brevard Jr. College, Cocoa, Fla. 32922
Dr. Robert G. Sherrill, Jefferson Clinic, 1515 6th Ave. So., Birmingham, Ala. 35233
Dr. Izzy Shever, 3750 Piedmont Rd., Pensacola, Fla. 32503
Ray L. Shirley, Nutrition Lab., Univ. of Florida, Gainesville, Fla. 32611
Jackson P. Sickels, 541 San Esteban Ave., Coral Gables, Fla. 33146
Dr. Joseph L. Simon, Dept. of Zoology, Univ. of South Florida, Tampa, Fla. 33620
Harold W. Sims, Jr., Dept. of Nat. Sci., St. Petersburg Jr. College, 2465 Drew St., Clearwater, Fla. 33515
John W. Sites, 1819 S.W. 35th Ave., Gainesville, Fla. 32601
Francis G. Slack, P.O. Box 15617, Four Points Br., West Palm Beach, Fla. 33401
Dr. John C. Slater (Honorary), Physics Dept., Univ. of Florida, Gainesville, Fla. 32611
Dr. Ernest T. Smerdon, Dept. of Ag. Engrg., Univ. of Florida, Gainesville, Fla. 32611
Alex G. Smith, Dept. of Physics & Astron., Univ. of Florida, Gainesville, Fla. 32611
Dr. Francis Albert Smith, 1023 55th Ave. So., St. Petersburg, Fla. 33705
Mrs. Francis A. Smith, 1023 55th Ave. So., St. Petersburg, Fla. 33705
Marshall E. Smith, 418 W. Platt St., Tampa, Fla. 33606
Dr. Richard C. Smith, Dept. of Physics, Univ. of West Florida, Pensacola, Fla. 32504
F. C. Snowden, Dir. RD&E, P.O. Box 12169, St. Petersburg, Fla. 33733
Dr. Boris Th. Sokoloff, Southern Bio-Research Inst., Fla. Southern College, Lakeland, Fla. 33803
Dr. Anthony T. Soldo, V.A. Hospital, 1201 N.W. 16th Terr., Miami, Fla. 33157
James Soule, 1179 McCarty Hall, Univ. of Florida, Gainesville, Fla. 32611
John F. Spalding, 100 Oak St., Box 303, Melbourne Beach, Fla. 32951
Daniel P. Spangler, Dept. of Geology, Univ. of South Florida, Tampa, Fla. 33620
Kenneth Sprague, Rm. 202, Nucl. Sci. Bldg., Univ. of Florida, Gainesville, Fla. 32611
Howard S. Stafford, 101 Martin St., Indian Harbor Beach, Fla. 32935
Charles H. Starn, 740 N.W. 65th Ave., Ft. Lauderdale, Fla. 33313
Sr. Agnes Louise Stechschulte, Ph.D., Barry College, 11300 N.E. 2nd Ave., Miami, Fla. 33161
Theodore M. Stefanik, 743 London Rd., Winter Park, Fla. 32789
Dr. Abraham M. Stein, Dept. of Biol. Sci., Fla. International Univ., Tamiami Trail, Miami, Fla. 33144
H. Edwin Steiner, Jr., Edu 308, Univ. of South Florida, Tampa, Fla. 33620

Dr. Don C. Steinker, Dept. of Geology, Bowling Green State Univ., Bowling Green, Ohio 43403
Marion Stevens, 3924 Cleveland St., Hollywood, Fla. 33021
Dr. Henry K. Stevenson, Biol. Sci. Dept., Fla. State Univ., Tallahassee, Fla. 32306
James A. Stevenson, 3540 Thomasville Rd., Tallahassee, Fla. 32303
Kerry K. Steward, 490 S.W. 62nd Ave., Plantation, Fla. 33314
Roger P. Stewart, Rt. 1, Box 236, Plant City, Fla. 33566
Violet N. Stewart, 5544 Terrace Ct., Apt. 2, Temple Terrace, Fla. 33617
Dale V. Stingley, P.O. Box 113, La Belle, Fla. 33935
Mrs. Frances L. Stivers, 2918 Fruitwood Lane, Jacksonville, Fla. 32211
Peter A. Stone, 43 N.E. 26th Ct., Ft. Lauderdale, Fla. 33308
Dr. Edwin F. Strother, Physics Dept., Fla. Inst. of Tech., Melbourne, Fla. 32901
Sidney A. Stubbs, P.O. Box 2066, Houston, Texas 70152
Dr. Thomas T. Sturrock, Dept. of Biol. Sci., Fla. Atlantic Univ., Boca Raton, Fla. 33432
Prof. Claude C. Stusgill, 630 N.E. 10th Ave., Gainesville, Fla. 32601
Carl T. Summerlin, Biol. Dept., Pensacola Jr. College, Pensacola, Fla. 32504
Mr. John W. Sutton, 736 4th Ave. No., Jacksonville Beach, Fla. 32250
D. C. Swanson, Physics Dept., Univ. of Florida, Gainesville, Fla. 32611
Camm C. Swift, Museum of Nat. History, 900 Exposition Blvd., Los Angeles, Calif. 90007
David E. Swindell, 905 E. Park Ave., Tallahassee, Fla. 32301
Dr. Durbin C. Tabb, 9850 Bahama Dr., Miami, Fla. 33157
William H. Taft, Univ. of South Florida, Tampa, Fla. 33620
W. Lee Tanner, Box 38, Lake Panasoffkee, Fla. 33538
William F. Tanner, Geology Dept., Fla. State Univ., Tallahassee, Fla. 32306
James R. Taylor, 10922 52nd Ave. No., St. Petersburg, Fla. 33708
John L. Taylor, P.O. Box 730, Lynn Haven, Fla. 32444
Dr. Walter K. Taylor, Dept. Biol. Sci., F.T.U., Box 25000, Orlando, Fla. 32816
Dr. Howard J. Teas, 6700 S.W. 130th Terr., Miami, Fla. 33156
Dan A. Thomas, Dean of the Faculty, Jacksonville Univ., Jacksonville, Fla. 32211
Dr. Garland L. Thomas, 200 E. Southgate Blvd., Melbourne, Fla. 32901
Prof. John J. Thomas, Medical Research Inst., Fla. Inst. of Tech., Melbourne, Fla. 32901
Dr. Anitra Thorhaug, RSMAS, 10 Rickenbacker Causeway, Miami, Fla. 33149
William J. Tiffany III, Marine Biomed. Inst., Univ. of Texas, 200 University Blvd., Galveston, Texas 77550
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Harold Yaffa, Biol. Dept., Miami-Dade Jr. Coll. North, Miami, Fla. 33167
Dr. Albina Yakaitis-Surbis, Univ. of Miami School of Med., P.O. Box 875, Biscayne Annex, Miami, Fla. 33152
Ralph W. Yerger, Dept. Biol. Sci., Fla. State Univ., Tallahassee, Fla. 32306
Harold Young, 925 E. Pearl St., Monticello, Fla. 32344
Dr. John L. Zaharis, 17790 S.W. 200th St., Miami, Fla. 33157
Warren Zeiller, Miami Seaquarium, Rickenbacker Cswy., Miami, Fla. 33152
Robert Zeppa, Dept. of Surgery, Box 875, Biscayne Annex, Miami, Fla. 33152
Benjamin O. Zirin, Ph.D., 199 W. 24th St., Hialeah, Fla. 33010

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Physical Sciences

X-RAY POWDER DIFFRACTION DATA FOR WAVELLITE

Frank N. Blanchard

Department of Geology, University of Florida, Gainesville, Florida 32611

X-ray powder diffraction data for wavellite in the Powder Diffraction File (Cards #2-0075 and 17-203) is incomplete and (in part) is indexed incorrectly; in addition, probably as a result of having been obtained with a powder camera, the relative intensities of the reflections do not correspond to those which are obtained by routine powder diffractometry. Because of this it is difficult to arrive at a correct identification of the mineral using only diffractometry data in conjunction with the Index or Fink Guide to the Powder Diffraction File.

The data presented in this report were obtained by diffractometry using wavellite from Jefferson County, Florida (Blanchard and Denahan, 1966), and the d-spacings and relative intensities are more likely to correspond closely with data from other samples of wavellite which are analyzed with the diffractometer. In addition to the wavellite from Jefferson County, I have x-rayed a large number of wavellite samples from Florida and a few wavellite samples from other locations. All have yielded very similar powder diffraction data.

During the final writing of this manuscript, a paper by Klemic and Mrose (1972) was called to my attention. Their paper includes powder diffraction data for wavellite from near Black River Falls, Wisconsin. The d-spacings which they list and their indexing correspond very closely with my data, except that down to d = 1.751 I find 11 lines (of low intensity) not listed in their data, and they list 3 lines (of low intensity) not included in my data. In addition, there are minor discrepancies in relative intensities, probably due largely to differences in degree of preferred orientation.

Methods—A hand-picked sample of wavellite, ground to –325 mesh, was prepared as a smear on a glass slide. Prior to analysis the diffractometer was aligned and the specimen support was shimmed so that at 0° 2θ the primary beam was split in half by the sample. Scans were made at 0.2° 2θ per minute, covering

TABLE 1. Powder Diffraction Data[1]

Observed d Å	Calculated d Å[2]	I relative	hkl
8.71	8.68	70	020
8.42	8.40	100	110
5.67	5.66	15	101
5.39	5.38	5	111
4.963	4.956	10	130
4.809	4.802	35	200
4.745	4.742	2	121
4.338	4.339	2	040
4.047	4.046	3	131
3.962	3.961	2	201
3.867	3.862	1	211
3.609	3.604	< 1	221
3.441	3.444	12	141
	3.435		012
3.272	3.269	3	231
3.224	3.219	48	240
3.149	3.148	8	310
3.082	3.078	3	122
3.000	2.997	1	032
2.963	2.959	3	151
2.928	2.925	5	241
2.899	2.893	3	060
2.874	2.872	< 1	311
2.801	2.801	15	330
2.764	2.761	2	321
2.612	2.611	1	251
2.603	2.601	4	331
2.578	2.576	13	161
2.545	2.543	2	232
2.477	2.478	1	260
2.400	2.401	7	400
	2.401		170
2.365	2.364	2	302
2.272	2.271	5	401
	2.271		171
	2.270		103
2.234	2.231	1	351
2.229	2.231	1	062
2.198	2.197	1	421
	2.196		123
2.192	2.194	1	252
2.172	2.173	< 1	162
	2.170		080
2.115	2.114	< 1	431
	2.113		133
2.102	2.102	18	271
	2.101		203
	2.101		440
2.085	2.086	< 1	213
2.053	2.052	< 1	361
2.045	2.042	< 1	223
2.027	2.026	1	181
	2.024		072
	2.023		262
2.014	2.012	1	441
	2.011		143
1.978	1.981	5	402
	1.981		172
	1.977		280
	1.975		233
1.958	1.960	6	370
1.910	1.910	< 1	510
1.904	1.902	< 1	281
	1.901		451
1.891	1.891	2	243
	1.891		190
1.844	1.845	< 1	082
	1.844		323
1.830	1.830	1	362
	1.825		191
1.812	1.812	1	521
	1.812		182
1.751	1.752	1	004
1.720		3	
1.703			

TABLE 1.
(CONTINUED)

Observed d Å	Calculated d Å[2]	I relative	hkl	Observed d Å	Calculated d Å[2]	I relative	hkl
1.674				1.455			
1.652				1.450			
1.610				1.411			
1.607		2		1.399			
1.600		2		1.382			
1.593		2		1.380			
1.570		2		1.345			
1.557		1		1.342			
1.554		1		1.320			
1.542				1.311			
1.539				1.309			
1.518				1.299			
1.485				1.263			
1.469							

[1]CuK_α Radiation, Diffractometer.
[2]Calculated for a = 9.604, b = 17.356, c = 7.009 (refined for observed reflections to 75° 2θ).

the range from 2° to 90° 2θ using 1° and 3° divergence slits and 0.02°, 0.05°, and 0.1° detector slits, and using Ni-filtered Cu-radiation. With the aid of the computer program of Appleman and Evans (1967) the observed reflections were indexed, lattice dimensions were refined, and d-spacings were calculated from the refined lattice dimensions.

RESULTS—Powder diffraction data are given in Table 1. For most of the reflection past 50° 2θ it was not possible to unequivocally index the reflections; therefore, hkl values are not listed for d-spacings smaller than 1.75 Å. Even at lower 2θ angles there are many cases where more than one family of lattice planes may contribute to an observed reflection, and in these instances the several possible hkl values are listed.

Cards #2-0075 and 17-203 from the Powder Diffraction File list 17 and 13 reflections corresponding to d values greater than 2 Å, whereas Table 1 shows 44 reflections. This greater number is due partly to higher resolution and partly to detection of low intensity reflections. The two lines at d = 8.71 and d = 8.42 are clearly resolved in normal diffractometer techniques, but are listed as a single line on both File Cards. This has led to at least one misinterpretation in the literature: "a characteristic double diffraction peak at 10.38° 2θ because isomorphous substitution of iron was present" (Fiskell and Rowland, 1960).

No unusual precautions were undertaken to promote random orientation of particals within the sample. Wavellite tends to be acicular parallel with [001] and has at least three cleavages ({110} perfect, {101} good, and {010} distinct); undoubtedly preferred orientation due to cleavage has resulted in enhancement of orders of the 110, 101, and 010 reflections. Therefore, the recorded relative intensities (measured as area under the peak above background) do not represent ideal random orientation, but do represent the approximate values that may be expected where routine diffractometry is the technique used.

The refractive indices of the wavellite from Jefferson County, Florida (measured by immersion methods) are $\alpha = 1.523 \pm .003$, $\beta = 1.531 \pm .003$, and $\gamma = 1.550 \pm .004$; these values fall in the lower part of the ranges given by Palache, et. al. (1951).

X-ray spectrochemical analysis for the proportion of Al_2O_3 to P_2O_5, made with synthetic standards closely approximating the proportions of these oxides in the ideal wavellite formula, indicates 1.65 atoms of Al for each atom of P. Thus there appears to be a deficiency of P or an excess of Al amounting to about 10% (atomic). Water content above 100° and below 400° C is 25.6%, a deficiency compared with the ideal formula (28.42%).

ACKNOWLEDGMENTS—Indexing of reflections, calculation of d-spacings and refinement of lattice constants was accomplished through facilities of the University of Florida Computing Center. James Dickinson assisted in obtaining some of the x-ray diffraction data.

LITERATURE CITED

APPLEMAN, D. E., AND H. R. EVANS, JR. 1967. Experience with computer self-indexing and unit cell refinement of powder data (abstr.). Geol. Soc. Amer. Spec. Pap. 115.

BLANCHARD, F. N., AND S. D. DENAHAN. 1966. Wavellite-cemented sandstones from northern Florida. Quart. J. Florida Acad. Sci. 29: 248-250.

FISKELL, J. G. A., AND L. O. ROWLAND. 1960. Soil chemistry of subsoils of west central Florida. Proc. Soil & Crop Sci. Soc. Florida 20: 123-138.

KLEMIC, H. AND M. E. MROSE. 1972. Geologic relations and x-ray crystallography of wavellite from Jackson County, Wisconsin, and their geologic implications. U. S. Geol. Surv. Prof. Paper 800-C: C53-C62.

PALACHE, C., H. BERMAN, AND C. FRONDEL. 1951. The System of Mineralogy of . . . Dana, 7th Ed. Vol. 2. John Wiley and Sons. New York, N. Y.

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FOOD HABITS AND REPRODUCTION OF THE TAILLIGHT SHINER, *NOTROPIS MACULATUS* (HAY), IN CENTRAL FLORIDA[1]

Mondell L. Beach

Florida Department of Natural Resources, Larson Building, Tallahassee, Florida 32304

Abstract: *Food habits and reproduction of the taillight shiner* (Notropis maculatus *(Hay)) were studied from 1718 fish collected in a small pond in Hillsborough County, Florida. The population consisted of two life stages, juvenile and adult. Both life stages showed similar dietary patterns, feeding primarily on algae from late summer through early winter, and Cladocera from late winter through spring. Except for one occasion, both life stages continually selected ostracods, and copepods usually were avoided. The breeding season, modulated by warm-waters and abundant sunshine, extended March—September with spawning terminating by October. Recruitment occurred from July through February. Mature females consistently were larger than mature males.*

Notropis maculatus is a small cyprinid fish occurring in temperate freshwaters of the southern midwest and southeastern United States. It ranges from southern North Carolina south to peninsular Florida, west along the gulf coastal plain, and north from the Mississippi Valley to southeastern Oklahoma and Missouri (Bailey, Winn, and Smith, 1954). In 1956, it was reported in west Texas by Hubbs, Kemp, and Gray. It is the common *Notropis* species distributed throughout Florida's lakes and streams (Carr and Goin, 1955), and is the largest generic representative in peninsular Florida (McLane, 1955).

The taillight shiner was described originally as *Hemitremia maculata* by Oliver Hay in 1880. It also was described as *Opsopoeodus bollmani* by C. H. Gilbert in 1888 and as *Notropis louisae* by Henry Fowler in 1940. However, Bailey, Winn, and Smith (1954) concluded in their Escambia River study that *H. maculata, O. bollmani,* and *N. louisae* were synonymous and combined them as *Notropis maculatus.*

Because published ecological material on *N. maculatus* is very scarce, a study of its life history in Central Florida was undertaken from March 1969 to March 1970.

Materials and Methods—Research was conducted in a 2.36 ha pond on the University of South Florida Golf Course in Tampa. The pond is bounded south by the no. 6 fairway, east by Cypress Swamp, and north and west by littoral areas rich with aquatic higher plants. The pond receives water largely through runoff and drains through Cypress Swamp and Thirteenmile Run into the Hillsborough River. During August and September, Cypress Swamp floods into the pond. The bottom consists of mud covered with a thin layer of silt. Hydrographic, physical-chemical, and climatological data are given in Table 1.

[1]From a thesis submitted in partial fulfillment of the MA Degree, University of South Florida, 1971.

TABLE 1. Hydrographic, physical-chemical, and climatological features of Golf Course Pond, Hillsborough County, Florida. Physical-chemical data represent nine month ranges (June 1969, to March 1970); climatological data represent thirteen month ranges (March 1969, to March 1970).

Hydrographic features:	
Surface area	2.36 ha
Volume	34,131.0 m^3
Mean depth	1.3 m
Maximum depth	3.2 m
Physical-chemical features:	
Water temperature (°C)	14-34.5
Turbidity (ppm)	24-45
pH	6.1-7.2
Alkalinity (ppm total carbonate)	26.8-42
Dissolved oxygen (ppm)	6.5-8.8
% saturation	75-117
Climatological features:	
Precipitation (cm)	0.13-30.18
Photoperiod (hours Light/hours Dark)	10.4L/13.6D-13.9L/10.1D

Sampling: Heavy growth of aquatic plants restricted collections to the north shore and northwest corner. Semimonthly fish samples were taken from June 10, 1969, through March 9, 1970, with a 4 × 20-ft 1/8-in minnow seine. Night samples were taken on July 2 and 18, and September 3 and 8. Fish were fixed in 10% formalin, later washed in tap water, and stored in 60% ethanol. Fish were weighed after the alcohol evaporated from the surface and total length measured. On the basis of length-frequency distributions and gonad development, fish 30 mm or less were considered to be juveniles. Fish were classified as: immature, mature or spent.

A length-wt regression equation was calculated for male, female, and juvenile fish, and respective residual mean squares, slopes, and elevations tested for significant differences. If there were no significant differences (95% level of significance) between males, females, and juveniles, monthly data were combined and compared.

Monthly zooplankton samples were collected at the surface and 1.0 m with a 1-liter container from September 1969, through March 1970. Zooplankton samples were concentrated with 0.076 mm sieve and preserved in modified Lugol's solution (Edmondson, 1959). Counts of copepods, cladocerans, ostracods, and rotifers were made for each sample, and a monthly mean value was computed for each organism from combined surface and 1.0 m samples. Counts were expressed as a percentage of the total monthly population.

Food Habits: The diet of juvenile and adult taillight shiners was determined from samples collected from June 1969, through March 1970. A random-stratified sample of 10 fish with full stomachs was selected from each life stage. The upper one-third of the S-shaped digestive tract was removed, the contents of the ten fish combined, and total counts made at 100× magnification. Whenever possible, three sub-samples from each life stage were examined. Specific items were expressed as percentages of the total stomach content, and monthly means computed. Selectivity for zooplankton food organisms was expressed as Ivlev's Electivity Index (1961). The Electivity Index (E) was extrapolated from a nomograph or calculated from the following Ivlev formula:

$$E = \frac{r_i - P_i}{r_i + P_i}$$

where r_i = the relative content of any food ingredient expressed as a percentage of the total food ration, and P_i = the relative value of the same environmental ingredient expressed as a percentage of the total environmental ration.

Reproduction: The mean length at which male and female fish became mature and time of spawning were determined from the total collection. Time of spawning was determined from gonad classifications, juvenile recruitment, and coefficients of condition ($K_{(TL)}$) (Lagler, 1956). Gonad classifications were expressed as a monthly percentage. Monthly mean coefficients of condition for male and female fish were computed and tested with an unpaired *t* test at the 95% level of significance. If significant differences were present, data were treated separately. Fecundity was estimated from the mean number of eggs greater than 0.8 mm in diameter in five mature females randomly selected from length intervals of 41-45 mm, 51-55 mm, and 56-60 mm.

RESULTS—*Sampling:* Based upon Stein's two-stage sampling procedure (95% confidence interval), a sample of 42 fish was required to estimate the adult mean length at ± 2.0 mm; 7 juveniles were required at ± 1.5 mm (Steel and Torrie, 1960). These criteria were fulfilled for adults in all months except April, May, June, and March (1970), and February for juveniles.

No significant differences were found within or between monthly male, female, and juvenile slopes, residual mean squares (chi-square = 29.1; d.f. = 20), and elevations. Therefore, data were combined and the calculated length-wt equation for the 1718 fish was: Log W = –5.3210 + 3.0734 (Log L).

Cladocera were the most abundant zooplankton group from September through March and averaged 28.3 organisms per l. They were predominant in all months except October, January, and February. The next largest group was the Copepoda (16.6/l) followed by the Rotifera (12.7/l) and the Ostracoda (4.4/1). Copepoda predominated in January and February, Rotifera in October, and Ostracoda were of minor importance. *Bosmina* and *Pleuroxus* were the most abundant cladocerans, while nauplii were the dominant copepod form. *Bosmina* was most abundant in September, October, and March; *Pleuroxus* was dominant in November, January, and February.

Food Habits: Diet of juvenile and adult fish consisted of six major food groups; algae, Rotifera, Branchipoda (Cladocera), Ostracoda, Copepoda, and Insecta (Chironomidae). Algae (45%) and Cladocera (32%) dominated the juvenile and adult total diets respectively (Table 2). Of secondary importance were Cladocera (25%) and Rotifera (18%) for juveniles, and algae (28%) and Ostrocoda (19%) for adults. Juveniles also consumed ostracods (7%) and copepods (3%), while copepods (9%), rotifers (6%), and insects (1%) were minor components of the adult diet.

Algae dominated the diet of both life stages from June through December except in October. *Closterium* was the dominant algal organism in both life stages,

TABLE 2. Diet of juvenile and adult *Notropis maculatus* collected from June 1969, through March 1970, in Hillsborough County, Florida. The upper number represents the monthly mean number of food items, the lower represents the percentage of the total monthly diet, and Tr designates those items comprising less than 1%.

ITEM	1969							1970		
	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
$N_{juvenile}$ =	0	8	30	2	30	30	10	10	6	0
N_{adult} =	2	30	30	30	30	30	30	30	30	20
ALGAE										
Micrasterias										
juvenile		8	12	2	3	20.3	1			
		12.3	15.2	8.3	2.6	9.9	Tr			
adult			22	68	1.3		4			
			26.6	55.0	1.4		3.5			
Cosmarium										
juvenile			6			20.3	2		3	
			7.6			9.9	1.1		1.7	
adult			5.3	2	3.7		8.3	1.3		2.5
			6.4	1.6	3.9		7.2	Tr		Tr
Closterium										
juvenile		18	12.7	12	20.7	47.7	92	30	8	
		27.7	16.7	50	18.2	23.2	52.6	13.8	4.7	
adult		37.5	2.7	2.7	9.7	47.7	21	34.7	26.3	22
		38.3	3.3	2.2	10.3	22.0	18.3	20.1	9.3	6.0
Navicula										
juvenile		4				16.3		4	6	
		6.2				7.9		1.8	3.5	
adult				1.3	5	17.7	2.3	2	7.3	13.5
				1.0	5.3	8.1	2.0	1.2	2.6	3.7
Unident. diatom										
juvenile		5	7.7	3	10		17	11		
		7.7	9.7	12.5	8.8		9.7	5.0		
adult	4	4.3					10		2	3
	16.7	4.5					8.7		Tr	Tr
Other algae										
juvenile		11	18.7		33		5	2	3	
		16.9	23.6		29.1		2.9	Tr	1.8	
adult	1	9.7	13		9.3	27.3	4	1.7		
	4.2	9.9	15.7		9.9	12.6	3.5	1.0		
Total algae										
juvenile		46	57.1	17	66.7	104.6	117	47	20	
		70.8	72.2	70.8	58.8	51.0	66.9	21.6	11.7	
adult	5	51.5	43	74	29	92.7	49.6	39.7	35.6	41
	20.8	52.7	52.0	59.8	30.8	42.7	43.2	23.0	12.6	11.1
CRUSTACEA										
Cladocera										
Pleuroxus										
juvenile			2				8	8	22	
			2.5				4.6	3.7	12.9	
adult		2.3	8.3	7.3	1.3	13.3	6.7	15.3	60	49
		2.3	10.0	5.9	1.4	6.1	5.8	8.9	21.3	13.3
Bosmina										
juvenile								45	11	
								20.6	6.4	
adult			3.7					26	19.3	33.5
			4.5					15.1	6.8	9.1

Table 2. (con'd)

Item	1969							1970		
	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Chydorus										
juvenile								42	52	
								19.3	30.4	
adult								8	67.3	33.5
								4.6	23.9	9.1
Other Cladocera										
juvenile			6.3	3	17.4	5.3		31	13	
			8.0	12.5	15.3	2.6		14.2	7.6	
adult	5	30	2.7	3.7	22.3	25.3	6.7	6	30	41.5
	20.8	30.7	3.3	3.0	23.7	11.7	5.8	3.5	10.6	11.2
Total Cladocera										
juvenile			8.3	3	17.4	5.3	8	126	98	
			10.5	12.5	15.3	2.6	4.6	57.8	57.3	
adult	5	32.3	14.7	11	23.6	38.6	13.4	55.3	176.6	157.5
	20.8	33.0	17.8	8.9	25.1	17.8	11.7	32.1	62.6	42.6
Ostracoda										
juvenile		3		2	2.7	36.3	19	9	8	
		4.6		8.3	2.4	17.7	10.9	4.1	4.7	
adult	8	10.7	7.3	27.7	10.7	45	9.7	18.3	45.3	122.5
	33.3	10.9	8.8	22.4	11.4	20.7	8.5	10.6	16.0	33.2
Copepoda										
Copepod nauplii										
juvenile					11.7	8.7			3	
					10.3	4.2			1.7	
adult			8.3		29	7.3	6.3	11	14.7	17
			10.1		30.9	3.4	5.5	6.4	5.2	4.6
Cyclops										
juvenile										
adult	1	3.3	5.7			8.3		2.3		
	4.2	3.4	6.9			3.8		1.3		
Other Copepoda										
juvenile		6		1	3.3					
		9.2		4.2	2.9					
adult	5			2.3			4.7	13.7	2.7	4.5
	20.8			1.9			4.1	8.0	Tr	1.2
Total Copepoda										
juvenile		6		1	15	8.7			3	
		9.2		4.2	13.2	4.2			1.7	
adult	6	3.3	14	2.3	29	15.6	11	27	17.4	21.5
	25.0	3.4	17.0	1.9	30.9	7.2	9.6	15.7	6.2	5.8
ROTIFERA										
juvenile		10	13.7		11.7	47.7	30	36	42	
		15.4	17.3		10.3	23.2	17.1	16.5	24.6	
adult			1.3	7.7		25	29.7	32	7.3	5.5
			1.6	6.2		11.5	25.9	18.6	2.6	1.5
DIPTERA										
Chironomidae (larva)										
juvenile						2.7	1			
						1.3	Tr			
adult			2.3	1			1.3			21.5
			2.8	Tr			1.1			5.8

Table 2. (con'd)

Item	1969							1970		
	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
NEMATODA (unident.)										
juvenile				1 4.2						
adult					1.7 1.8					
Total										
juvenile		65	79.1	24	113.5	205.3	175	218	171	
adult	24	97.8	82.6	123.7	94	216.9	114.2	172.3	282.2	369.5

diatoms (especially *Navicula*) were of secondary importance, and *Micrasterias* and *Cosmarium* usually were encountered in small numbers. Cladocera were highly seasonal in both life stages. *Pleuroxus* was dominant in adult fish while juvenile fed on several Cladocera genera (*Bosmina, Chydorus,* and *Pleuroxus*).

Both life stages generally followed identical zooplankton selectivity pattern frequently selecting for ostracods (Table 3). Juvenile and adult selectivities averaged +0.18 and +0.36 respectively. Copepod nauplii were rarely selected, while copepoda adults and Rotifera were avoided. Cladocera (*Chydorus* and *Bosmina*) were selected for only in January and February with both life stages being highly selective for *Chydorus* (+1.0).

Reproduction: Sexual dimorphism was found in the taillight shiner. Mature female mean lengths consistently were greater than those of mature males; 41.86 vs. 39.34 mm. All fins of the male had dusky spots while only the dorsal, anal, and caudal fins of the female were marked. Red coloration in the pelvic and dorsal fins of breeding males was intensified by dark anterior and posterior margins.

The breeding season of *N. maculatus* extended from March through October (Table 4). During the breeding season, photoperiod increased from 11.8L/12.2D (March) to 13.9L/10.1D (June), and decreased to 11.8L/12.2D by October. Water temperatures increased from March (20°C) through June (34.5°C), and decreased through October (31°C). Fish started maturing in February (9%) and reached full maturity by May and June. Recruitment occurred from July through February and was maximal in October (Fig. 1). Spawning terminated in October as evidenced by the diminishing percentage of mature fish (10%) and the increasing percentages of spent and immature fish (73% and 17% respectively) (Table 5). The winter population was composed largely of immature and spent fish. The percentage of immature fish decreased in February and March as mature fish increased indicating the onset of spawning.

The monthly mean coefficients of condition showed highly significant differences between male and female fish during September and January, and significant differences in March 1969. $K_{(TL)}$ data indicated peak spawning in April, July, and October. $K_{(TL)}$ values increased from 0.7256 in April to 0.7897 in June corresponding with the early spawning period, decreased from July (0.5958) through October (0.5884) as a result of recruitment of smaller adults and late spawning, and increased to 0.6884 by March.

TABLE 3. Zooplankton electivity indices (E) for juvenile and adult *Notropis maculatus* collected from September 1969, through March 1970, in Hillsborough County, Florida

Item	1969			1970			
	Sept	Oct	Nov	Jan	Feb	Mar	6 mo. mean
CRUSTACEA							
Cladocera							
Sida							
juvenile				−1.0	+1.0		
adult				−1.0			−.17
Pleuroxus							
juvenile	−1.0	−1.0	−1.0	−.41	−.27		−.61
adult	−.64	−.63	−.60	−.07	−.02	+.48	−.25
Macrothrix							
juvenile	−1.0	−1.0	−1.0	−1.0	−1.0		−.83
adult	−1.0	−1.0	−1.0	−1.0	+1.0	−1.0	−.83
Daphnia							
juvenile	−1.0		−1.0		−1.0		−.50
adult	−1.0		−1.0		−1.0		−.50
Bosmina							
juvenile	−1.0	−1.0	−1.0	+.46	−.30		−.84
adult	−1.0	−1.0	−1.0	+.26	−.27	−.58	−.60
Chydorus							
juvenile	−1.0	−1.0	−1.0	+1.0	+1.0		−.83
adult	−1.0	−1.0	−1.0	+1.0	+1.0	+1.0	
Total Cladocera							
juvenile	−.69	−.37	−.92	+.49	+.24		−.21
adult	−.92	+.01	−.50	+.22	+.30	−.04	−.15
Copepoda							
Cyclops							
juvenile	−1.0		−1.0	−1.0	−1.0		−.67
adult	+.12		+.31	−.90	−1.0	−1.0	−.61
Copepod nauplii							
juvenile	−1.0	+.04	−.35	−1.0	−.88		−.53
adult	−1.0	+.52	−.40	−.64	−.70	−.41	−.44
Diaptomus							
juvenile	−1.0	−1.0	−1.0	−1.0	−1.0		−.83
adult	−1.0	−1.0	−1.0	−1.0	−1.0	−1.0	−1.0
Total Copepoda							
juvenile	−.64	+.16	−.42	−1.0	−.91		−.47
adult	−.81	+.53	−.18	−.71	−.72	−.58	−.41
Ostracoda							
juvenile	+.38	−.48	+.38	+.35	+.46		+.18
adult	+.71	+.23	+.44	+.07	+.09	+.61	+.36
ROTIFERA							
juvenile	−1.0	−.66	−.02	−.36	−.04		−.35
adult	−.13	−1.0	−.35		−.78	−.88	−.52

The mean number of eggs per female was dependent upon fish length. Females of the 36-40 mm interval averaged 95 eggs; 41-45 mm interval fish averaged 109 eggs; 46-50 mm interval fish averaged 125 eggs; 51-55 mm interval fish averaged 175 eggs; and 56-60 mm interval fish averaged 231 eggs.

TABLE 4. Monthly gonad classification of male and female *Notropis maculatus* collected from March, 1969, through March, 1970, in Golf Course Pond, Hillsborough County, Florida. Gonads are expressed as a percent of the total monthly catch for a given sex.

Month	Number collected	Gonad Classification green %	mature %	spent %
1969				
March				
male	30	7	90	3
female	33	12	88	
April				
male	20		50	50
female	6		100	
May				
male	11		82	18
female	13		100	
June				
male	1			100
female	1		100	
July				
male	58	9	77	14
female	39	49	51	
August				
male	115	26	52	22
female	165	58	40	2
September				
male	131	14	46	40
female	318	53	37	10
October				
male	35	11	17	72
female	54	22	4	74
November				
male	44	61		39
female	47	55		45
December				
male	15	100		
female	19	100		
1970				
January				
male	61	100		
female	48	100		
February				
male	50	86	14	
female	41	95	5	
March				
male	22	6	94	
female	8	14	86	

DISCUSSION—Little published information is available on the dietary patterns of other *Notropis* species. Algae and diatoms were the dominant dietary items of juvenile *N. rubellus* (Reed, 1957), while insects were dominant in adult fish (Pfeiffer, 1957). Insects were dominant in adult *N. hudsonius* (McCann, 1959; Smith and Kramer, 1964), and zooplankton were dominant in adult *N.*

atherinoides (Fuchs, 1967). The predominance of zooplankton in adult *N. maculatus* also was reported by McLane (1955).

The general selectivity trends for food organisms is a function of the environmental ration, and a food organism's size and mobility (Ivlev, 1961). The apparent selectivity for ostracods and against copepods may be a result of mobility differences. The selectivity of *N. atherinoides* for larger zooplankton organisms (i.e., Cladocera) has been noted by Fuchs (1967) and Gray (1942). If ostracods become limiting, *N. maculatus* may select Cladocera because of their large size.

Most delineations of the *Notropis* breeding season are limited to the cooler regions of the northern United States and restrict breeding to June through August at water temperatures ranging from 24.6°C to 37°C. In Florida, *N. chalybaeus* (Marshall, 1946) and *N. maculatus* (McLane, 1955) have extended breeding seasons and spawn from April through September. The extended breeding season of *N. maculatus* may be related to the warm temperatures and abundant sunshine characteristic of Florida's summer, spring, and fall seasons.

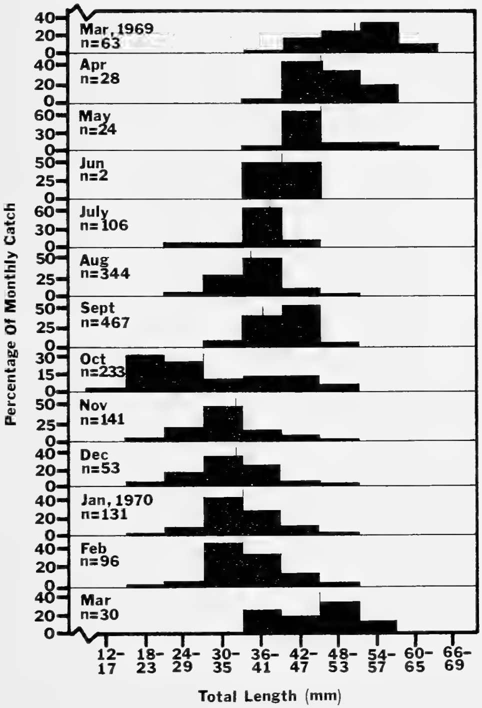

Fig. 1. Length-frequency histogram of *Notropis maculatus* collected March 1969 through March 1970 in Hillsborough County, Florida. Vertical lines indicate population mean lengths.

Harrington (1950, 1959) has shown the dependence of the cyprinid (*Notropis*) reproductive cycle upon photoperiod and temperature; long days and high temperatures are necessary for full maturity. Unless thresholds are met, oogenesis and spermatogenesis do not surpass secondary growth and primary spermatocyte phases respectively. In late summer, breeding color can be eliminated or hastened by depressing or elevating the temperature respectively (Harrington, 1959). Light may prime the reproductive cycle, with temperature triggering spawning (Breder and Rosen, 1966). The early spawning activities of *N. maculatus* may be correlated with the more rapid warming of shore waters than the center regions of the pond, and be modulated by light and temperature.

N. maculatus, as revealed by the length-frequency method, has a one year life history. To determine age by this method, individuals group about certain modal sizes (life stages) over a short sampling period according to normal distribution (Applegate, 1943). The degree of life stage separation depends upon the overlap extent of consecutive life stage length-frequency distributions. Overlap depends upon the sampling period length, intraspecific growth rate, and duration of the breeding season. Since growth in length is more rapid in young fish, they would be more discernible in a length-frequency distribution if the species does not have an extended breeding season. An extended breeding would result in overlap. Other causes of overlap are changing environmental conditions, lack of uniform growth rate within an age group, biased sampling, and retardation of growth with age (Rounsefell and Everhart, 1953). The failure of the *N. maculatus* length-frequency data to distinguish between life stages may be largely attributed to an extended breeding season. Perhaps some of the progeny from the earlier limits of the breeding season attain reproductive status by the end of the breeding season and spawn during their first season.

TABLE 5. Monthly per cent composition of juvenile, male, and female *Notropis maculatus* collected from March, 1969, through March, 1970, in Golf Course Pond, Hillsborough County, Florida.

	Juvenile	Male	Female	Adult
1969				
March		48	52	100
April		79	21	100
May		46	54	100
June		50	50	100
July	8	55	37	92
August	19	33	48	81
September	4	28	68	96
October	62	15	23	38
November	36	31	33	64
December	34	29	37	66
1970				
January	17	47	36	83
February	5	51	44	95
March		72	28	100

Carlander (1950) describes the coefficient of condition as a sensitive measure of change and differences in body form varying with season, sexual maturity, size, age and sex. Summerfelt and Minckley (1969) have used it to define spawning. The $K_{(TL)}$ decreases observed for *N. maculatus* in April, July, and October indicate probable spawning periods. After each of the above dates, increases in $K_{(TL)}$ values were produced largely as a result of increased gonadal tissue; later, increases were probably due to increased somatic tissue.

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LITERATURE CITED

Applegate, V. C. 1943. Partial analysis of growth in a population of mudminnows, *Umbra limi* (Kirtland). Copeia 1943: 92-96.

Bailey, R. M., H. E. Winn, and C. L. Smith. 1954. Fishes from the Escambia River, Alabama, and Florida, with ecological and taxonomic notes. Proc. Acad. Nat. Sci. Phila. 106: 109-164.

Breder, C. M., Jr., and D. E. Rosen. 1966. Modes of reproduction in fishes. American Museum of Natural History Press. Garden City, New York.

Carlander, K. D. 1950. Handbook of Freshwater Fishery Biology. Wm. C. Brown Co. Dubuque, Iowa.

Carr, A., and C. J. Goin. 1955. Guide to the Reptiles, Amphibians, and Freshwater Fishes of Florida. Univ. Florida Press. Gainesville.

Edmondson, W. T. 1959. Methods and equipment. pp. 1194-1202, *In* W. T. Edmondson (ed.), Freshwater biology, 2nd ed. Wiley. New York.

Fowler, H. W. 1940. A collection of fishes obtained on the west coast of Florida by Mr. and Mrs. C. G. Chaplin. Proc. Acad. Nat. Sci. Phila. 92: 2-4.

Fuchs, E. H. 1967. Life history of the emerald shiner, *Notropis atherinoides*, in Lewis and Clark Lake, South Dakota. Trans. Amer. Fish. Soc. 96: 247-256.

Gilbert, C. H. 1888. Notes of fishes from the lowlands of Georgia, with a description of a new species (*Opsopoeodus bollmani*). Bull. U. S. Fish Comm. 8: 225-229.

Gray, J. W. 1942. Studies of *Notropis atherinoides atherinoides* Rafinesque in the Bass Island region of Lake Erie. M. S. thesis, Ohio St. Univ. Columbus.

Harrington, R. W. 1950. Preseasonal breeding by the bridled shiner, *Notropis bifrenatus*, induced under light-temperature control. Copeia 1950: 304-311.

__________. 1959. Photoperiodism in fishes in relation to the annual sexual cycle. Amer. Assoc. Adv. Sci. 55: 651-667.

Hay, O. P. 1880. On a collection of fishes from eastern Mississippi. Proc. U. S. Nat. Mus. 3: 488-515.

Hubbs, C. L., R. J. Kemp, and C. E. Gray. 1956. Three shiners, *Notropis ortenburgeri*, *Notropis maculatus*, and *Notropis blennius*, added to the known east Texas fauna. Texas J. Sci. 8: 110-112.

Ivlev, V. S. 1961. Experimental ecology of feeding of fishes. Yale Univ. Press. New Haven. (Translated by Douglas Scott)

Laǵler, K. F. 1956. Freshwater Fishery Biology. 2nd ed. Wm. C. Brown Co. Dubuque, Iowa.

Marshall, N. 1946. Studies of the life history and ecology of *Notropis chalybaeus* (Cope). Quart. J. Fla. Acad. Sci. 9: 163-188.

McCann, J. A. 1959. Life history studies of the spottail shiner of Clear Lake, Iowa, with particular reference to some sampling problems. Trans. Amer. Fish. Soc. 88: 336-343.

McLane, W. M. 1955. The fishes of the St. Johns River system. Ph.D. thesis. Univ. Florida. Gainesville.

PFEIFFER, R. A. 1955. Studies of the life history of the rosyface shiner, *Notropis rubellus*. Copeia 1955:95-104.

REED, R. J. 1957. Phases of the life history of the rosyface shiner, *Notropis rubellus*, in northwestern Pennsylvania. Copeia 1957: 286-290.

ROUNSEFELL, G. A., AND W. H. EVERHART. 1953. Fishery Science, Its Methods and Applications. John Wiley and Sons. New York.

SMITH, L. L., AND R. H. KRAMER. 1964. The spottail shiner in Lower Red Lake, Minnesota. Trans. Amer. Fish. Soc. 93: 35-45.

SUMMERFELT, R. C., AND C. O. MINCKLEY. 1969. Aspects of the life history of the sand shiner, *Notropis stramineus* (Cope), in the Smoky Hill River, Kansas. Trans. Amer. Fish. Soc. 98:444-453.

Florida Sci. 37(1):5-16. 1974.

Earth and Planetary Sciences

SEASONAL VARIATION OF PHYSICAL OCEANOGRAPHIC PARAMETERS ON THE FLORIDA MIDDLE GROUND AND THEIR RELATION TO ZOOPLANKTON BIOMASS ON THE WEST FLORIDA SHELF[1]

HERBERT M. AUSTIN[2] AND JAMES I. JONES

Department of Oceanography, Florida State University, Tallahassee, Florida 32306

ABSTRACT: *The region of the West Florida Shelf known as the Florida Middle Ground is situated along the boundaries of three water masses, the Gulf Loop Current, the West Florida Estuarine Gyre, and the Florida Bay Waters. During the summer circulation patterns are principally derived from the Loop Current, tidal forces, and water column stratification. Winter circulation is primarily dependent upon wind and tide as the generating forces.*

The oceanographic conditions of the region result in high water column zooplankton standing crops. These populations are comparable to those reported from regions of upwelling.

THE FLORIDA MIDDLE GROUND is a region of limestone outcrops on a drowned karst topography (Price, 1954). From a depth of 40 m these outcrops rise to within 25 m of the surface. The slope of the shelf is 0.2 m per km to the east of the Grounds, while to the west the slope increases to 1.1 m per km. Geologically, the area lies on the seaward edge of the continental shelf. Hydrologically this is a complex area of mixing between the Caribbean-derived Loop Current (Chew, 1955a), the West Florida Estuarine Waters, and the Florida Bay Waters (Fig. 1).

This region is also of considerable physical and biological interest. Published studies in the area have been limited to general fishery (Moe, 1963), geological (Jordan, 1952; Price, 1954), and physical (Chew, 1955a, 1955b) surveys.

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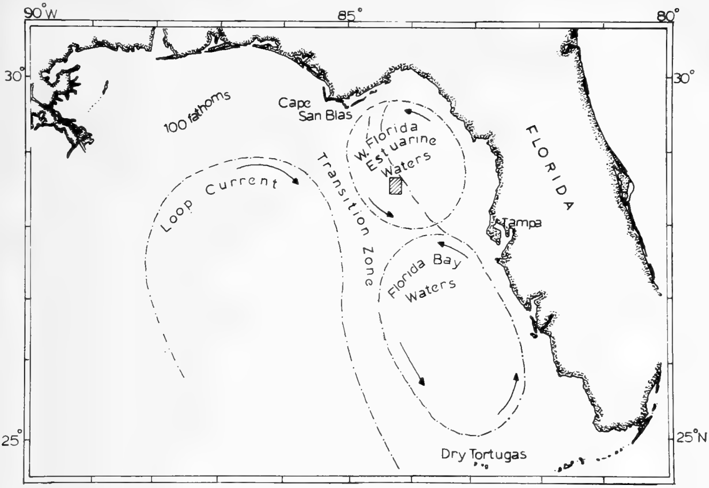
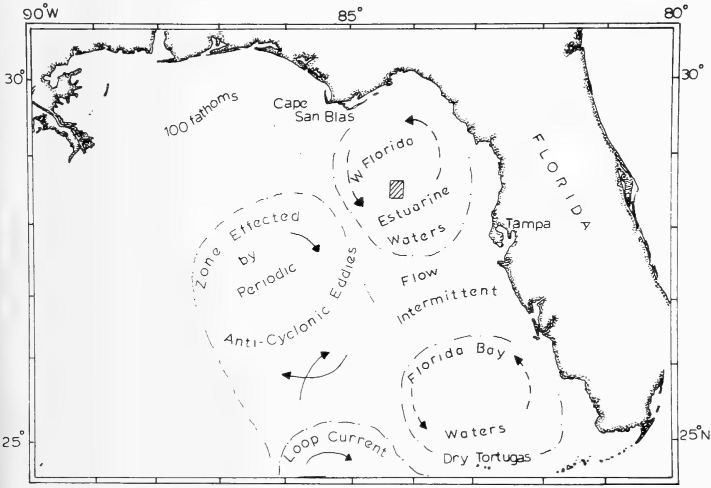
[2]Present address: New York Ocean Science Laboratory, P. O. Drawer EE, Montauk, New York 11954.



A. SUMMER CIRCULATION EASTERN GULF OF MEXICO
▨ FLORIDA MIDDLE GROUND



B. WINTER CIRCULATION EASTERN GULF OF MEXICO
▨ FLORIDA MIDDLE GROUND

Fig. 1a. Summer water masses of the eastern Gulf of Mexico, including the Florida Middle Ground; b. Winter water masses of the eastern Gulf of Mexico, including the Florida Middle Ground.

Because only limited data were available on the distribution of zooplankton in these waters a program was initiated by the Department of Oceanography of the Florida State University designed to observe the spatial and temporal distribution of such organisms in this area.

METHODS—A monthly 24 to 48 hr anchored station was occupied at 28° 30′N 84° 14′W from June 1969 through August 1970. This station consisted of hourly bathythermographic, bi-hourly hydrographic, and opening-closing plankton casts every 6 hr.

Plankton were collected in 0.5 m square opening, 200 μ mesh nets equipped with flow meters and an opening-closing mechanism (Niskin and Jones, 1963). All collections were made by casting the nets for 0.5 hr from the anchored vessel, sufficient water was filtered (55-554 m^3) to allow large samples to be obtained (8-165 ml). In addition to the anchored station a monthly hydrographic-plankton transect was run from inside the Middle Ground, across it, and seaward to the 200 m isobath. In general the transect consisted of from three to five stations, often with B.T. casts in between. At least three nets were cast at each station.

Bulk plankton was measured for displacement vol, and the data reduced to standing crop or biomass, expressed as ml of plankton/m^3. These determinations were made by recording the vol of the sample and the preserving fluid. The sample was filtered with a 200 μ mesh filter and the vol of the filtrate recorded. The difference between the two volumes was the displacement volume. Despite its inherent inadequacies this method has found wide usage (Deevey, 1952; King, 1958; Nakai and Honjo, 1962; Cushing, 1969) and is one of the accepted methods of determining zooplankton biomass (Ahlstrom, 1969).

Temperatures were measured by bucket thermometer ($\pm$.10°C) and a 60 m range bathythermograph ($\pm$0.5°C). Water samples for salinity determinations were drawn from the hydrographic casts from 1.7 l Niskin water samples and the salinity measured ashore with an inductive salinometer-conductivity meter ($\pm$0.05‰).

Cruises were conducted on board the Florida State University R/V TURSIOPS, the Florida Institute of Oceanography R/V ISLAND WATERS, and the R/V JOIE DE VIVRE.

RESULTS—*Hydrographic Conditions*: From June through early September the water is stratified. Figure 2 depicts the spatial distribution of temperature and salinity across the Middle Ground at 28° 30′N during August 1969 and Fig. 3 the temporal variations during the anchored station. Chew (1955b) has suggested that the summer shelf surface waters are derived from the inner shelf and that the water below the thermocline may be from offshore. This supposition is supported by the data of Austin (1971) and Jones (1973). The presence of these offshore waters on the shelf suggests that deeper offshore water from the Loop Current or its associated SUW [Subtropical Underwater], (Wüst, 1964; Armstrong, 1967) may periodically flood over the shelf area, impinging shoreward below the thermocline. Stations occupied 50 and 100 km to the east of the Middle Ground have shown no evidence of these higher salinity waters. Figure 4 depicts monthly averages for the Middle Ground (28° 30′N 84° 15′W) and shows summer stratification. These values were arrived at by averaging the measured values at standard 5 m depths over each 24 hr anchor station. Chew (1955a), by an analysis of thermocline topography, determined that the major summer shelf mixed-layer circulation patterns are warm anti-cyclonic eddies and tongues, which break off from the Loop Current system, flooding over the shelf from the northwest. Gaul (1967) has reported the existence of such eddies off Panama City, 280 km to the west. Vicks (1967) discussed how these eddies, as described by Gaul, bring highly productive waters over the shelf near to shore, and cited them as the reason for the high catches of the sport fishing fleets off Destin and Panama City. Gaul pointed out the importance of the effects of shelf topography on the circulation, citing the de Soto Canyon as a major factor for the patterns observed. These eddies, when over the West Florida Shelf, modify the dynamics and locations of the semi-permanent West Florida Estuarine Gyre and the Florida Bay Gyre (Austin and Cruise, 1972). The current patterns on the West Florida Shelf appear to be directly related to gyre and super-imposed eddy locations.

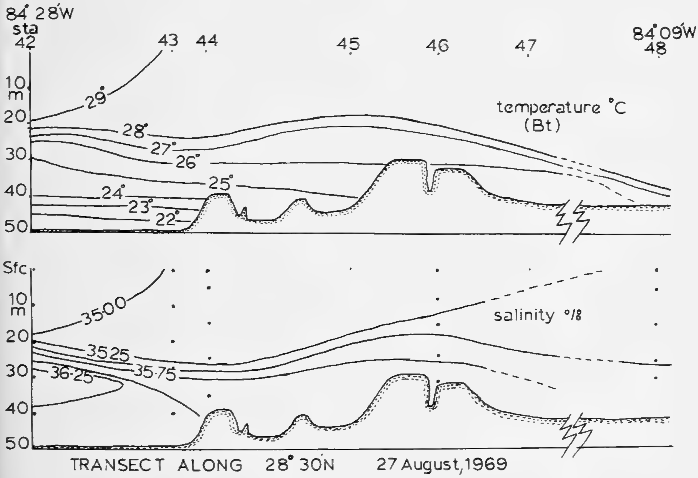


Fig. 2. Temperature and salinity profile from a hydrographic transect along 28° 30'N, 27 August, 1969, crossing the Florida Middle Ground at 28° 30'N 84° 15'W.

During summer it appears that the Loop Current is the main driving force of the West Florida Shelf circulation. There is evidence for a 2-layered flow with the thermocline as the shear zone. Direct current observations by divers, surface current measurements and the tidally periodic displacement of the thermocline suggest internal waves are present during summer (H. Austin, unpublished).

Fall storms and autumnal cooling result in the breakdown of thermal stratification, providing a surface-to-bottom mixed layer (Fig. 4). At this time, cells of cool ($<$ 24°C) highly saline water (36.00 to 36.30‰) flood with an apparent tidal periodicity over the region (Fig. 5a). These cells show temperature-salinity rela-

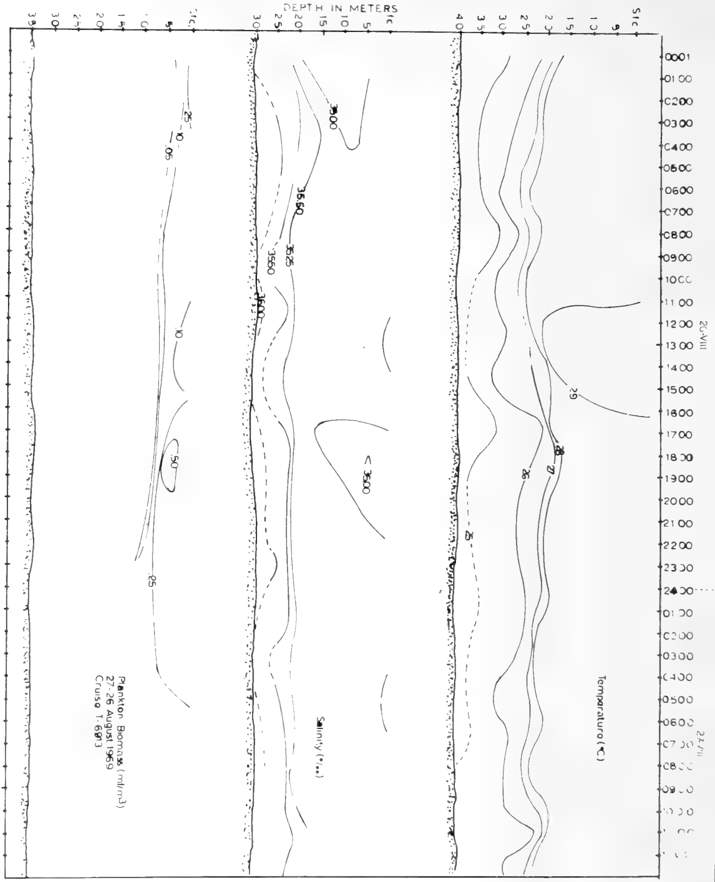


Fig. 3. Vertical temperature, salinity and bulk plankton profiles for a 36 hr anchored station 26-27 August, 1969, 28° 25′N, 84° 18′W.

tionships similar to deeper "mainstream Loop Waters" further off-shore (Fig. 6a and b) (Gaul, 1967). Tides in the Eastern Gulf of Mexico are mixed, and preliminary surface current data show that the tidal stage on the Middle Ground corresponds with the reported tidal period for Cedar Key, Florida.

The tidal periodicity of these cells suggests that the vertical displacement of the offshore thermocline is of sufficient magnitude to allow sub-thermocline water to "slosh" up over the shelf.

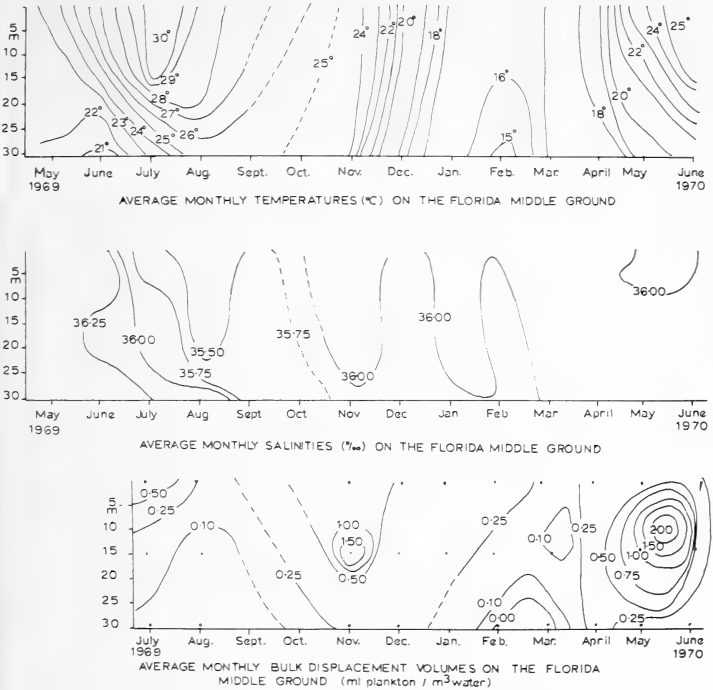


Fig. 4. Average monthly temperature, salinity, and bulk plankton profiles on the Florida Middle Ground, May, 1969 to June, 1970.

Through December to March salinities remain fairly constant (36.00-36.10‰) (Fig. 4 and 8). Temperatures reached the seasonal minima in February (15° C). During February a weak thermocline was established. This was observed as warmer (17-19° C) more saline (36.00-36.10‰) shelf water (Fig. 7 and 8). This thermocline was associated with a 5 knot WSW wind after the passing of a warm front. During the 36-hr anchored station the cold front came through. Thereafter winds were 25-30 knots from the west and north. Within 6 hr of the front's passing the thermocline was gone, replaced by a 15-16° isothermal layer (Fig. 8).

Surface current-meter studies (H. Austin, unpublished data) show that, in general, an easterly current coincides with periods during which warm (19-21° C) off-shore waters are present, cool (< 19° C) inshore waters coincide with the westerly flow. Figure 7a suggests the presence of a warm eddy to the west of the Middle Ground on 18 February 1970. This eddy was probably broken off from the Loop Current further south (Gaul, 1967; Austin, 1971), and was moving northward.

The winter circulation patterns are not dependent upon the driving forces of

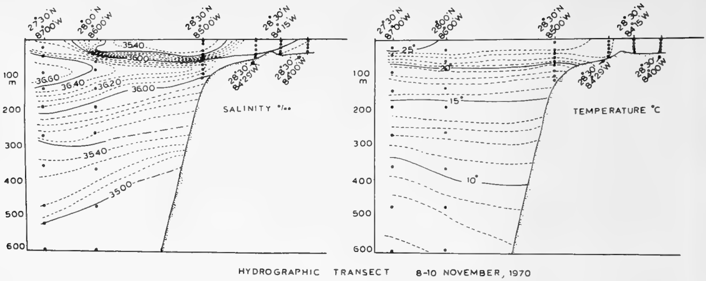


Fig. 5. Vertical salinity and temperature profiles across the Florida Middle Ground, 8-10 November, 1969.

the Loop Current as they are during the summer. During winter, the West Florida Shelf circulation is dependent primarily upon local wind conditions and possibly to some extent upon tidal forces.

Spring heating results in the formation of weak, vertical thermal gradients which strengthen as summer approaches (Fig. 4). Surface temperatures for May average 23° C on the surface, and between 19 and 20° C near the bottom (Fig. 9). A weak halocline also forms during May, but is not present during April. Surface salinities average around 36.00‰, and bottom values around 36.10‰.

Other data collected during the spring of 1970 (from the EGMEX series, Rinkel, 1971) show that the waters below the thermocline are essentially from the Loop Current (Austin and Cruise, 1972) and that the surface waters which are

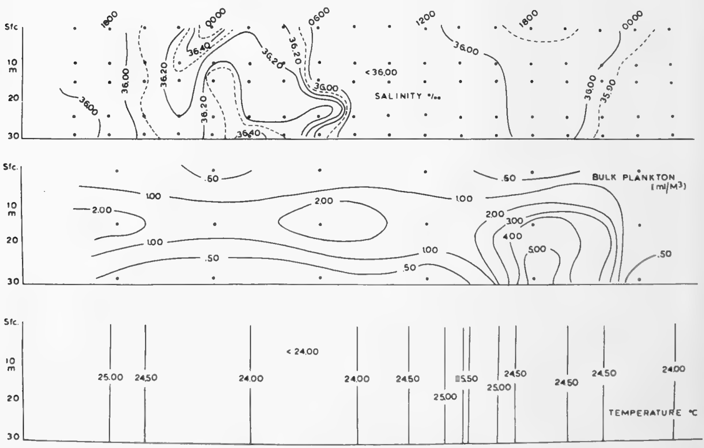


Fig. 6. Vertical salinity, bulk plankton, and temperature for 48 hr anchored station, 10-12 November, 1969, 25° 25′N, 84° 18′W.

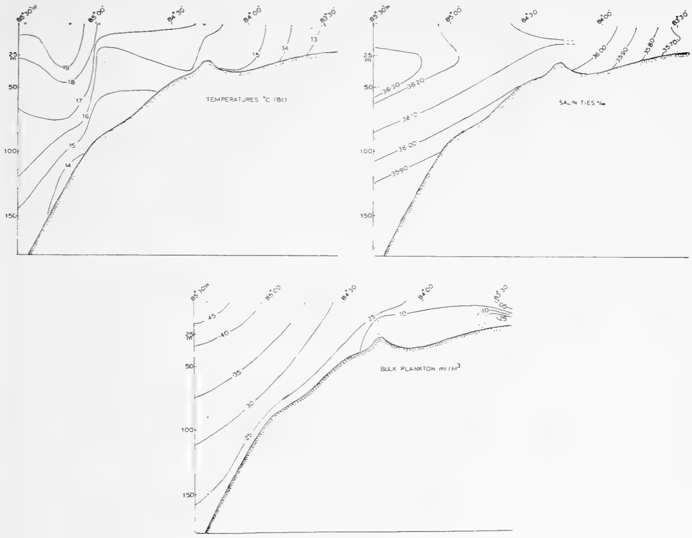


Fig. 7. Vertical temperature, salinity, and bulk plankton profiles for a transect along 28° 31′N 84° 15′W.

predominantly from the West Florida Estuarine Gyre are periodically replaced by eddies of Loop Current water that split off from the northern Loop boundary (Austin, 1971).

During late April to late May the "spring intrusion" of the Loop (Leipper, 1970) becomes an increasingly important factor in shaping circulation patterns on the Middle Ground. This is apparent from the distribution of surface temperatures and salinities (Austin, 1971; Williams, 1972).

Climatologically, the Middle Ground lies in a region of both convergence and divergence. Chew (1955b) discusses the potential mechanisms of surface convergence on the West Florida Shelf as a result of the conservation of mass, as a water column moves seaward. Smith, et al. (1951) cited Hydrographic Office charts and delineated regions of convergence and divergence from climatological surface currents. Bogdanov, et al. (1968) discuss the climatological and hydrographic parameters of the outer West Florida Shelf slope and suggest mechanisms which provide year round conditions conducive of upwelling and downwelling (convergence).

Chew assumed a constant velocity along the gyre boundaries. This need not be true, however; as mass may also be conserved, by the formation of perturbations in regions of curvature with a resultant reduction in net current velocity. These perturbations, or tongues, have been observed along the northern edge of the

Loop Current, (Fig. 10) and may account for the eddies that break off and flood over the shelf. Note the eddy of warm (25° C) water northeast of the Loop Current which several days previous was a perturbation.

According to Chew (1955a) and Smith et al. (1951) the Middle Ground is a region ideally suited for convergence to occur. Not only can this occur as two separate water masses converge, but also from their data the geographic location

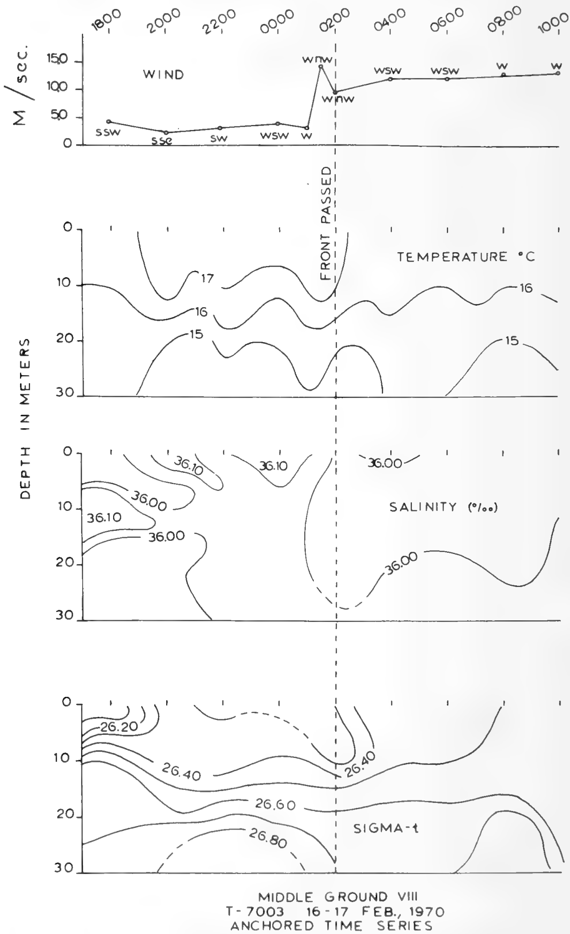


Fig. 8. Vertical temperature, salinity and σ_t profiles for a 17 hr anchored station 16-17 February, 1970 at 28° 25′N 84° 18′W; including wind velocities during the 17 hr period.

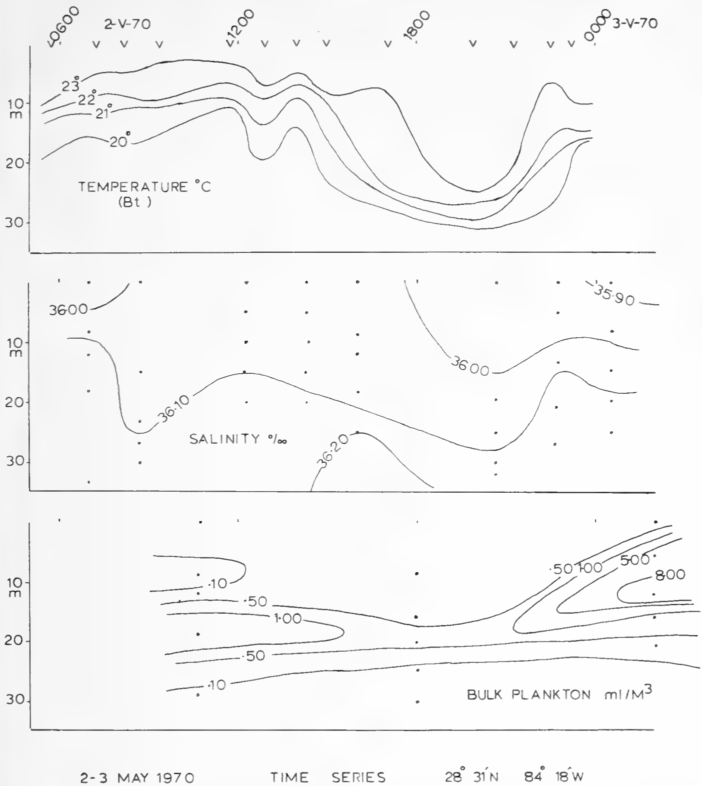


Fig. 9. Vertical temperature, salinity, and bulk plankton profiles for an anchored station, 2-3 May, 1970, 28° 31′N, 84° 18′W.

is in the region where these convergent currents turn seaward. From these data, as well as from this study, it appears that the Middle Ground lies in a zone of both convergence and divergence between the semi-permanent Florida West Coast Estuarine Gyre and the Loop Current. The upwelled water (Bogdanov, et al., 1968) superimposed upon a westward (Smith et al., 1951) or southern flow (Austin and Cruise, 1972) and enhanced tidally provides a strong mechanism for mixing. The entire system is further complicated by the proximity of the southward flowing Loop Current which, during the warmer months, entrains shelf waters into its flow from the region (Austin, 1971). The effects of this mixing of the water masses, as will be discussed, results in high zooplankton standing crops.

Biological Conditions: Late summer (August) standing crops of zooplankton over the Middle Ground exhibited a range of 0.04-0.35 ml/m^3 in the surface waters, averaging 0.19 ml/m^3 and a range of .01 to 0.20 ml/m^3 at the thermocline and below (15-20m), averaging 0.09 ml/m^3. Short term variations showed highest surface concentrations (0.29-0.35 ml/m^3) when warm (28.5-29.0°C) lower salinity (35.00‰) waters were advected in from the east. Lower concentrations (0.05-0.12 ml/m^3) were measured when cooler (28.0 to 28.5°C) more saline (35.00‰) waters were brought in from the west.

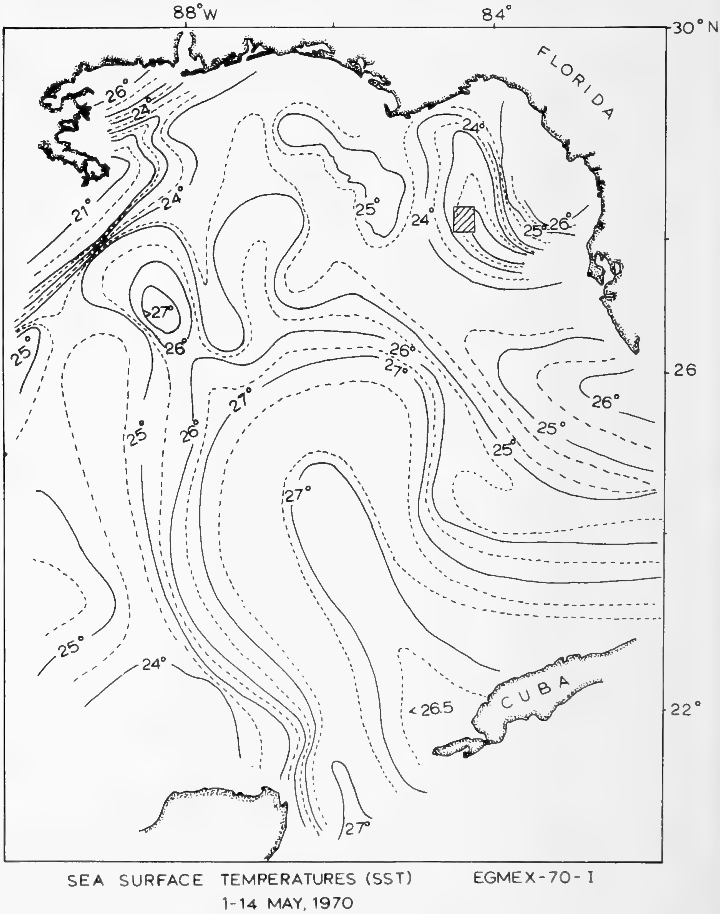


Fig. 10. Sea surface temperatures for the eastern Gulf of Mexico, May, 1970. Florida Middle Ground (from Austin, 1971).

Dense zooplankton concentrations were measured during the fall (November) several weeks after the change in the thermal structure on the shelf (Fig. 3). At this time of the year the thermocline is found further off-shore at a depth of 50 m (Fig. 6). It appears that cells of cool (24.5°C), higher salinity (36.00-36.40‰) sub-thermocline water upwell and move in over the shelf.

These cold-saline cells are coincident with lower (0.5 ml/m^3) than average fall (0.87 ml/m^3) shelf plankton concentrations. Concentrations up to 2.9 ml/m^3 precede and follow these cells, probably associated with a mixing phenomenon occurring along their borders. One cell of waters was observed which suggested complete mixing of offshore and shelf waters (salinity 36.00-36.10‰, temperature 24.5-25.0°C), and which supported some of the highest observed concentrations (2.0-5.4 ml/m^3) of the plankton (Fig. 6).

During winter averaged standing crop values remain fairly constant and were generally higher (0.25-0.50 ml/m^3) than average summer surface concentrations (0.10-0.25 ml/m^3, Fig. 3). Lowest concentrations for the year, however, were encountered at 30 m during February and March, when temperatures were also the lowest of the year (14-15°C), and salinities were below 36.00‰ (Fig. 3). The open Gulf (Loop Current) is characterized by Caribbean planktonic populations, and the shelf by subtropical to warm-temperate populations (Pierce, 1952; Austin, 1971; Cruise, 1971). During February the low temperatures are below that tolerated by most Gulf and Caribbean forms (Austin, 1972; Williams, 1972). Warm Loop Current waters are too far offshore and to the south to have a pronounced warming effect. The possibility of eddies breaking off from the Loop and moving northward toward the region of the Middle Ground is suggested by the cruise in February (Fig. 7) 1970. Concentrations of surface plankton were observed during this February cruise to the southwest of the Middle Ground, entering the region of increased positive horizontal thermal gradients associated with the Loop Current. During the February cruise this plankton-temperature relationship (Fig. 7) was noticed in conjunction with the eddy. These eddies have also been observed in the summer by several investigators (Austin, 1955; Armstrong, 1967; Birchett, 1967).

Spring warming results in a zooplankton bloom, occurring during May and extending into June, with first population increases beginning in April. May values averaged .56 ml/m^3 with concentrations as high as 8.0 ml/m^3 observed. These phenomenally high concentrations were observed during the project EGMEX (Eastern Gulf of Mexico) cruises, a synoptic study of the Loop Current (Rinkel, 1971; Williams, 1971). Phenomena observed during the study of the Loop Current may explain these high concentrations. The large scale perturbations along the edge of the Loop Current exhibited dense (.50-1.00 ml/m^3) plankton concentrations along their colder margins (Rinkel, 1971; Williams, 1971). It is quite apparent in Fig. 10 that in May prior to the EGMEX investigation a perturbation had separated itself from the Loop and formed an eddy which flooded over the Middle Ground region. The mixing associated with this condition could have caused just such a short term concentrated bloom as is depicted in Fig. 9.

DISCUSSION—Highest zooplankton standing crops were encountered during the summer in the mixed layer, with lower concentrations found below the thermocline. We suggest two possible reasons for these higher mixed layer standing crops. First, since a two-layer flow has been observed, it is possible that the inner-shelf waters above the thermocline and the deeper waters from the off-shore Loop System support different plankton assemblages. King (1949) has suggested that shelf waters are richer in total plankton, although poorer in number of species than waters of the open Gulf. Plankton rich waters have been observed in near coastal waters by Austin and Cruise (1972). Preliminary data from the central Eastern Gulf have shown that many planktonic forms are not encountered in high salinity core [36.50‰ of the SUW (Austin, 1971)]. If these Middle Ground bottom waters are indeed from the deep SUW offshore, it explains depauperate fauna below the thermocline during the summer, and its associated high salinity, compared to the higher plankton values above it. Because the Middle Ground is a region of convergence (Smith, et al., 1951; Chew, 1955b), the second possibility is that a tendency exists for the plankton to become concentrated in the convergence zones. It follows then that the plankton would be concentrated above the thermocline inasmuch as the convergence occurs in the mixed layer.

TABLE 1. Zooplankton Standing Crop, expressed as ml/m^3 of plankton on the Florida Middle Ground during 1969-1970.

Month	Average monthly concentrations (averaged over 24 or 48 hr anchor station)	
July, 1969	0.55 ml/m^3	(Sfc.)
	0.22	(15m)
August, 1969	0.19	(Sfc.)
	0.09	(15m)
November, 1969	0.62	(Sfc.)
	1.70	(15m)
	0.29	(30m)
December, 1969	0.45	(Sfc.)
	0.29	(15m)
	0.34	(30m)
January, 1970	0.30	(Sfc.)
	0.40	(15m)
February, 1970	0.34	(Sfc.)
	0.17	(15m)
	0.04	(30m)
March, 1970	0.13	(Sfc.)
	0.09	(15m)
	0.13	(30m)
April, 1970	0.42	(Sfc.)
	0.45	(15m)
May, 1970	0.27	(Sfc.)
	1.36	(15m)
	0.06	(30m)

TABLE 2. Zooplankton standing crop, expressed as ml/m³ from various locations and seasons.

a. Adapted from Bigelow and Sears (1939)

Locality	Season	Authority	ml/m³
Martha's Vineyard	Sept.-Oct., '35	Clark & Zinn	0.04
	Nov.-Dec., '35	1937	0.70
	Jan.-Mar., '36		0.90
	April-June, '36		0.12
	July-Aug., '36		0.09
Gulf of Maine	September, '33	Redfield	0.21
	October, '33	(unpublished	0.13
	December, '33	data)	0.17
	January, '34		0.12
	March, '34		0.05
	April-May, '34		0.16
	May-June, '34		0.26
	June-July, '34		0.34
	September, '34		0.50
Nova Scotia,	May, '15	Huntsman	0.45
Newfoundland Shelf	June, '15	(1919)	0.25
	July, '15		0.30
West Greenland	August, '24	Størmer (1929)	0.17
Iceland	July, '24	Størmer (1929)	0.20
Southern Norwegian Sea	July-Aug., '24	Størmer (1929)	0.30
North Sea	June, '26	Savage	0.57
	August, '26	(1931)	0.50
	November, '26		0.60
English Channel	April, '25	Russell	0.01
	May, '25	(1927)	0.10
	June, '25		0.02
	July, '25		0.05
	August, '25		0.05

b. Adapted from Hopkins (1964).

Continental Shelf off North Carolina	Jan.-June, '58	St. John (1958)	0.28
Block Island Sound	Jan.-June, '51	Deevey (1952)	0.68
Slope Waters off New Jersey	May-June, '62	Grice and Hart (1962)	0.27
Sargasso Sea	May-June, '62	Grice and Hart (1962)	0.02

Other investigations, with quantitative data, have yielded either yearly averaged values, or one-time/one station collection data. Figure 3 depicts the averaged monthly anchor station concentrations for a year, beginning July, 1969 and ending June, 1970. Extreme values ranged from a low of 0.0 ml/m^3 at 30 m on February and March, to a high of over 8.0 ml/m^3 in May, at 10 m. Table 1 shows averaged monthly values for the Florida Middle Ground.

The continental shelf areas off the Northeastern United States are considered to be regions of high biologic activity (Table 2). At times standing crop of plankton over the Middle Ground exceeds the levels reported for regions of upwelling (Table 3, Cushing, 1969). The plankton concentrations observed on the Florida Middle Ground during periods of upwelling exceed the values reported by Cushing by a factor of ten.

TABLE 3. Zooplankton standing crop in regions of upwelling, from Cushing, 1969 (Table 1, "Annual Primary, Secondary, and Tertiary Production in the Upwelling Areas").

Location	ml/m^3
California	0.20-.50
Costa Rica	0.30
Peru	0.60
Somali	0.25
Benguela	0.32-.75
Java	0.14
Madagascar	0.53
Canary	0.38
Florida Middle Ground	0.39 (Sfc.)
	0.53 (15m)
	0.17 (30m)

The high seasonal standing crop on the Florida Middle Ground is due to a variety of factors which are fundamentally related to its geographic and hydrological location. The topography encountered at the seaward edge of the West Florida Shelf, and the proximity of three distinctly different water masses, with their associated convergence, divergence (upwelling), and mixing, account for the high relative productivity of the area. The Loop Current boundary waters, with their relatively high plankton concentrations (Austin, 1971, Williams, 1971) upwell, converge, and mix with the shelf waters causing long term dense plankton concentrations. Seasonally these circulation conditions may be related to the periodic "red tide" phenomenon which occurs in the spring on the West Florida Shelf. Grice and Hart (1962) in their study of the western Atlantic continental shelf, Gulf Stream, and Sargasso Sea, noted plankton concentration-water mass relationships similar to the eastern Gulf of Mexico. Dense planktonic populations appear in the boundaries between cool shelf waters and high speed tropically derived flows such as the Loop Current and the Gulf Stream. These dense plankton concentrations are found in the turbulent upwelling regions where shelf waters are being entrained into the major flow. Preliminary data from the EG-MEX series indicate that the plankton concentrations in the center of the Loop

Current gyre are as low as those in the Sargasso Sea (.05 ml/m^3). This situation should be expected, as the gradient of physical parameters along a transect from the center of the Loop gyre, through the velocity core, and up onto the West Florida Shelf are similar to the gradients encountered as one passes from the Sargasso Sea into the Gulf Stream, and up onto the Western Atlantic Shelf.

Circulation patterns on the northeastern Florida Shelf are complex and poorly known. Major climatic circulation patterns depend upon the location of the Loop Current, and the West Florida Estuaries Gyre. The location and shape of the boundaries of these gyres is dependent upon wind conditions and tide. At times the boundary of one water mass may overlay the boundary of its denser neighbor. These conditions are further complicated by intrusions of such short-term phenomena as upwelling and the splitting off of perturbations to form eddies which mix with the adjoining waters.

Preliminary data, from investigations of selected biological indicator species (foraminifera, pteropods, phyllosomae, and sergistid shrimp, indicate that the Loop Current supports a fauna distinctly different from that of each of the shelf water masses. The Middle Ground, falling between these masses, is a region of dynamic hydrographic conditions and faunistic transition. Studies are currently in progress to determine the extent of this mixing, to attempt to trace off-shore waters over shelf areas, and to measure entrainment of shelf waters by the Loop Current.

LITERATURE CITED

AHLSTROM, E. 1969. Recommended procedures for measuring the productivity of plankton standing stock and related oceanic properties. 59 pp. National Acad. Sci. Washington, D.C. 59 pages.

ARMSTRONG, R. 1967. The subtropical underwater of the eastern Gulf of Mexico. Bur. Comm. Fish. Rev. 29: 46-48.

AUSTIN, G. 1955. Some recent oceanographic surveys of the Gulf of Mexico. Trans. Amer. Geophys. Union 35: 885-892.

AUSTIN, H. 1971. The characteristics and relationships between the calculated geostrophic current component and selected indicator organisms in the Gulf of Mexico Loop Current System. Ph.D. Dissertation, Dept. Oceanography, Florida State Univ. Tallahassee.

———— 1972. Note on the distribution of the phyllosoma of the spiny lobster, *Panulirus* ssp. in the eastern Gulf of Mexico. Proc. Nat. Shellfisheries Assoc. 62: 26-30.

———— AND J. CRUISE. 1972. The West Florida Estuarine Gyre. 35th Ann. Meet. Amer. Soc. Limnol. Oceanogr. Tallahassee, Florida, March 1972.

BIGELOW, H. AND M. SEARS. 1939. Studies of the waters of the continental shelf Cape Cod to Chesapeake Bay, Md. Mus. Comp. Zool. 54: 183-378.

BIRCHETT, J., III. 1967. Temperature-salinity relationships in the surface layers of the eastern Gulf of Mexico in August, 1966. MS thesis, Department of Oceanography, Texas A. and M. Univ.

BOGDANOV, V., A. SOKOLOV, AND N. KHRUMOV. 1968. Regions of high biological and commercial productivity in the Gulf of Mexico and Caribbean Sea. Oceanology 8: 371-380.

CHEW, F. 1955a. The summer circulation of the Florida west coast offshore water as deduced from the pattern of thermocline depths and a nongeostrophic equation of motion. Spec. Rprts. Fla. State Bd. Cons. Tech. Rep. 55-12: 12 pp.

————. 1955b. On the offshore circulation and a convergence mechanism in the red tide region of the west coast of Florida. Trans. Amer. Geophys. Union 36: 963-974.

CRUISE, J. 1971. The planktonic shrimp genus *Lucifer*: Its distribution and use as an indicator organism in the eastern Gulf of Mexico. MS Thesis, Dept. Oceanography, Florida State Univ. Tallahassee.

CUSHING, D. H. 1969. Food Agr. Organ., U.N. Fish. Tech. Pap. 84, 40 pp.

DEEVEY, G. 1952. Quantity and composition of the zooplankton of Block Island Sound, 1949. Bull. Bingham Ocean. Coll. 13: 65-119.

GAUL, R. 1967. Circulation over the continental margin of the northeastern Gulf of Mexico. Ph.D. Dissertation, Dept. Oceanography, Texas A. and M. Univ.

GRICE, G. AND A. HART. 1962. The abundance, seasonal occurrence and distribution of the epizooplankton between New York and Bermuda, Ecol. Monogr. 32: 287-309.

HOPKINS, T. 1964. Plankton of Saint Andrews Bay System Florida. Ph.D. Dissertation, Dept. Biology, Florida State Univ. Tallahassee.

JONES, J. 1973. Physical oceanography of the northeastern Gulf of Mexico & Florida continental shelf area. pp. IIB1-15. *In* Jones, J., R. Ring, M. Rinkel and R. Smith (ed.), A Summary of Knowledge of the Eastern Gulf of Mexico. Publ. Florida State Univ. Syst. Inst. Oceanog. Tallahassee.

JORDAN, G. 1952. Continental slope off Appalachicola River, Florida. Bull. Amer. Assoc. Petrol. Geol. 35:

KING, J. 1949. A preliminary report on the plankton of the west coast of Florida. Quart. J. Florida Acad. Sci. 12: 109-137.

________. 1958. Variation in abundance of zooplankton and forage organisms in the central Pacific in respect to the Equatorial upwelling. Proc. 9th Pac. Sci. Cong. 16: 98-107.

LEIPPER, D. 1970. A sequence of current patterns in the Gulf of Mexico. J. Geophys. Res. 75: 637-657.

MOE, M. 1963. A survey of offshore fishing in Florida. 117 pp. Florida Bd. Cons. Prof. Pap. Ser. No. 4.

NAKAI, Z. AND K. HONJO. 1962. Comparative studies on measurements of the weight and volume of plankton samples. Proc. 9th Sess. Indo-Pac. Fish Council Sect. II: 9-16.

NISKIN, S. AND J. JONES. 1963. New collecting and recording devices for limnological and oceanographic research. Proc. 6th Conf. Great Lakes Res., Univ. Mich., Great Lakes Res. Div. Inst. of Sci. and Tech.

PIERCE, E. L. 1952. The Chaetognatha of the west coast of Florida. Florida Eng. Indust. Exp. Sta., Eng. Prog. 6: 4-26.

PRICE, W. 1954. Shorelines and coasts of the Gulf of Mexico. *In*: Gulf of Mexico, its origin, waters and marine life. U.S. Fish Wildl. Bull. 87:36-54.

RINKEL, M. 1971. Results of cooperative investigations—A pilot study of the eastern Gulf of Mexico. Gulf & Carib. Fish. Inst., Ann. Proc. 23: 91-107.

SMITH, F. G. W., F. MEDINA AND A. B. ABELLA. 1951. Distribution of vertical water movement calculated from surface drift vectors. Bull. Mar. Sci. 1: 187-195.

VICKS, N. 1967. Fishery hydrography of the northeastern Gulf of Mexico, 3rd Ann. I.O.F. Meet. 1966.

WILLIAMS, L. 1971. Selected planktonic Foraminifera as biological indicators of hydrological conditions in the eastern Gulf of Mexico. MS Thesis, Dept. Oceanography, Florida State Univ. Tallahassee.

WILLIAMS, S. 1972. The temporal and spatial variation of selected Thecosomatous pteropods from the Florida Middle Ground. MS Thesis, Dept. Oceanography, Florida State Univ. Tallahassee.

WÜST, 1964. Stratification and circulation in the Antilles-Caribbean Basins. Columbia Univ. Press. New York.

Florida Sci. 37(1):16-32. 1974.

THE VEGETATION OF SOUTHERN FLORIDA[1]

Robert W. Long

Department of Biology, University of South Florida, Tampa, Florida 33620

Abstract: *The vegetation of southern Florida has been of interest to ecologists for many years. Five physiographic provinces are recognized for the area: the Sandy Flatwoods, the Everglades, the Big Cypress Swamp, the Atlantic Coastal Ridge, and the Coastal Marshes and Mangrove Swamps. There are 1647 species of vascular plants in this area with 60.6% of the total of tropical origin. The four components of the vegetation are the tropical flora, the temperate flora, the endemic flora, and the introduced flora. The endemic flora is approximately 10% of the total and most of these appear to be related to the temperate Appalachian flora. Additional research is needed to clarify the origin of Florida's endemic species.*

Over the years there has been an enduring interest among biologists in the ecology of southern Florida. Much of this interest comes from the fact that this area south of Lake Okeechobee supports the only tropical flora in continental United States and thus is botanically unique. Early students and collectors such as J. L. Blodgett (1809-1853), A. W. Chapman (1809-1899), Ferdinand Rugel (1806-1874) and A. P. Garber (1838-1881) recognized the unusual opportunities for the discovery of new species, and sent specimens to John Torrey at Columbia University and Asa Gray at Harvard for identification and description. Millspaugh (1907) was the first to prepare a careful ecological and floristic survey of the vegetation for a portion of the region, while J. K. Small (1869-1938) was the most prolific writer on the plant life of Florida (1903, 1913a, 1913b, 1933). He published a long series of papers describing the ecology and botany of southern Florida in the Bulletin of the Torrey Botanical Club and the Journal of the New York Botanical Garden from 1901 until his death. Other workers such as Harper (1927), Harshberger (1914), Davis (1943), Moldenke (1944), and Alexander (1955) and Craighead (1971) have made contributions to our understanding of the vegetation of the area.

Recently, biological interest has been largely concerned with ecological damage in southern Florida caused by large scale land development and exploitation. Many natural areas are beginning to change or disappear, and biologists, as well as laymen, are becoming alarmed at the loss of plant and animal life. Botanists in Florida were aware that much of the vegetation was disappearing even before the turn of the century. The burning and draining of the Everglades accelerated during the 1920's, causing Dr. Small to write one of his most provocative books, From Eden to Sahara (1929) documenting the destruction of the luxuriant tropical flora of southern Florida. Because the flora of this part of Florida is becoming seriously depauperate, a floristic and ecological survey was

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undertaken to record permanently the present state of the vegetation. The floristic results were published recently (Long and Lakela, 1971). It is now possible to carry out detailed ecological and vegetational analysis with a means for accurate identification of the species involved, and hopefully this will facilitate new research in the area. The purpose of this paper is to present the results of a statistical and ecological study of the major elements of the vegetation of southern Florida.

Climate and Geology—Geological evidence suggests that southern Florida has only been available to plant colonization since the Pleistocene, and during this epoch only during periods of glaciation. Much of southeastern United States and parts of central and northern Florida have had almost continuous cover of vegetation since Pliocene times and earlier. Geography and climate have doubtless been important, along with the historical factor, in determination of the vegetational composition of southern Florida. The proximity of the Gulf Stream, high summer rainfall and high humidity, and mild winters with a midwinter dry season give the area an almost Antillean, insular climate.

Geological investigations, particularly petroleum drilling records for peninsular Florida, demonstrate that the area was separated from the continent by a seaway during the Oligocene. Peninsular Florida is thought to be the emergent portion of a much broader projection from continental North America, referred to as the "Floridan Plateau". It is underlain chiefly by marine limestones, clays, sandstones, and salt. The sea level rose and fell repeatedly over the Floridan Plateau during the Pleistocene, and evidence of recent submergence can readily be seen in southern Florida in the marine sediments and shoreline features.

Southern Florida is essentially flat and of low elevation, and drainage is southerly. Overflow from Lake Okeechobee used to pass as a sheet into the Everglades before canals were cut. Today, however, drainage occurs principally through the Caloosahatchee canal and river to the west, and through the St. Lucie canal to the east.

Geologists recognize five physiographic areas in southern Florida. They are *The Sandy Flatlands, The Everglades, The Big Cypress Swamp, The Atlantic Coastal Ridge,* and *The Coastal Marshes and Mangrove Swamps.* The Sandy Flatlands area surrounds Lake Okeechobee on the west and east, and then passes south beyond Naples in Collier County. The Everglades extends south of Okeechobee, and ends in the salt marshes and mangroves of Florida Bay. The Cypress Swamp is hammock and swamp country west of the Everglades and is bounded by the Sandy Flatlands on the west. Generally, the Big Cypress is a low-lying area of poor drainage that is flooded during the rainy season. The Atlantic Coastal Ridge runs along the Atlantic side of southern Florida rising slightly from the Everglades and gradually lowering to the ocean in the south. The ridge reappears in the lower Florida Keys from Big Pine Key to Key West. The Coastal marshes and mangrove swamps border the southern end of the peninsula from Ft. Lauderdale to Naples forming a narrow band of vegetation behind the sandy beach ridge.

FLORISTIC ELEMENTS OF THE VEGETATION—In order to obtain a careful floristic and ecological analysis of the flora, each species was recorded on a data sort punch card and coded for significant biological information. In addition to the taxonomic designation, three general categories of data were examined for each taxon: life form, geographical and historical content, and ecology. The system used in this analysis is presented in Fig. 1.

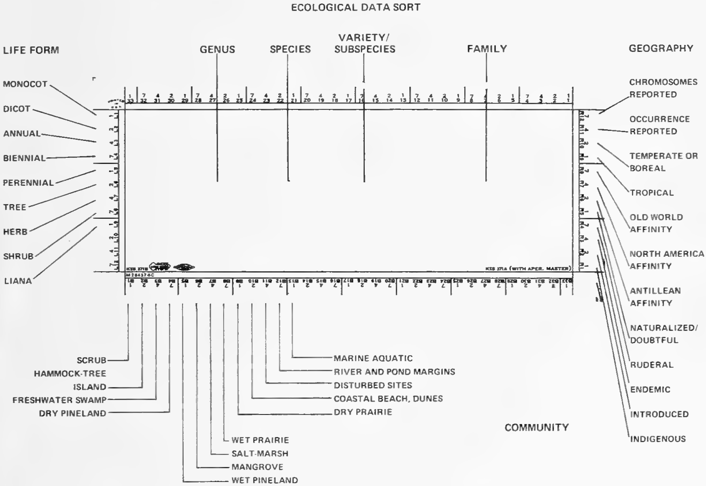


Fig. 1. The Ecological Data Sort. Categories utilized in the ecological and floristic analysis of plant species occurring in southern Florida.

The flora contains 1,647 species of vascular plants of which 1,564 are flowering plants (Table 1). Harper (1949) has estimated the number of species of flowering plants for Florida as 2,500. Species by species comparisons show that the vegetation is predominately tropical in origin with 60.6% of the total composed of plants with generally tropical distribution such as the following:

FERNS AND FERN ALLIES
Lomariopsis kunzeana
Psilotum nudum
Schizaea germanii
Tectaria minima

TREES
Crescentia latifolia
Citharexylem fruticosa
Cocothrinax argentea
Lysiloma bahamensis
Sysygium jambos
Tabebuia pallida
Tamarindus indica

SHRUBS AND HERBS
Angadenia berterii
Asystasia gangetica
Catopsis floribunda
Bulbostylis ciliatifolia
Flaveria linearis
Evolvulus alsinoides
Hippocratea volubilis
Melochia hirsuta
Panicum repens
Pisonia rotundata
Tithonia diversifolia
Tournefortia volubilis

Of the tropical species, 880 are Antillean in distribution, or about 90% of the total number of tropical species. The remaining tropical forms are from Central and South America for the most part with the following species being representative:

Trees	Shrubs and Herbs
Bucida bucerus	*Alternanthera indica*
Callophyllum inophyllum	*Capparis cynophallophora*
Canella winterana	*Croton linearis*
Drypetes diversifolia	*Cyperus odoratus*
Ficus citrifolia	*Desmodium canum*
Krugiodendron ferreum	*Evolvulus wrightii*
Nectandra coriacea	*Fimbristylis miliacea*
Pithecellobium unguis-cati	*Gouania lupoloides*
Spondias purpurea	*Tetrazygia bicolor*
Swietenia mahogoni	*Thallasia testudinum*

The life form analysis showed the woody flora to be composed of 329 species of trees, shrubs, and lianas, with 77% of this flora of tropical origin, and 182 of 329 taxa are of Antillean origin. Of the total number of vascular plants 64.7% of the species are herbaceous, while the remaining 35.3% are woody. Thus, even though the flora is predominately tropical in origin, unlike most wet seasonal tropical vegetation that of southern Florida is chiefly herbaceous in life form, at least as far as species diversity is concerned.

The major plant groups, however, are temperate or cosmopolitan in distribution. The Poaceae (grass) family is largest with 194 species; the Asteraceae (sunflower) family is second with 153 species. The Fabaceae (pea) have 134 taxa, the Orchidaceae (orchid) have 70 taxa, and the Cyperaceae (sedge) have 62 taxa. Of the five largest plant families in the vegetation, only two (orchid and pea) are essentially tropical groups. If we continue the analysis, the next largest families are tropical, however, with the Euphorbiaceae (spurge), 61 taxa, Rubiaceae (madder) 40 taxa, and Malvaceae (mallow) with 32 taxa.

The non-tropical element of the vegetation is made up mostly of species whose general distribution occurs to the north or to the west of southern Florida. The 626 "temperate species" are those whose ranges extend into Florida principally from the southeastern coastal plain flora with such species as:

Ferns and Fern Allies	Shrubs and Herbs
Anchistea virginica	*Amorpha herbacea*
Isoetes flaccida	*Aster caroliniensis*
Pteridium aquilinum	*Befaria racemosa*
Thelypteris gongylodes	*Burmannia capitata*
Trees	*Callicarpa americana*
Bumelia tenax	*Cyperus pumilus*
Cephalanthus occidentalis	*Eriocaulon ravenelii*
Cornus foemina	*Eupatorium capillifolium*
Diospyros virginiana	*Itea virginica*
Ilex cassine	*Panicum breve*
Morus nigra	*Paspalum fluitans*
Rhus copallina var. leucantha	*Peltandra virginica*
Sambucus simpsonii	*Spirodela polyrhiza*

Another important component is derived from the naturalized flora referring to species that have intentionally or unintentionally been brought into the area and are now self-reproducing. Many of these species are ruderals, or weeds, and some are extremely successful in adapting to their new environment as can be seen from the following representative list:

Argemone mexicana
Cenchrus brownii
Oxalis stricta
Linum usitatissinum
Trianthema portulacastrum
Phytolacca rigida
Phytolacca americana
Lepidium virginicum
Boerhavia repens
Boerhavia erecta
Gomphrena decumbens
Amaranthus hybridus
Amaranthus viridis
Bidens pilosa
Verbena bonariensis
Chenopodium album
Sonchus asper
Sonchus oleraceus

In the ecological data sort, 257 species were identified as being naturalized. Some of these, such as the *Schinus terebinthifolius* (Brazilian holly), *Melaleuca quinquenervia* (punk tree), *Casuarina equisetifolia* (Australian pine), and *Eichhornia crassipes* (water hyacinth) were introduced for horticultural purposes, but have escaped and become serious plant pests throughout much of southern Florida. The introduced flora amounts to 15.8% of the total flora, and of this number 32.7% are herbaceous weeds.

The fourth important component of the vegetation of southern Florida is the endemic flora. The identification of Florida species having very limited distribution has been of interest to botanists for many years. Harper (1949) listed 427 endemic species of flowering plants for Florida; the largest number of Florida endemics was based on Small (1933). Howard (1954) suggested there were 385 endemics in four geographical areas: 189 taxa chiefly in the Central Florida lakes district; 123 in southern Florida and the Keys; 39 in northern peninsular Florida; and 34 in the Florida panhandle. Campbell (1940) believed that the presence of endemics was correlated with the existence of island refugia during Tertiary times.

In our analysis 160 taxa were identified as being endemic, either to southern Florida and the Keys, exclusively, or to southern peninsular Florida. In general this would indicate that about 10% of the total flora is composed of endemic taxa. The flora is 87% dicotyledons, and 60% of these are herbaceous. Some examples of these endemics are presented in this list:

*Aristida patula**
Cassia keyensis
Cereus eriophorus var. *fragrans*
Cereus gracilis var. *aboriginum*
Cereus robinii var. *keyensis*
Chamaesyce cumulicola
*Croton floridanus**
Cynoctonum succulentum
Flaveria floridana
Forestiera segregata var. *pinetorum*
Helianthemum nashii
Heterotheca traceyi
Lachnocaulon floridanum
*Lechea cernua**
Liatris garberi
Limonium carolinianum var. *angustatum*
Linum carteri var. *smallii*

*also in peninsular Florida

Opuntia triacantha
Opuntia spinosissima
Passiflora multiflora
Piriqueta caroliniana var. *glabra*
*Sabatia grandiflora**
*Sida rubromarginata**
*Stipa avenacioides**
Tephrosia corallicola
Tephrosia angustissima
Tragia saxicola
Urechites lutea var. *sericea*
Vernonia blodgettii
*Zamia integrifolia**

Two additional taxonomic groups should be examined before leaving this part of the analysis, the fern flora and the gymnosperms. There are 76 species of Pteridophytes present in the vegetation, and these are predominately tropical in their distribution. *Equisetum* is not present, although tropical species such as *Schizaea germanii, Microgramma heterophylla,* and *Ctenitis sloanei* are well established in the area. Four species each of *Selaginella* and *Lycopodium,* and one of *Isoetes* are occasional to rare. Both tropical and nontropical groups are represented in the total flora (cf. Tables 2 and 4.)

Although numerically gymnosperms easily are the most abundant large plants, their diversity is the least of all major taxonomic groups. The extensive pine forests and cypress swamps are conspicuous vegetational formations, but only four genera of gymnosperms are present: the conifers *Pinus, Taxodium* (cypress), and *Juniperus* (juniper); and the cycad *Zamia* (coontie). Associated with the pine and cypress forests are floristically rich plant communities that generally characterize the vegetation of the area.

Plant Formations[2]—On the Sandy Flatlands and on the Atlantic Coastal Ridge are found three conspicuous plant formations. They are the Scrub Forests, the Dry Pineland Community, and the Wet Pineland Formation. The Scrub Forests contain a number of low trees and shrubs with little herbaceous ground cover. Some indicator plants here are *Pinus clausa* (sand pine), *Quercus myrtifolia* (myrtle-leaf oak), *Quercus virginiana* var. *geminata* (sand oak), and grasses and forbs such as *Aristida condensata* (needle-grass), *Galactia regularis* (milk-pea), *Heterotheca scabrella* (golden-aster), *Liatris tenuifolia* (blazing-star), and *Palafoxia feayi.* These plant associations are well-developed in the Lake District of Central Florida. A second important formation is the Dry Pineland found on nearly level plains of open forests, grasses and other herbs. Species typically found here are *Pinus elliottii* var. *densa* (slash pine), *Diospyros virginiana* (persimmon), *Serenoa repens* (saw palmetto), *Zamia pumila* (coontie), *Brysonima cuneata* (locustberry), *Guettarda scabra* (velvetseed), and numerous herbs such as *Agalinis filifolia* (false foxglove), *Eupatorium villosum* (boneset), and *Stipulicida setacea.*

The Wet Pineland formation occurs on seasonally flooded low areas, and is especially well-developed along the western margin of the Big Cypress Swamp. From the standpoint of diversity, this is the richest plant association in southern Florida (Fig. 2.). Species found here include *Morus nigra* (mulberry), *Forestiera segregata* var. *pinetorum* (Florida privet), *Pinus elliottii* var. *densa* (Slash pine), *Erythrina herbacea* (coral bean), and numerous herbs such as *Spiranthes vernalis*

[2]The use of the terms formation, association, and community to describe plant groups is not done in any formal sense implying precise definition. There is no implication of Clementian terminology. The terms are used more or less interchangably.

(ladies tresses orchid), *Xyris elliottii* (yellow-eye grass), *Ipomoea tenuissima* (glades morning glory), and *Polygala nana* (milkwort).

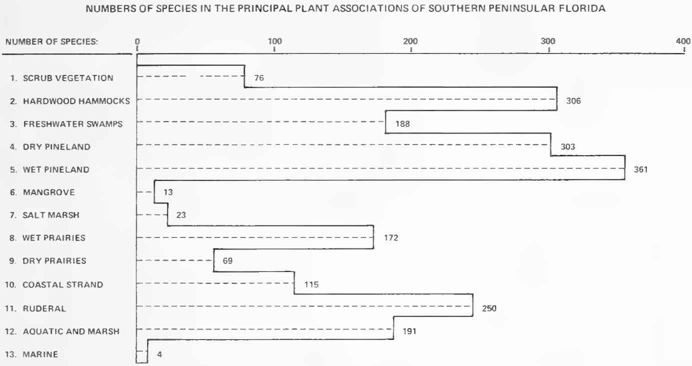


Fig. 2. The relative numbers of different species found in the principal plant formations of southern Florida.

In the Everglades region there are three principal formations present. The most characteristic in appearance are the hammocks and tree islands (Fig. 3.). These are groups of broadleaf, evergreen trees often associated with palms that form dense forests in relatively small areas. Examples of plants found here are *Bursera simaruba* (gumbo limbo), *Dipholis salicifolia* (bustic), *Coccoloba diversifolia*(tie-tongue), *Simaruba glauca* (paradise tree), *Lysiloma latisiliqua* (wild tamarind), *Mastichodendron foetidissimum* (mastic), *Eugenia* sp. (stopper) and *Citharexylum fruticosum* (fiddlewood). The largest areas in southern Florida are covered by treeless Wet Prairies, and they are best developed in the Everglades (Fig. 4.). This vast formation is also one of the richest and most diverse floristically in the area. The dominant species is *Cladium jamaciense* (saw grass), and other characteristic species associated with this community are *Typha latifolia* (cattail), *Pontederia lanceolata,* (pickerel weed), *Sagittaria lancifolia* (arrow-leaf), *Eriocaulon decangulare* (hat pin), *Amphicarpum muhlenbergianum* (blue maidenscane), *Cyperus haspan* (galingale) and *Erianthus giganteus* (plume grass). Ecotones between wet prairies and pineland are occupied by Dry Prairie Communities that are often referred to as "palmetto prairies". Plants commonly found here include *Aristida gyrans* (three-awn grass), *Andropogon glomeratus* (beard grass), *Cyperus pollardii* (sedge), *Paspalum giganteum* (paspalum grass), *Eriochloa michauxii* (cup grass), and *Lygodesmia aphylla* (rush pink). The floristic composition of this formation is quite variable, although the tendency to xeric conditions results in a dominance of grass species.

Finally, along the canals, ponds, and lakes are found highly mixed communities that contain the elements of several kinds of associations, a Pond and River Margin Community. Common species include *Cephalanthus occidentalis* (buttonbush), *Fraxinus caroliniana* (water ash), *Carya aquatica* (water hickory), *Celtis laevigata* (hackberry), *Schinus terebinthifolius* (Brazilian holly), *Persea borbonia* (red bay), and *Woodwardia virginica* (chain fern). In some areas this vegetational association may form dense growth, while in others the plants may occur as a narrow band of plants along a waterway.

Fig. 3. (upper photo) Dense hardwood hammock growth on Cape Sable, East Cape. In the foreground are stems of the cactus *Cereus pentagonus*; in the background are tall stems of wild papaya, *Carica papaya*.

Fig. 4. (lower photo) Wet prairies of the Everglades formation with small hardwood hammock tree islands in the background.

The Big Cypress Swamp area contains not only pond and river margin associations but also a distinctive Freshwater Swamp Formation. These forests are flooded by shallow surface water throughout most of the year, and they may be found in many parts of southern Florida (Fig. 5.). Some characteristic plants occurring here are *Salix caroliniana* (southern willow), *Taxodium distichum* (bald cypress), *Ilex cassine* (dahoon), *Saururus cernuus* (lizard tail), *Scirpus validus* (bulrush), *Ludwigia repens, Myriophyllum pinnatum* (milfoil), and *Juncus polycephalus* (rush).

Along the southwestern and southern coastlines of peninsular Florida are some of the largest and best developed mangrove swamps in the world. Mangrove is a term applied to any plant that resembles *Rhizophora mangle* (red mangrove) in its general morphology and ecology. In addition to this species, other "mangrove" species are *Avicennia germinans* (black mangrove), *Conocarpus erectus* (buttonwood), and *Laguncularia racemosa* (white mangrove). Associated with mangrove communities are *Caesalpinia crista* (gray nicker), *Batis maritima* (saltwort), *Dalbergia ecastophyllum, Salicornia perennis* (glasswort), and *Rhabdadenia biflora* (rubber vine).

A formation closely related ecologically to mangroves is the Salt Marsh Community which covers large areas in southern Florida around tidal estuaries, bays and inlets (Fig. 6.). This community is floristically closely similar to the mangrove community and differs chiefly in the absence of tree-forms. Plants found here include *Borrichia arborescens* (sea oxeye), *Borrichia frutescens, Spartina patens* (cordgrass), *Spartina spartinae, Limonium carolinianum* (sea lavender), *Distichilis spicata* (saltgrass), *Cyperus ligularis* (sedge), and *Hyptis pectinata* (bittermint).

Perhaps the most distinctive plant community in southern Florida is the Coastal Dune and Strand Formation. Sandy beaches and dunes are usually very narrow and offer limited range for plants, but the floristic composition of this part of the area is remarkably uniform and is very similar to that found generally around the Caribbean basin. Some of the species typically found in this formation are *Batis maritima, Cakile fusiformis* (sea rocket), *Coccoloba uvifera* (sea grape), *Iva frutescens* (marsh elder), *Scaevola plumieri, Suriana maritima* (bay cedar), *Tournefortia gnaphalodes* (sea lavender), *Uniola paniculata* (sea oats), and *Yucca aloifolia* (Spanish bayonet).

Marine Communities of vascular plants are extensive in shallow water of bays and near-beach areas where they often form dense submarine meadows of saltwater vegetation. Species included in this formation are *Halophila engelmannii* (sea grass), *Thalassia testudinum* (turtle grass), *Ruppia maritima* (ditch grass) and *Syringodium filiformia* (manatee grass). Finally, there are numerous Ruderal Associations that are weed communities that may be highly variable in floristic composition, or may be composed of relatively few, abundant species. These associations may be found on ecologically disturbed or altered sites such as roadsides, burned-over areas, and around excavations. Some common weeds found in southern Florida are listed in Table 1.

TABLE 1. A summary of the flora of southern Florida based on the ecological data sort analysis.

	Families	Genera	Species	Varieties or Subspecies
Pteridophyta	18	37	76	6
Gymnospermae	4	4	7	2
Angiospermae				
Liliatae	32	186	490	25
Magnoliatae	125	537	1074	157
Total	179	762	1647	190

ORIGIN OF THE VEGETATION—Although parts of northern and central Florida, and much of southeastern United States have had continuous vegetation since Pliocene times and earlier, large areas of the southern tip of the Floridan peninsula has been submerged until recent times. At the end of the last glaciation, the sea rose to its present level. Former shorelines can be identified by beach ridges, dunes, and wave-cut benches. The last major coastal terraces still visible in southern Florida are the Penholoway at plus 70 ft, the Talbot at plus 42 ft, and Pamlico at plus 25 ft.

Migration into newly emergent southern Florida came from three principal biogeographic areas: (1) From the Southeastern Coastal Plain and temperate areas to the north; (2) from the Antillean region, the Yucatan peninsula, and other areas of tropical America; (3) from island refugia of Tertiary and Pleistocene age, principally of Central Florida and of the Atlantic Coastal Ridge. Thus, the vegetation is derived from three, biogeographically dissimilar floras. In addition, in modern times a significant number of naturalized species have further enriched the total flora.

The presence of a comparatively high endemic flora raises the question as to how the species reached southern Florida. It would seem improbable that all could have evolved to morphological and physiological distinctness in a few thousand years. Although James (1961) is doubtful there ever was a series of island refugia, he does agree with the general view that the endemics are largely relict species. However, Howard (1954) tends to believe the presence of endemics . . . "indicate a vigorous and young flora" . . . Which view is closer to the fact has yet to be proven. Only by careful analysis of each species, using biosystematic techniques, can the question of the origin of endemics be resolved (cf. Long, 1971).

Howard believes that the vegetation of southern Florida is essentially isolated from other floras because of geological and climatic factors. The Lake District of central Florida, the Everglades, the limestone outcrops, and the frost line together form a barrier that prevents any large scale migration of the tropical flora. Within the area, however, environmental factors of soil, drainage patterns, and climate have formed a wide variety of ecological niches that resulted in the evolution of a highly diversified vegetation. Elements of past floras, such as the arcto-Tertiary flora that once covered much of the southeastern United States and influenced the development of the modern vegetation of that area (Sharp, 1951), apparently had little effect on the vegetation of southern Florida (Howard, 1954).

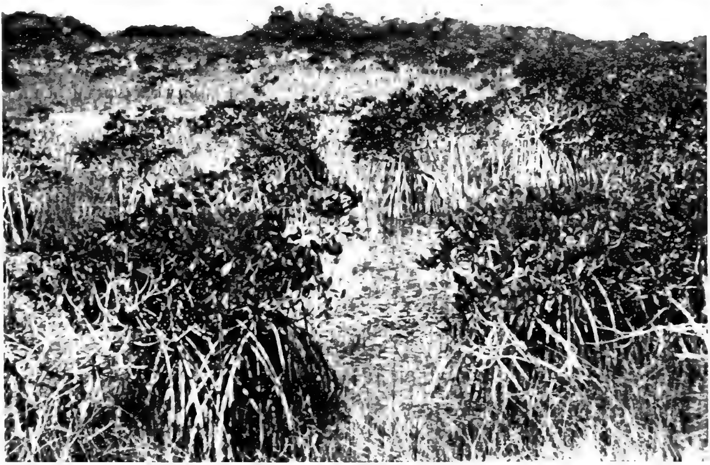


Fig. 5. (upper photo) The Cypress Formation in the Everglades National Park, referred to as a "dwarf cypress forest." The trees are mature but never reach full height.

Fig. 6. (lower photo) Red mangrove community growing in shallow brackish water near Flamingo, Florida in the Everglades National Park.

CONCLUSION—The floristic complexity of the vegetation is due to the fact that the tip of the peninsula is near the tropic zone and conditions are suitable for the growth of many tropical species. Yet, the Floridan peninsula is connected to a large land mass that has been occupied by a rich temperate flora, and consequently some migration has taken place from the southeastern coastal plain into Florida from the north. The confluence of a diverse temperate flora and an equally diverse tropic flora has resulted in the unique vegetational association characteristic of southern Florida. Various climatic and geological factors have prevented a northward migration of the tropical component although there has been some extension of the tropical vegetation up along the Atlantic Coastal Ridge to Merritt Island. Statistically, the vegetation is predominately Antillean in origin, but there is a significant temperate element in the flora. When compared to many other tropical floras, that of southern Florida is interesting in being predominately herbaceous, a life form ordinarily associated with temperate or boreal vegetation. Moreover, the largest families are not of tropical species, but of cosmopolitan or temperate genera.

Vegetational patterns are further complicated by the admixture of a significant endemic flora and a naturalized flora. A number of endemics, such as taxa in *Cereus* and *Opuntia* are found on geologically very young land, and there are a number of unsolved problems regarding their origin.

Much research also remains to be done on the naturalized flora that includes a number of obnoxious weeds. The casual introduction of certain species, such as *Eichhornia crassipes* and *Melaleuca quinquinervia*, has led to serious economic consequences, and continued introductions of new plants could possibly cause equally unfortunate results.

Detailed ecological analyses of the vegetation need to be carried out in all the major physiographic provinces of southern Florida. If we are to preserve parts of the area we need to understand the complex ecosystems that support the animal and plant populations. Hopefully, with new tools for the identification of plant species there will be an increased interest in ecologically orientated research that will provide the basis for better understanding the vegetation of southern Florida.

LITERATURE CITED

ALEXANDER, T. R. 1955. Observations on the ecology of the low hammocks of southern Florida. Quart. J. Florida Acad. Sci. 18: 21-27.

CAMPBELL, R. B. 1940. Outline of the geological history of peninsular Florida Proc. Florida Acad. 4: 87-105.

CRAIGHEAD, F. C., SR. 1971. The Trees of South Florida. Vol. 1. Univ. Miami Press. Coral Gables.

DAVIS, J. H. 1943. The natural features of southern Florida. Florida State Geol. Surv. Bull. 25. Dept. Conservation, Tallahassee.

HARPER, R. M. 1927. Natural resources of southern Florida. Ann. Rpt Florida State Geol. Surv. 18: 27-192.

HARPER, R. M. 1948 (1949). A preliminary list of the endemic flowering plants of Florida. Part II. Quart. J. Florida Acad. Sci. 11: 39-57.

HARSHBERGER, J. W. 1914. The vegetation of South Florida. Trans. Wagner Free Institute Sci. Phil. 3: 51-189.

Howard, R. A. 1954. Contribution of the Caribbean flora to the southeastern coastal plain. (paper addressed to systematic section, Botanical Society of America Annual Meeting, Gainesville, Fla.).

James, C. W. 1961. Endemism in Florida. Brittonia 13: 225-244.

Long, R. W. 1971. Genetic and morphological relationships of the southeastern Coastal Plain endemic *Ruellia noctiflora*. Bull. Torrey. Bot. Club. 98: 16-21.

__________, and Olga Lakela. 1971. A Flora of Tropical Florida. Univ. Miami Press. Coral Gables.

Millspaugh, C. F. 1907. Flora of the Sand Keys of Florida. Field Col. Mus. Publ. 118, Bot. Ser. 2: 191-245.

Moldenke, H. N. 1944. A contribution to our knowledge of the wild and cultivated flora of Florida, I. Amer. Midl. Nat. 32: 529-590.

Sharp, A. J. 1951. The relation of the Wilcox flora to some modern floras. Evolution 5: 1-5.

Small, J. K. 1903. Flora of Southeastern United States. New York.

__________. 1913a. Flora of Miami. New York.

__________. 1913b. Flora of Florida Keys. New York.

__________. 1929. From Eden to Sahara, Florida's Tragedy. The Science Press. Lancaster, Pa.

__________. 1933. Manual of the Southeastern Flora. Univ. North Carolina Press. Chapel Hill.

Florida Sci. 37(1):33-45. 1974.

Biological Sciences

LIGHT AND ELECTRON MICROSCOPE STUDIES ON THE GAMETES OF THE GREEN ALGA, *CAULERPA* (CHLOROPHYTA, SIPHONALES)

Colleen A. Lohr and Clinton J. Dawes

Department of Biology, University of South Florida, Tampa, Florida 33620

Abstract: *The development of papillae and the fine structure of gametes from six species of the green coenocytic alga,* Caulerpa *are described. The gametes are of uniform structure and resemble other green algal flagellates. Each gamete has a pair of flagella, apically inserted, a single central nucleus, and a basal plastid. A rough endoplasmic reticulum, Golgi bodies, and mitochondria are present.*

The giant green algal coenocyte *Caulerpa* is pan-tropical in distribution and has been used in numerous studies on polarity, development and growth (Dawes and Rhamstine, 1967; Dawes and Barilotti, 1969). More recently Goldstein and Morrall (1970) and Price (1972) have reviewed the literature and described some aspects of reproduction in the genus. The recent studies supported earlier reports concerning reproduction.

To date, no information on induction of gametogenesis has been published. Furthermore, there is little information on the cytoplasmic organization during gametogenesis, and no work published on the gametes themselves. The purpose of this report is to present information on the fine structure of the gametes of a number of species of *Caulerpa*. In addition, some information is presented on the developmental sequence in the formation of these gametes.

MATERIALS AND METHODS—Six species of *Caulerpa* were collected along the Florida coasts, either in the Keys or from the west coast. These species included *Caulerpa cupressoides* (Vahl) C. Agardh, *C. mexicana* (Sonder) J. Agardh, *C. prolifera* (Forsskal) Lamouroux, *C. racemosa* (Forsskal) J. Agardh, *C. sertularioides* (Gmelin) Howe, and *C. verticillata* J. Agardh. All six species were grown in 20 gallon aquaria with subsand filters and 12/12 light-dark regimes at 25°C., and all species underwent gametogenesis in the aquaria.

Plants that were in the process of gametogenesis were collected from the culture tanks at various stages and prepared for electron microscopy. The procedures of fixation, dehydration, and embedding were essentially those outlined by Dawes and Rhamstine (1967) and Dawes and Barilotti (1969). Material was fixed in isotonic solutions of 5% glutaraldehyde buffered in cacodylic acid and postfixed in 2% osmium tetroxide in the same buffer. The material was dehydrated in ethanol, transferred to acetone by three steps and infiltrated and embedded in Epon-Araldite plastic (Mollenhauer, 1963). Ultrathin sections cut on an MT-2 Sorvall Ultramicrotome were stained with the double stain of uranyl acetate followed by Reynold's (1963) lead citrate.

RESULTS—*Developmental Features and Light Microscope Observations.* Goldstein and Morrall (1970) have presented a detailed description of the formation of the gametes as seen at the light microscope level. The species described in this paper follow the same general pattern of papillae formation, cytoplasmic clumping and the subsequent formation of a networked or reticulated cytoplasm. The entire process took from 48–72 hr.

Initial development of gametogenesis was usually observed after the beginning of the 12 hr light period on day 1. Hair-like extensions of the cell wall on both the blades and the rhizome portions of the plant were found to develop. These papillae were first green and contained typical cytoplasm. Papillae size varied but averaged 2mm wide and 5mm long.

By the end of the first 12 hr of light the cytoplasm of the blades was slightly blotchy with gross dark green clumps and yellowish white regions (Fig. 1). Upon examination with the light microscope the chloroplasts were found to be clumped around nuclei in the dense green regions.

After the following 12 hr dark period, and at the beginning of the second 12 hr day period (day 2), the process of reticulation of the cytoplasm continued and the papillae became white to almost colorless. At this stage the cytoplasm had the appearance of a green network with almost no cytoplasm at all at the base of the blades. The papillae were completely clear of organelle-bearing cytoplasm. Under the light microscope the dense green cytoplasmic clumps were found to consist of a number of subunits, each consisting of a plastid and a nucleus. Actual cleavage at this point was not readily apparent.

By the end of the second 12 hr light period, yellowish masses of cytoplasm were evident at the base of each of the papillae. Under the light microscope small ($5\ \mu \times 2\ \mu$) ellipsoid to spherical cells could be seen. No motility was evident however.

After the second 12 hr dark period and immediately after the initiation of the third light period, gamete release commenced. The process was rapid, taking only about 5–10 min. A large (800μ diameter) yellowish mass rapidly formed at the tip of each papillae and then were released from the papillae into the seawater (Fig. 2). These clumps floated in the water for some time and then settled on the sides and bottom of the culture tank. The motile cells were released from these clumps.

The gametes were of two sizes and both sizes appeared to be produced from the same plant (Fig. 3). The gametes had a pair of apically inserted flagella, and an eyespot located laterally at approximately two thirds the length of the cell. The chloroplast was found in the posterior portion of the cell. A refractive body was visible in most gametes just posterior to the flagellar area.

Electron Microscope Observations. In all six species the gametes were of uniform structure. Gametes were of pyriform shape and each contained a single, basal chloroplast, a central nucleus and a pair of apical flagella (Fig. 4, 5).

The nucleus lacked a nucleolus, was about 1 μ in diameter, and was surrounded by rough endoplasmic reticulum. Usually, one or more mitochondria and a Golgi body were located near the nucleus (Fig. 7).

The flagella were inserted at right angles to one another with the flagellar roots extending into the anterior portion of the cell (Fig. 4, arrows). In cross section, the flagella had the typical 9 + 2 tubular arrangement.

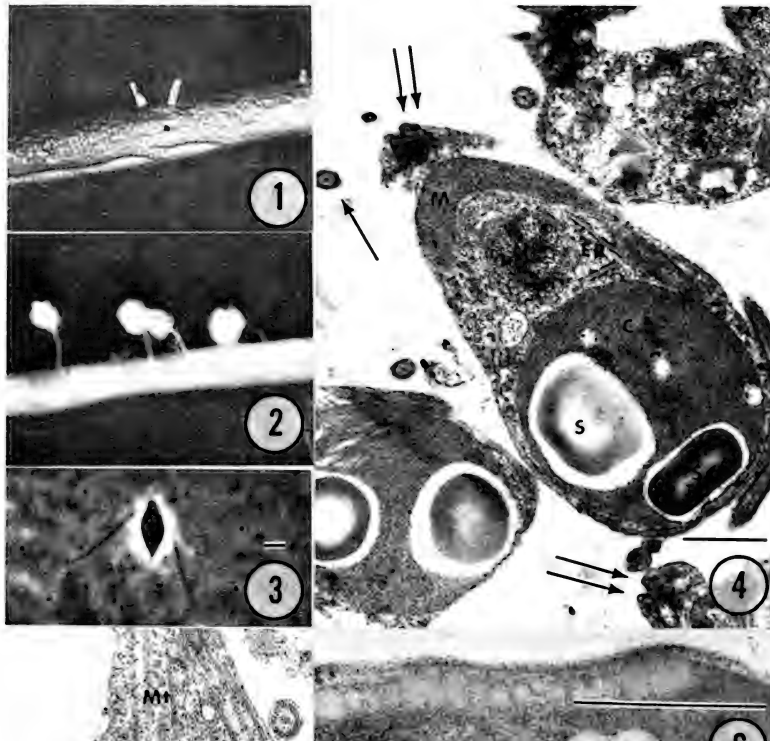
The chloroplast differed from the vegetative chloroplast of *Caulerpa* (Dawes and Rhamstine, 1967) in that the thylakoids were densely packed with little stroma present. Lipid bodies were lacking and one or more large starch grains were present.

The eyespot was present in the chloroplast of all six species and consisted of a single row of up to 30 osmiophilic bodies (Fig. 6). These lipid-like spheres were closely packed together just under the chloroplast envelope and adjacent to the plasma membrane and forming a bulge in that region.

The refractive body seen in the light microscope is believed to be a contractile vacuole that is found in the same location, approximately midway in the cell and adjacent to the nucleus. The vacuole had "alveolar-like" membranes projecting into it and was adjacent to the plasmamembrane.

Discussion—The present paper extends our understanding of the process of gametogenesis in *Caulerpa* and for the first time describes the ultrastructure of the gametes. In all six species studied, the gametes were similar in ultrastructure, and quite typical of green algal flagellates such as those described for *Bryopsis* by Urban (1969). In fact, the gamete structure for *Bryopsis hypnoides* and *Caulerpa prolifera* is almost identical. Electron microscope observations have shown the presence of eyespots in gametes of all of the species of *Caulerpa* examined in this study.

A number of light microscopic studies of the gametes of *Caulerpa* have confirmed the bi-flagellate nature of the cell. Dostal (1928) and Schussnig (1929), not withstanding their arguments as to the first observation, both noted the presence of eyespots and a single chloroplast. Miyake and Kunieda (1937) reported that *C. brachypus* produced "male" gametes that lacked an eyespot and



Figures 1-7: Fig. 1. Light micrograph of papillae on the blade of *Caulerpa prolifera.* Note the reticulated nature of the blade cytoplasm with almost colorless papillae. Fig. 2. Light micrograph showing the yellowish mass at the tip of the papillae in *C. prolifera.* These develop after the second 12 hr dark period and then are released from the papillae. The gametes can be found in these clumps. Fig. 3. Light micrograph of a gamete of *Caulerpa.* Gametes are pyriform shape with two apically inserted flagella, and resemble other green flagellates. The unit mark equals 1 μ. Fig. 4. Electron micrograph of gametes of *Caulerpa prolifera.* Double arrows show the flagellar roots; single arrows indicate flagella cross sections showing the 9 + 2 tubular arrangement. Note the chloroplast (C) with two starch grains (S), the nucleus (N), rough endoplasmic reticulum (ER), and mitochondria (M). 14,800 ×. Fig.

green color. We have found no distinction between the larger and smaller gametes studies.

With regard to size, all reports tend to indicate that the gametes are small (5-7μ long) for *C. brachypus,* (Myake and Kunieda, 1937); (5-6μ long) for *C. prolifera,* (Schussnig, 1929). This study also confirms the size range of 5-7μ for the gametes of the species studied.

It appears that a number of research projects on gametogenesis in *Caulerpa* should be initiated. Attempts to first induce gametogenesis will be required if cytoplasmic organization is to be followed during gametogenesis. Secondly, nuclear studies must be completed to determine chromosome number in the gametes and vegetative plants.

LITERATURE CITED

DAWES, C. J. AND BARILOTTI, D. C. 1969. Cytoplasmic organization and rhythmic streaming in growing blades of *Caulerpa prolifera.* Amer. J. Bot. 56: 8-15.

———— AND RHAMSTINE, E. 1967. An ultrastructural study of the giant green algal coenocyte, *Caulerpa prolifera.* J. Phycol. 3: 117-126.

DOSTAL, R. 1928. Zur frage der Fortpflanzungorgane der Caulerpaceen. Planta 5: 622-634.

GOLDSTEIN, M. AND MORRALL, S. 1970. Gametogenesis and fertilization in *Caulerpa.* Ann. New York Acad. Sci. 175: 660-672.

MIYAKE, K. AND KUNIEDA, H. 1937. On sexual reproduction of *Caulerpa.* Cytologia 8: 205-207.

MOLLENHAUER, H. 1963. Plastic embedding mixtures for use in electron microscopy. J. Stain Tech. 39: 111-114.

PRICE, I. R. 1972. Zygote development in *Caulerpa.* Phycologia 11: 217.

URBAN, P. 1969. The fine structure of pronuclear fusion in the coenocytic marine alga *Bryopsis hypnoides.* J. Cell Biol. 42: 606-611.

REYNOLDS, E. S. 1963. The use of lead citrate at high pH as an electron opaque stain in electron microscopy. J. Cell Biol. 17: 208.

SCHUSSNIG, B. 1929. Die fortpflanzung von *Caulerpa prolifera.* Oesterr. Bot. Zeitschrift 78: 1-8.

Florida Sci. 37(1):45-49. 1974.

5. Electron micrograph of the gamete of *Caulerpa prolifera.* Note the central nucleus (N) and the adjacent numerous mitochondria (M). Microtubules can be seen in the region of the flagellar root (Mt), and the arrow indicates a flagella cross section. 24,000×. Fig. 6. Electron micrograph of *Caulerpa racemosa* showing the area of the eyespot. The eyespot was found in all six species studied. The eyespot consists of osmiophilic bodies just under the chloroplast envelope. 31,000×. Fig. 7. Electron micrograph of a gamete of *Caulerpa prolifera.* The refractive body seen in the light microscope is believed to be a contractile vacuole labelled CV. Note the alveolar appearance of the vacuole. The nucleus (N), rough endoplasmic reticulum (ER), Golgi body (G), and chloroplast (C) with a starch grain (S) can be seen. 32,900×.

LAURENCIA BRONGNIARTII (RHODOPHYTA-RHODOMELACEAE) FROM FLORIDA

H. E. Hackett

Biology Department, Bates College, Lewiston, Maine 04240

Abstract: Laurencia brongniartii *J. Ag. is newly reported for Florida and for only the second time from the West Indian region. The type specimen came from Martinique but all other records have been from the Indo-Pacific until this discovery of drift material on the southeast coast of Florida. It is apparently a deep water alga whose Florida habitat is uncertain, but probably from a reef between the ocean beach and the edge of the continental shelf off the southeast coast of Florida.*

Along the open beach of Broward County between Hillsboro and Fort Lauderdale, there is a productive rocky reef that appears to support a tropical flora of great diversity. Following windy weather, many species are found adrift on the beach.

Collections were made at this site from 1957 to 1961 averaging three times a month except during the summer. Sporadic collections were made over the last ten years. Several SCUBA investigations of the reefs were conducted.

Specimens of *L. brongniartii* J. Ag. were found only on three occasions along the open beach. On April 12, 1959, and Jan. 7, 1962, single specimens were found. Several fragments were collected from debris after the severe storm of March 4-9, 1962.

Taxonomy—*Laurencia brongniartii* was first described by J. Agardh from the collections of Brongniart in Martinique. Yamada (1931) examined the supposed type at Lund and a similar specimen from Brongniart's herbarium at Paris. At that time Yamada placed *L. concinna* Montagne in synonomy.

The alga (Fig. 1) clearly may be placed in the subgenus *Laurencia* section Pinnatifidae as recognized by Saito (1967). To 5 cm in height it is compressed and pinnatified, branching opposite or occasionally alternate below with some older parts appearing costate. The opposite pinnae may be unequally developed. The cortical cells are round to quadrate in cross section and have secondary pit connections in surface or longitudinal views. The cortical cells never project from the surface as they do in so many other species. Medullary cells of the lower parts have uniformly thick walls, and only twice were lenticular thickenings of medullary cells seen. Both were in mid parts of a tetrasporophytic plant. Saito has emphasized the taxonomic importance of such thickenings in other sections of the genus. The tetrasporangial initials appear to originate from the lower side of the mother cell and are borne in rows parallel to the axis in slightly distended pinnae. The spores at maturity are oval, 65μ long and 55μ wide.

Fig. 1. *Laurencia brongniartii* J. Ag. from the drift collection of Jan. 7, 1962, Hillsboro Beach, Broward County, Florida. × 1.5

DISTRIBUTION—While *L. brongniartii* has not been reported again in the West Indian region until this Florida record, there are two specimens in Farlow Herbarium (Harvard) collected by Hooper at Key West about 1850. They seem to be this species.

The alga is occasional in the Indo-Pacific and is probably a pan-tropical entity. Taylor (1960) in his work on the tropical algae of the eastern coast of the Americas lists *L. brongniartii* as an uncertain record. These findings remove it from that category.

Specimens are deposited in the herbarium of Duke University, Durham, N. C. and in the collections of Yuzuru Saito at Hokkaido University, Hokkaido, Japan.

DISCUSSION—The only other distinctly flattened species of *Laurencia* in the West Indian region are, also, very rare. *Laurencia lata* Howe and Taylor was dredged from deep water off Brazil. The other, *L. pinnatifida* (Gmelin) Lamouroux, is known from Venezuela (Diaz-Piferrer, 1970); and there are uncertain records from Jamaica and Brazil (Taylor, 1960). This latter species, which most resembles *L. brongniartii,* is a common littoral to sublittoral alga on the European coast and from Iceland to the Canary Islands, Morocco and the Mediterranean. There are unverified records of *L. pinnatifida* in the Indo-Pacific. The branching is usually alternate, the cortical cells are palisade-like in cross section, and lenticular thickenings of the medullary cells are conspicuous and abundant. According to Saito (1969) tetrasporangial initials originate from the upper side of the mother cell.

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LITERATURE CITED

DIAZ-PIFERRER, M. 1970. Adiciones a la flora marina de Venezuela. Caribbean J. Sci. 10: 159-198.

SAITO, Y. 1967. Studies on the Japanese species of *Laurencia*, with special reference to their comparative morphology. Mem. Fac. Fish. Hokkaido Univ. 15: 1-81.

________. 1969. on morphological distinctions of some species of Pacific North American *Laurencia*. Phycologia 8: 85-90.

TAYLOR, W. R. 1960. Marine algae of the eastern tropical and sub-tropical coasts of the Americas. Univ. Mich. Press. Ann Arbor.

YAMADA, Y. 1931. Notes on *Laurencia*, with special reference to the Japanese species. Univ. Calif. Publ. Bot. 16: 185-310.

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Biological Sciences

OBSERVATION ON A SEA URCHIN CAPTURING A JUVENILE MULLET[1]

R. GRANT GILMORE AND ROBERT H. GORE

The Harbor Branch Foundation Laboratory, R.F.D. 1, Box 196, Ft. Pierce, Florida 33450; and The Smithsonian Institution, Ft. Pierce Bureau, R.F.D. 1, Box 194, Ft. Pierce, Florida 33450

ABSTRACT: *Captured, aquarium held, sea urchins of a presumably normally herbivorous species were observed on several occasions to catch and eat live fish. Perhaps food deprivation stimulated the predative behavior.*

LYTECHINUS VARIEGATUS (Lamarck) is a common littoral and sublittoral sea urchin found from Bermuda and North Carolina throughout the West Indies to Brazil (Clark, 1902). In south Florida it is commonly collected in beds of Turtle Grass (*Thalassia testudinum* König) which reportedly comprises a major part of its diet (Moore and McPherson, 1965). *Lytechinus variegatus* is usually thought of as a sedentary or slow-moving herbivore incapable of feeding on other than benthic flora and fauna. Thus, it was surprising to observe one of these urchins capture, kill and ingest a free-swimming juvenile mullet *Mugil curema* (Cuvier & Valenciennes). In this paper we briefly describe our observations of this behavior and suggest reasons for its occurrence.

[1]Scientific contribution No. 34 from the Harbor Branch Foundation Science Laboratory.

Observations—A 50 gallon glass aquarium filled with non-flowing but filtered and aerated seawater (35‰) had been maintained as a holding tank for animals collected incident to a field survey of the Indian River area. Animals in the tank in early March 1972 consisted of a dorid nudibranch, *Polycera hummi* Abbott, several small oysters, *Crassostrea virginica* (L.), and three species of adult sea urchins. These included one *Tripneustes ventricosus* (Lamarck), one *Echinometra lucunter* (L.) and four *Lytechinus variegatus*. All urchins had been collected in early January 1972; the *Tripneustes* from the grass flats in Biscayne Bay, Florida, the other urchins from water 80 ft deep offshore, Ft. Pierce, Florida.

On March 2, six juvenile mullet about 20 mm total length each, were placed in the tank for purposes of observing growth rates. All specimens appeared healthy and actively swam throughout the water column in the aquarium. Approximately three minutes after the mullet were introduced one of the juveniles swam down into the vicinity of a white *Lytechinus*. As the mullet swam over the dorsal surface of the urchin it appeared to touch either the spines or the extended tube feet. The dorsal spines suddenly folded over the mullet on either side, trapping it securely. Although the fish struggled violently and attempted to escape it was held fast by the spines. The tube feet of the urchin then rapidly extended and attached to the mullet which was manipulated forward and carried downward toward the oral surface of the urchin. The captured mullet was observed for the next 15 min, at the end of which time the fish was held close to the urchin's mouth but was not yet eaten. The mullet remained in sight at all times since the urchin itself was tilted slightly upward against the front glass of the aquarium. At this point observations were unfortunately interrupted and, when resumed approximately one hr later the mullet was eaten.

This behavior seemed so unusual that an attempt was made the next day to re-elicit the response. All other animals were removed from the aquarium except the urchins and the nudibranch. A series of juvenile clupeid fishes from 15 to 20 mm total length were collected by dipnet from a nearby channel and ten of these were introduced into the tank. The process of dip-netting had severely traumatized the clupeids and most appeared to be injured or dying, swimming erratically with little or no control over buoyancy. In spite of this uncontrolled swimming none of the clupeids were trapped, even though they blundered repeatedly into the dorsal and lateral spines of the urchins. One fish, however, while swimming with difficulty along the surface of the sand on the tank bottom, moved under the ventral spines of a *Lytechinus* that was partially raised off the substrate by a small rock. Immediately all the spines in the lower quadrant of the urchin closed around the fish, trapping it in the same manner as observed for the mullet. The fish struggled for about five min but remained trapped both by the urchin spines and the substrate of the tank. Although this fish and urchin were observed for an additional 45 min no further reaction was noted and the fish was not moved by the urchin from its original position of capture.

Several of the dead or dying clupeids were picked up from the tank bottom with long handled forceps and placed directly on the dorsal spines of one of two *Lytechinus* which had crawled to the water surface at the front of the tank. Five attempts were made to force the urchin to accept the fish. In each instance the dorsal spines closed around the clupeid with the same type of previously observed response. However, after a short period of time, generally about 30 sec, the spines opened up and the fish was cast off by the extended tube feet of the urchin.

A clupeid was offered to the second urchin with the same closing response of the spines occurring. In this instance the urchin did not reject the fish but moved it rapidly down its test and directly to the mouth. Since the urchin was pressed against the glass front of the aquarium both it and the fish were easily observed. The clupeid was inserted tail first into the rapidly opening and closing mouth and feeding, as evidenced by obvious jaw movement, began. After approximately half an hr had elapsed the urchin removed the fish from its mouth by using the adoral tube feet, and re-inserted the clupeid head first back between the jaws. At this time it could easily be seen that the fish was being eaten. Numerous jagged bite-marks were evident over the posterior half of the body. Within an additional 20 min the entire clupeid was eaten.

Throughout this period no other urchin species captured any clupeids, living or dead. When presented with a fish in a manner similar to that used with *Lytechinus*, both *Tripneustes* and *Echinometra* rejected the fish in the same manner as did the first *Lytechinus* tested.

Discussion—All urchins in the tank are species generally considered to be chiefly herbivores or detrital feeders (see, e.g., Moore and McPherson, 1965; McPherson, 1965). *Lytechinus variegatus* is most often characterized as a grazer, subsisting mainly on sea grasses such as *Thalassia* (Moore et al., 1963a, b). However, a related deep-water species, *Lytechinus euerces* Clark, allegedly preys on bottom fauna such as bryozoans, corals, worms and small mollusks, albeit in a seemingly unspecialized or unselective manner (Lewis, 1963).

Although many other species of urchins are carnivorous, they are usually thought of as unselective scavengers or omnivores eating meat on a facultative rather than an obligate basis. Living organisms may, however, be captured if they are sluggish, moribund or dying (Hyman, 1955). Furthermore, predation by urchins on other urchins is not unknown. *Eucidaris tribuloides* (Lamarck) has been observed to attack and feed on *Encope michelini* Agassiz and *Mellita quinquesperforata* (Leske) in the laboratory, while *Lytechinus variegatus* was so aggressive toward *Encope* that they had to be kept in separate tanks (personal communication, Dr. Porter M. Kier). *Diadema antillarum* Philippi will also devour *Clypeaster rosaceus* and *T. ventricosus* when sufficiently starved (Quinn, 1965). Well fed *Diadema*, on the other hand, evinced no interest in other urchins until deprived of algal food for a period of two weeks or more. Interestingly, in the same study (Quinn, 1965) *Diadema* made no attempt to feed on *Lytechinus variegatus* also present, nor did *Lytechinus* feed on any other urchin present, although both species had been similarly starved.

To our knowledge, the only other urchin species which has been observed to actually catch and eat a free-swimming fish is *Arbacia punctulata*. This urchin was seen to trap a "partly spent" *Fundulus heteroclitus* against the glass of an aquarium in a manner similar to that of *Lytechinus* in the present study (Parker, 1932, photograph).

No "sea grasses" of any type were available to our urchins and, except for occasional feedings of brine shrimp nauplii or bits of dead shrimp every third or fourth day, the only other food available appeared to be small patches of red or brown algae growing on the glass of the tank (but see below). It would thus seem that after two months the urchins in this tank were in at least a moderate state of food deprivation.

As noted by Quinn (1965) starvation is sufficient impetus to cause a change in feeding preference in *Diadema* from herbivore to active and predatory carnivore. Such a change might also have been induced in our *Lytechinus* and could possibly explain the capturing behavior we observed.

It is nonetheless difficult to say whether the response we recorded was actual and directed predation or simply a defensive response by the urchin to a fortuitously edible contact stimulus. For, contrary to the behavior shown by *Diadema*, *Lytechinus* did not actively seek out the fish as a food organism, but appeared, rather, to "take advantage" of what could well have been an accidental situation.

Hyman (1955) summarized studies on the spine closure response in urchins. Generally, a stimulus to an area on an urchin will cause adjacent spines to point in the direction of the stimulus. If the stimulus is maintained or repeated intermittently the urchin spines may "freeze" for a period of time in the defensive closed position.

Hyman also provides a good discussion of the various types of pedicellariae which occur in urchins. *Lytechinus variegatus* possesses very prominent globiferous pedicellariae (Moore, 1965) which contain a toxin having similarities to acetylcholine (Mendes et al., 1963; Halstead, 1965).

With the foregoing aspects in mind it is easily seen how a fish such as the juvenile mullet could be captured. The swimming fish might have come in contact with the spines which responded in the defense reaction, folding over and effectively trapping the fish. Continued struggling by the mullet could then conceivably cause the spines to freeze in the defensive position until the pedicellariae were able to subdue the fish. In this respect, Parker (1932) noted that *Fundulus* when caught by *Arbacia* " . . . soon succumbs . . . as though it had been poisoned . . .". In each case the fish may then be carried to the mouth for feeding.

None of the foregoing discussion, of course, takes into consideration what effects, if any, prolonged food deprivation may have had on a possible lowering of the threshold which elicited the spine closure behavior. It would be interesting to determine if, in fact, starvation causes an increase in sensitivity in the defense reaction of *Lytechinus*.

Prior to making the observations herein reported we had noted with passing interest that other very small fish (e.g., juvenile pipefish) which were placed in the large aquarium often disappeared overnight. Until we saw the actual capture of the juvenile mullet by *Lytechinus* we did not consider "predation" by the urchins as a possible cause of the fishes' disappearance. Heretofore, we had assumed that the fish had died due to some trauma induced during collection, and that they were subsequently scavenged by the echinoids.

If the behavior exhibited by the echinoids can occur in the laboratory under conditions of food deprivation, it may also take place in nature during times of food scarcity; for example, in areas where grass beds have been destroyed or severely damaged by causes such as pollution, dredge and fill operations, or by storms and associated tidal currents.

We have never observed "predation" of the type just described in the natural habitat, and as far as we are aware there is no report of such natural "predation" in the literature. Further observations on naturally occurring populations of echinoids such as *Lytechinus* may show that such behavior is more common than would be suspected.

ACKNOWLEDGEMENTS—We extend our thanks and appreciation to Dr. Porter M. Kier, Division of Echinoderms, National Museum of Natural History (NMNH) for information on *Lytechinus* and for critical review of the manuscript. Dr. Kier and Mr. Thomas Phelan (NMNH) collected the echinoids reported herein.

NOTE ADDED IN PROOF: On May 20, 1974 the following observation was recorded for a specimen of the echinoid *Echinometra lucunter* which was being held in a holding aquarium 24″ L × 12″ W × 18″ H (seawater S‰ 34‰; Temp. 22°C). Approximately 20 mosquitofish (*Gambusia* sp.) were introduced as food for a single Golden Tail Moray Eel, *Muraena miliaris,* at 1300 hrs. Immediately after being placed in the water a small, apparently uninjured, female *Gambusia,* blundered into the echinoid's spines. The echinoid, which was at the surface of the water, immediately pinned the fish against the glass of the aquarium in a manner similar to that described above for *Lytechinus*, i.e. by preventing movement of the head and tail. Tube feet from the urchin began immediately to attach to the fish and the still struggling fish was rapidly carried toward the echinoid's mouth. Upon contact with the mouth parts the prey was pulled to the center of the ventral surface and the echinoid began feeding. By 1600 hrs over 50% of the fish had been consumed, including most of the head and the entire ventral surfaces. This now brings to three the number of echinoid species known to capture and ingest small fish in this manner. We thank Mr. Hank Adolfi for providing these observations.

LITERATURE CITED

CLARK, H. L. 1902. The littoral echinoderms of Porto Rico. Fishery Bull. U. S. Fish Comm. 20 (for 1900): 231-263.

HALSTEAD, B. W. 1965. Poisonous and Venomous Marine Animals of the World. Vol. 1. Invertebrates. U. S. Gov't. Printing Office. Washington, D. C.

HYMAN, L. H. 1955. The Invertebrates: Echinodermata. McGraw-Hill. New York.

LEWIS, J. B. 1963. The food of some deep water echinoids from Barbados. Bull. Mar. Sci. Gulf & Carib. 13: 360-363.

MCPHERSON, B. F. 1965. Contributions to the biology of the sea urchin *Tripneustes ventricosus.* Bull. Mar. Sci. 15: 228-244.

MENDES, E. G., L. ABBUD AND S. UMIJI. 1963. Cholinergic action of homogenates of sea urchin pedicellariae. Science 139: 408-409.

MOORE, H. B. 1965. The correlation of symmetry, color and spination in an urchin. Bull. Mar. Sci. 15: 245-254.

———— AND B. F. MCPHERSON. 1965. A contribution to the study of the productivity of the urchins *Tripneustes esculentus* and *Lytechinus variegatus.* Bull. Mar. Sci. 15: 855-871.

————, T. JUTARE, J. C. BAUER AND J. A. JONES. 1963a. The biology of *Lytechinus variegatus.* Bull. Mar. Sci. Gulf & Carib. 13: 23-53.

————, ————, J. A. JONES, B. F. MCPHERSON, AND C. F. E. ROPER. 1963b. A contribution to the biology of *Tripneustes esculentus.* Bull. Mar. Sci. Gulf & Carib. 13: 267-281.

PARKER, G. H. 1932. On certain feeding habits of the sea urchin *Arbacia.* Amer. Natural. 66: 95-96.

QUINN, B. G. 1965. Predation in sea urchins. Bull. Mar. Sci. 15: 259-264.

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GROWTH AND REPRODUCTION OF *ECHINASTER ECHINOPHORUS*

John C. Ferguson

Dept. of Biology, Eckerd College, Box 12560, St. Petersburg, Florida 33733

Abstract: *A two-year study reveals* Echinaster *has a more pronounced annual cycle of organ index change than reported previously for other starfishes. It is greatest in males and appears to be related to a major fall accumulation of nutritional reserves anticipating spawning the following May.*

Starfish, like many other organisms, should not be considered immutable entities whose physiological properties may be once measured, reported, and compared with accounts in the literature of those of other organisms. Rather, in many cases these animals undergo profound physiological and biochemical changes throughout the year, correlated with regular cycles of growth and reproduction. Thus, in respect to many of their biological characteristics, specimens collected at any one time may be very different from those collected at another. These facts are apparent from a number of published reports on several species (Farmanfarmaian et al., 1958; Greenfield et al., 1958; Pearse, 1965 and 1968; Mauzey, 1966; and Rao, 1966). It is also evident from these reports that there are great differences between various species in the nature of their annual cycles, and that it is most inappropriate to infer the conditions existing in one species from published reports on another.

In the Tampa Bay area, *Echinaster echinophorus* is a hardy, small, red starfish (order Spinulosa) found relatively abundantly on tidal grass flats. Since it is being used extensively for various basic physiological, biochemical, and behavioral investigations by workers at several institutions, knowledge of its specific annual cycle of growth and reproduction has special significance. A very brief preliminary description of its cycle was presented previously (Ferguson, 1969), but the following account represents a detailed description of the basic changes in this species as measured over an extended period.

Materials and Methods—At approximately monthly intervals, during low spring tides, collections were made from a population of *Echinaster echinophorus* located in lower Tampa Bay, at which time the water temperature was also recorded. After the specimens were returned to the laboratory, 20 individuals of moderate size (usually 7-14 g) were weighed. They were then dissected and sexed by the appearance of their gonads. Testes are light in coloration and milky in texture; ovaries are more orange and granular. Their gonads and digestive glands were removed and weighed. The wet weight of these organs was computed as a percent of the total wet body weight and referred to as "gonad index" and "digestive gland index".

RESULTS—Generally, males were about as prevalent in the population as females. They often tended to be slightly smaller than females, especially during the summer months. Size and external appearance, however, did not prove to be reliable criteria for determining sex.

The data obtained over a two-year period of study are presented in Fig. 1, which shows the variations in organ indices for both males and females, the statistical limits (standard deviation and standard error), and the recorded water temperature at each collection.

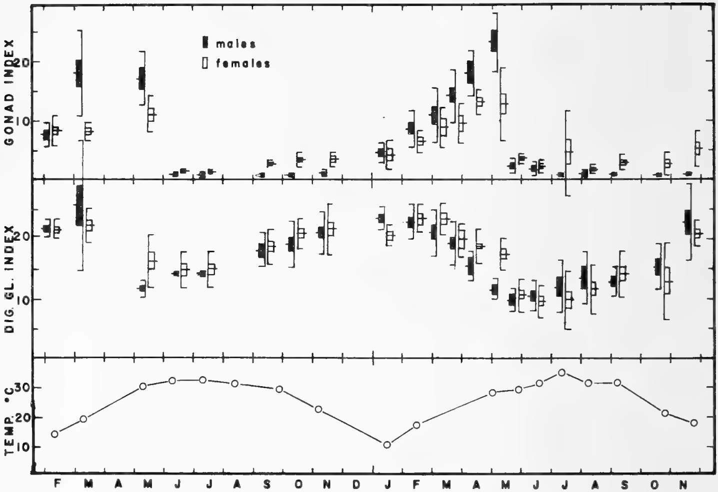

Fig. 1. *Echinaster* gonad index and digestive gland index, and environmental temperature over a two-year period. Shows mean, standard error, and standard deviation for approximately 10 males (dark) and 10 females (light) at each sampling.

A considerable systematic variation in both the size of the gonads and the size of the digestive glands throughout a twelve month cycle was noted. The variations seen in *Echinaster* are more dramatic than those of most other species thus far reported in the literature. This result is not too unexpected, as the seasonal range of water temperature experienced in St. Petersburg is greater than that of the higher and lower latitude stations examined by other investigators.

In both years spawning occurred only during a very brief period in mid May, and was simultaneous for males and females. In the early summer, following the spawning period, the gonads are very small—less than a tenth of their pre-spawning size in the case of the males. The change for the females is less pronounced. During this early summer period, the digestive glands are also at their smallest, about half maximum size.

Throughout the summer and early fall, while the water temperature is very warm, there is an increase in the mass of the digestive glands of both sexes, probably representing the accumulation of nutritive reserves in these organs. By the late summer the ovaries have also gained slightly in mass, but the testes are little changed. In specimens with larger ovaries, the digestive gland index tends to be lower.

At about the end of the year there begins a dramatic growth of both the ovaries and the testes. This growth period begins a month or two before the lowest winter water temperatures are reached. The growth of the male gonads is more rapid than the female, and by February the mean gonad index of the males has surpassed that of the females.

It is also in February, after about four to six weeks of active gonadal growth, that the growth of the digestive glands, which has been continuing since early summer, ceases, and they gradually begin to diminish in size.

The period of February to May is characterized by continued gonadal growth at the expense of digestive gland mass in both sexes. Correlated closely with the greater growth rate that occurs in the testes is a more pronounced diminution of the digestive glands of the males. There appears to be a late decrease in the digestive gland index of the females right at the time of spawning, bringing it into approximate equality with the males.

Discussion—It is evident from this study that preparation for reproduction in *Echinaster* involves profound changes in the body that extend throughout a considerable period of time. Indeed, at any given period of the year the animals are either recovering from their single annual spawning or are preparing for it. The major adjustment appears to be a transfer of nutrient reserves from storage depots in the digestive glands to sustain a massive enlargement of the gonads in late spring. By this means, the energy cost of reproduction is spread more uniformly throughout the year. In terms of their nutritional requirements, the starfish population would not need to excessively exploit (and possibly degrade) their environment in the period immediately preceding reproduction.

Doubtless, the extensive preparation for reproduction in this species must involve significant cyclical changes in its physiology and biochemistry. These changes do not appear to correlate directly with any obvious alteration of temperature or other environmental conditions, yet they occur consistently from year to year. Certainly, the elucidation of the mechanisms involved in this cycle, and the factors which control it, remains as one of the major problems in echinoderm biology.

Summary—The gonad index and digestive gland index of a population of *Echinaster echinophorus* in lower Tampa Bay was measured over a two-year period. Spawning was observed to occur in mid May, resulting in a reduction of the gonads to as little as one-tenth their former size. In early summer the digestive glands are also diminished. They gradually accumulate nutritive reserves until February, at which time they are about twice as big as they are in early summer. They then apparently lose nutritive stores to the developing gonads. The female gonad index begins to increase in late summer. A more dramatic increase in the rate of growth of both testes and ovaries begins in January, while the water temperature is still decreasing. The rate of growth of the testes is greater than that

of the ovaries, which correlates with a more rapid diminution of the digestive glands in the males than in the females.

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LITERATURE CITED

FARMANFARMAIAN, A., A. C. GIESE, R. A. BOOLOOTIAN, AND J. BENNETT. 1958. Annual reproductive cycles in four species of west coast starfish. J. Exptl, Zool. 138: 355-367.

FERGUSON, J. C. 1969. Amino acids in the annual cycle of the starfish, *Echinaster echinophorus*: preliminary observations. Amer. Zool. 9: 1116.

GREENFIELD, L., A. C. GIESE, A. FARMANFARMAIAN, AND R. A. BOOLOOTIAN. 1958. Cyclic biochemical changes in several echinoderms. J. Exptl. Zool. 139: 507-524.

MAUZEY, K. P. 1966. Feeding behavior and reproductive cycles in *Pisaster ochraceus*. Biol. Bull. 131: 127-144.

PEARSE, J. S. 1965. Reproductive periodicities in several contrasting populations of *Odontaster validus* Koehler, a common Antartic asteroid. Biology of the Antartic Seas II, Antartic Res. Ser. 5: 39-85.

_________. 1968. Patterns of reproductive periodicities in four species of Indo-Pacific echinoderms. Proc. Indian Acad. Sci. 67: 247-279.

RAO, K. S. 1966. Reproductive and nutritional cycles of *Oreaster hedemanni* Lutken. J. Mar. Biol. Assoc. India 8: 254-272.

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Biological Sciences

AQUATIC VASCULAR PLANTS OF LAKE APOPKA, FLORIDA

T. LLOYD CHESNUT AND E. H. BARMAN, JR.

Institute of Natural Resources, Georgia College, Milledgeville, Georgia 31061
(Formerly Florida Technological University, Orlando)

ABSTRACT: *Advanced eutrophication of the lake has resulted in massive algal blooms which have shaded out bottom dwelling plants so effectively that some can be found there no longer.*

LAKE APOPKA, Florida forms the headwaters of the Oklawaha River Drainage Basin. Until 25 years ago, it was considered one of the best bass fishing lakes in the country. This was due in part to profuse growths of aquatic plants that provided suitable habitats for large populations of game fish and associated invertebrate fish food organisms. Prior to 1946, the lake was described as being extremely clean with luxuriant growths of eelgrass, *Vallisneria americana*, and pondweed, *Potamogeton illinoensis* (Dequine, 1950).

A 8,000 ha marsh associated with the lake and consisting primarily of rooted emergent plants was drained and converted into muck farms in the early 1940's. A hurricane uprooted large quantities of the remaining plants in 1947. As a result, the lake lost one of its primary sources of nutrient assimilation. Cultural eutrophication was also enhanced by large quantities of nutrients entering from three main sources: (1) the surrounding muck farms which pumped excess water from their fertilized fields into the lake; (2) untreated citrus processing wastes; and (3) sewage effluents. In addition, a herbicide spray program for the control of water hyacinth (*Eichhornia crassipes*) was conducted on the lake until 1968. Boyd (1969) has shown that these plants absorb large amounts of nutrients. Thus, additional nutrients were released inadvertently to an already overloaded system through the control program.

As a consequence of cultural eutrophication, the lake has become a large energy pool supporting almost continual heavy algal blooms. This overabundance of algae prevents the penetration of sunlight into the lower reaches of water causing death of huge amounts of lower lying algae (Henley and Chesnut, 1971). Dead algal cells along with decaying hyacinths and other plants and the suspension of the existing peat bottom has resulted in a bottom characterized by loose, unconsolidated sediments or silt (Schneider and Little, 1969).

Clugston (1963) reported the common aquatic and marsh plants observed growing in Lake Apopka during a survey conducted in 1959. His discussion of plant distribution and abundance serves as the comparative basis for this paper. The current survey was conducted during the summer of 1971 and the spring of 1972.

Results and Discussion—Fourteen species of aquatic plants were recorded in Lake Apopka during this study (Table 1). Several changes that have occurred since Clugston's (1963) survey were observed. Perhaps the most significant changes are the dramatic increase in water hyacinth and the absence of submerged plants.

Table 1. Aquatic vascular plants of Lake Apopka.

Eichhornia crassipes (Mart.) Solms	*Panicum paludivagum* Hitchc. & Chase
Alternanthera philoxeroides (Mart.) Griseb	*Panicum hemitomon* Schult.
Lemna sp.	*Scirpus validus* Vahl
Nuphar advena (Ait.) Ait. f.	*Typha domingensis* Pers.
Pontederia lanceolata Nutt.	*Cladium jamaicensis* Crantz
Sagittaria lancifolia L.	*Hydrocotyle umbellata* L.
Sagittaria latifolia Willd.	*Jussiaea michauxiana* Fern.

Dequine (1950) reported *Potamogeton illinoensis* in quantity. A few small patches of eelgrass (*Vallisneria americana*) and southern naiad (*Najas guadalupensis*) were recorded during the 1959 survey. However, no submerged plants were found during this survey in spite of the fact that extra effort was taken to find plants previously recorded. In fact, the senior author has worked on the lake since 1968 and has sighted no submerged macrophytes. The absence of submerged species may be due to shading resulting from heavy algal blooms

(Henley and Chesnut, 1971) and large mats of water hyacinth. Because these plants require a reasonably firm substrate for root anchorage, the loose, unconsolidated silt that characterizes the bottom of most of the lake may also be a contributing factor.

The most common plant found on Lake Apopka is the water hyacinth. This floating hydrophyte covers almost the entire perimeter of the lake in a band that ranges from 10 to 30 m wide. In some areas, these dense aggregations may be invaded by emergent hydrophytes to form sudd communities (Schulthorpe, 1967). The 1959 survey reported the water hyacinth to be restricted to inaccessible coves in the Gourd's Neck and in canals of the lake's north shore. This paucity was probably due to an effective hyacinth control program which was initiated in the late 1940's. Since this program was terminated in 1968, hyacinth has reproduced at a rapid rate, drawing on the vast amount of available nutrients in the lake.

The large amount of hyacinth has been responsible for some of the recent changes in the vegetative characteristics of the lake. Wind blown mats of several hundred ha tend to accumulate in coves and around points of land. Occasionally, hyacinths will build against a windward shore in mats estimated to be several thousand ha when prevailing winds occur for extended periods of time. As these mats pile up against the shore, emergent species are broken and uprooted. The few remaining patches of panic grass and maiden cane are subjected to this type of stress. Peripheral plants of stands of *Typha* are sometimes flattened by these mats.

Floating islands of hyacinth supporting *Typha, Pontederia,* and *Sagittaria* are common. Some of these mats result from the breakup of sudd communities although a second mechanism may be responsible. Small isolated patches of emergent vegetation are sometimes surrounded by hyacinths. Wave action on the accumulations of hyacinths results in the uprooting of the emergent plants. These are then supported and carried along by the dense mats of water hyacinth.

Floating fern, *Salvinia rotundifolia,* and giant duckweed, *Spirodela* sp. were common in coves prior to 1959. Neither species was recorded during the current survey. Duckweed, *Lemna* sp., has not been previously recorded for Lake Apopka, but it was found in quiet coves and backwater areas where there were few hyacinths.

Alligatorweed, *Alternanthera philoxeroides,* was observed growing in shallow water on the north shore of Pine Island. This is apparently the first record of this introduced plant in Lake Apopka. The leaf beetle, *Agasicles* sp., which has been introduced to control this weed, was seen to be feeding heavily on the weed and in fact may be effecting some control. Its limited abundance may also be due to the inability of alligatorweed to invade and effectively compete with water hyacinth (Schulthorpe, 1967). Although alligatorweed was not recorded in other areas of the lake, it could be present in some of the less accessible backwater areas.

Only one floating-leaved hydrophyte occurs on the lake. Spatterdock, *Nuphar advena,* is found in small patches near Gator Island at Winter Garden and Hog Island on the north shore. The few remaining plants appear to be on the decline. This may be due to the development of an unsuitable substrate for root anchorage because of muck accumulation. These plants are also heavily damaged by phytophagous insects (primarily *Arzama* and *Belura* sp.). Sheffield and Kaleel (1970) reported that water lily (*Nymphaea* sp.) grew from exposed sediments taken from Lake Apopka. Water lily was not recorded by Clugston, and it was not seen during our survey.

Emergent plants are abundant around most of the lake's perimeter, although spike rush (*Eleocharis* sp.), recorded by Clugston, was not observed during this study. The most abundant was pickerelweed, *Pontederia lanceolata.* The largest stand of this plant was found on the western shore between Smith's Island and the Beauclair Canal as was reported from the earlier survey. However, in contrast to the 1959 survey when the pickerelweed occurred unmixed, a large amount of cattail, *Typha domingensis* is now interspersed among the stand. This is indicative of natural succession occurring in this area of very shallow water. Cattails are scattered in small patches in other protected areas of the lake such as coves and land projections. As mentioned previously, those in more exposed areas are stressed physically by the large floating masses of water hyacinths thus limiting their distribution.

Two important emergent aquatic plants growing in Lake Apopka are panic grass, *Panicum paludivagum,* and maiden cane, *Panicum hemitomon.* Panic grass is far more abundant than maiden cane. The usual distribution is in small patches 10 to 20 m from shore in those areas where a sand bottom still persists. These are found primarily in the area of Crown Point, the east shore fish camps, and Smith and Pine Islands. It is found in lesser abundance along the south shore. Neither species was recorded along the north shore which has a muck bottom.

Hog Island remains as one of the land marks of Lake Apopka. There is no land area associated with the "island." It consists of a shallow portion of the lake that is covered with softstem bulrush, *Scirpus validus.* The size of this stand averages 25 to 30 m wide in a band ca. 1 km long. Small areas of softstem bulrush were also noted along the northeastern shore, the western shore and near Crown Point.

Small stands of arrowhead, *Sagittaria lancifolia,* are present around most of the lake's edge. Occasionally, duck potato, *Sagittaria latifolia,* was recorded in association with arrowhead. Neither plant was found growing in open water. The usual habitat was the marsh areas between open water and the land.

Sawgrass, *Cladium jamaicensis,* is found only in small clumps on the eastern and western shores. Water pennywort, *Hydrocotyle umbellata,* and water willow, *Jussiaea michauxiana,* are found as both emergent species in shallow waters and as floating hydrophytes on masses of floating organic matter.

Those plants that normally inhabit the moist shore areas immediately adjacent to the lake's edge were recorded only in a passive manner. The cultivated escape elephant-ear (*Colocasia esculenta*) is reported here because of its abundance. Sightings of these plants were made in nearly all areas of the lake. The southern bayberry (*Myrica coriten*), the red maple (*Acer rubrum*), the Florida elm (*Ulmus americana floridana*) and buttonbush (*Cephalanthus occidentalis*) were other prominent shore species. One species of marsh plant, the swamp lily (*Crinum americanum*), recorded by Clugston was not observed during this study.

Several changes have occurred in the aquatic macrophytes of Lake Apopka. Species previously recorded for the lake but not observed in this study are: *Potamogeton illinoensis* (Dequine, 1950), *Vallisneria americana, Najas guadalupensis, Salvinia rotundifolia, Spirodela* sp., *Eleocharis* sp., and *Crinum americanum* (Clugston, 1963). Two species, *Lemna* sp. and *Alternanthera philoxeroides* not reported previously were collected during this study. The disappearance of submerged attached hydrophytes is perhaps the most significant change. Water hyacinth is also much more abundant than indicated in previous studies.

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LITERATURE CITED

BOYD, C. E. 1969. The nutritive value of three species of water weeds. Econ. Bot. 23: 123-127.

CLUGSTON, J. P. 1963. Lake Apopka, Florida, a changing lake and its vegetation. Quart. J. Fla. Acad. Sci. 26: 168-174.

DEQUINE, J. F. 1950. Results of roughfish control operations in Lake Apopka during December 1949 and January 1950. Mimeographed report, Florida Game and Fresh Water Fish Comm. 7 pp.

HENLEY, D. E. AND T. L. CHESNUT. 1971. Biological documentation; Oklawaha Basin restoration project. Florida Dept. Pollution Contr. Tech. Rpt. 35 pp.

SCHNEIDER, R. F. AND J. A. LITTLE. 1969. Characterization of bottom sediments and selected nitrogens and phosphorus sources in Lake Apopka, Florida. Federal Water Pollution Contr. Admin. Tech. Rpt. 35 pp.

SCHULTHROPE, C. D. 1967. The Biology of Aquatic Vascular Plants. Edward Arnold, Ltd. London.

SHEFFIELD, C. W. AND R. T. KALEEL. 1970. Lake Apopka and aquatic weeds. Hyacinth Contr. J. 8: 45-47.

Florida Sci. 37(1):60-64. 1974.

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FLORIDA SCIENTIST

QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

Editor: Harvey A. Miller
Department of Biological Sciences
Florida Technological University
Orlando, Florida 32816

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Biological Sciences

SEASONALITY OF FISHES IN A SOUTH FLORIDA BRACKISH CANAL

Fredrick W. Brockmann

Deltona Corporation, 3250 S. W. 3rd Ave., Miami, Florida 33129

Abstract: *The ichthyofauna in this Collier County estuary varied seasonally as salinity changed. Apparent salinity tolerances are noted for 31 species.*

This paper is the first in a series dealing with a survey of the fish species in the Marco Island area, Collier County, southwest Florida.

Part of a study of the ichthyofauna of an area consists of observations on variations in seasonal occurrence of the fishes. Widest variations in occurrence could be expected in the estuarine areas of south Florida where wet and dry seasons alternate with corresponding great fluctuations in salinity. Station 9 was selected for this report on that basis. It is a roadside canal receiving rainfall runoff from surrounding marshes and higher ground in the summer followed by saltwater intrusion from downstream tidal waters in the dry winter season.

Numerous authors have studied seasonality and distribution of estuarine fishes in and around the Gulf of Mexico. Reid (1954) extensively studied the marine fishes of Cedar Key, Florida, as did Wang and Raney (1971) for the Charlotte Harbor estuary, Lee County, Florida, and Springer and Woodburn (1960) for Tampa Bay. Other studies of note in Florida are Gunter and Hall (1965) of the Caloosahatchee estuary, Moe (1972) and Springer and McErlean (1962). The distribution of fishes in relation to salinity and invasion into fresh water has been discussed by Gunter (1945, 1956, 1957, 1961), Odum (1953) and Hulet, et al. (1967).

My study was made at the Marco Applied Marine Ecology Station of the Deltona Corporation.

Material and Methods—Material for the present study was collected at three month intervals beginning November, 1971, and ending November, 1972.

The station was initially fished in October, 1971, with a 25′ × 4′ × ¼″ Common Sense Minnow Seine, but due to the desire for a complete census of fish present and the presence of underwater obstructions, subsequent sampling was with a 5% emulsified solution of Noxfish applied at approximately 1 ppm. To prevent escape of fish, on sampling days a net was put across the canal about 50 ft below the culvert under the road to a trailer park and another at the mouth of the culvert. The Noxfish was mixed in buckets and distributed by hand in early samples; later, a Hudson 6215 sprayer was employed. After identification and measurements, most fish were discarded. Only a few specimens of each species were kept for the laboratory's reference collection. Salinities were determined with an optical refractometer.

Station Description—Station 9 is located in the roadside canal along the east side of State Road 951 between U. S. 41 and Marco Island, 3.9 miles north of the Marco toll bridge, at the intersection of SR 951 and the Port-au-Prince Trailer Park road. The sample area is an L-shaped pool approximately 75 × 50 ft. The larger pool arm is 15 ft, and the smaller is 10 ft wide. Depth varies from one to five ft. The bottom of the larger arm of the pool is hard sand overlain by a layer of detritus; in the smaller, downstream section, the bottom is a deep, sticky mud. Much of the margin of the area is grass and sedges, with a portion bordered by white mangroves, *Laguncularia racemosa.* At the apex of the L is a shallow area which supports a bed of widgeon grass, *Ruppia maritima.*

Results and Discussion—The salinity at station 9 was found to vary greatly, and was dependent upon the seasonal rainfall pattern. The following salinities and temperatures were observed:

6 October 1971	3.3 ppt	28.3°C
8 November 1971	1.7 ppt	20.9°C
24 November 1971	4.9 ppt	24.4°C
7 February 1972	12.8 ppt	23.9°C
11 May 1972	39.3 ppt	31.8°C
25 August 1972	0 ppt	27.2°C
2 November 1972	8.9 ppt	26.8°C

Freshwater conditions were found in August during the rainy season, whereas the water was hypersaline in May, at the end of the dry season. Varying degrees of brackishness were observed at other times.

I have concluded that the wide variations in fish species present were related more to these salinity variations than to seasonal temperatures, which ranged from 23.9° C to 31.8° C on sampling days. Table 1 clearly shows that there is a direct relationship between higher salinities and fewer species. Non salinity-related fish movements are exemplified by juvenile snook, tarpon and ladyfish which entered the area as seasonal immigrants. The seasonal occurrence in inland waters of juvenile snook and tarpon is well documented (Wade, 1969; Dahlberg, 1972; Marshall, 1958), and seems to be a requirement in their early life history.

Table 1 lists the fish species taken in this project grouped by the salinities at which they occurred. The data show several principal types of fish involved (Table 2, after Darnell, 1962).

TABLE 1. Occurrence of Fish by Salinities at Station 9.

	0-4.9 ppt.	8.9 ppt	12.8 ppt	39.3 ppt
Mugil cephalus—striped mullet	x		x	x
Lepisosteus platyrhincus—Florida spotted gar	x	x	x	x
Elops saurus—ladyfish	x			x
Trinectes maculatus—hog choker	x	x	x	x
Lophogobius cyprinoides—crested goby	x	x	x	x
Microgobius gulosus—clown goby	x	x	x	x
Jordanella floridae—flagfish	x	x	x	x
Cyprinodon variegatus—sheepshead minnow	x	x	x	x
Gambusia affinis—mosquitofish	x	x	x	x
Poecilia latipinna—sailfin molly	x	x	x	x
Lucania parva—rainwater killifish	x	x	x	x
Fundulus confluentus—marsh killifish	x	x	x	x
Menidia beryllina—tidewater silversides	x	x	x	x
Lepomis macrochirus—bluegill	x		x	
Heterandria formosa—least killifish	x	x	x	
Fundulus seminolis—Seminole killifish	x	x	x	
F. similis—longnose killifish			x	
Centropomus undecimalis—snook	x	x		
Dormitator maculatus—fat sleeper	x	x		
Lucania goodei—bluefin killifish	x	x		
Fundulus grandis—Gulf killifish	x	x		
F. chrysotus—golden topminnow	x	x		
Diapterus olisthostomus—Irish pompano		x		
Lepomis gulosus—warmouth	x	x		
L. marginatus—dollar sunfish		x		
L. microlophus—redear sunfish		x		
Megalops atlantica—tarpon	x			
Diapterus plumieri—striped mojarra	x			
Micropterus salmoides—largemouth bass	x			
Ictalurus natalis—yellow bullhead	x			
Adinia xenica—diamond killifish	x			
Gobiosoma bosci—naked goby	x			
Lepomis punctatus—spotted sunfish	x			
Notropis emiliae—pugnose minnow	x			
Eucinostomus argenteus—spotfin mojarra	x			
Totals	31	22	16	13

The area surrounding the station to the south and east is low-lying, much of it a permanent or semipermanent swamp prior to the digging of canals for fill and drainage. It is from these swampy areas, no doubt, from which the freshwater species entered the canal, and which probably still serve as a reservoir and refuge during the dry season when salinities are high.

There were four species of primary freshwater fish which were found here only at salinities less than 4.9 ppt, *Micropterus salmoides, Lepomis punctatus, Ictalurus natalis,* and *Notropis emiliae. I. natalis* and *N. emiliae* were found on two occasions, November, 1971, and August, 1972, when the salinities were 0.0 and 4.9 ppt, respectively. *Micropterus salmoides* and *L. punctatus* were taken once each. *Lepomis punctatus* in November, 1971, and *M. salmoides* in August 1972.

Three additional species of primary freshwater fish were taken at a slightly higher salinity, 8.9 ppt—*Lepomis gulosus, L. marginatus,* and *L. microlophus.* This indicates a higher salinity tolerance than has previously been recognized for these species. Other principally freshwater species taken at this salinity were *Gambusia affinis, Heterandria formosa, Fundulus chrysotus, F. seminolis* and *Lucania goodei.* On several occasions speckled melanistic male *Gambusia affinis* were taken, also one completely black male *Poecilia latipinna.* These may have been discarded aquarium fish from the upstream trailer park.

Lepomis macrochirus, Heterandria formosa and *Fundulus seminolis* were also taken at a salinity of 12.8 ppt. Springer and Woodburn (1960) found *L. macrochirus* at a salinity of 18.2 ppt, and Gunter and Hall (1965) stated that the highest salinity at which *F. seminolis* is known is 13.5 ppt. They also recorded two specimens of *H. formosa* from a salinity of 30.2 ppt, but stated that all others of this species were taken at a salinity range of 0.12-0.65 ppt. Dahlberg (1972) did not find *H. formosa* at a salinity above 4.0 ppt.

A group of brackish-tolerating or -preferring marine fish were taken at station 9 at salinities at or below 8.9 ppt. The fat sleeper, *Dormitator maculatus,* is known

TABLE 2. Classification of the fishes at Station 9 based on zoogeographic classification and occurrence by salinities.

I. Freshwater species	
A. Strictly freshwater	
Ictalurus natalis	*Lepomis punctatus*
Notropis emiliae	*Micropterus salmoides*
B. Facultative invaders of brackish water	
Lepisosteus platyrhinchus	*Lucania goodei*
Gambusia affinis	*Heterandria formosa*
Lepomis gulosus	*Fundulus seminolis*
L. macrochirus	*F. chrysotus*
L. marginatus	*Jordanella floridae*
L. microlophus	
II. Euryhaline species. Fishes tolerating a wide salinity range.	
A. Anadromous fishes. Entering freshwater to breed; may reside in freshwater.	
Dormitator maculatus	
B. Catadromous fishes. Entering the sea to breed.	
None encountered in this study.	
C. Marine or brackish-water fishes that invade fresh water.	
1. Frequent invasion, often for a considerable time and distance.	
Poecilia latipinna	*Microgobius gulosus*
Megalops atlantica	*Menidia beryllina*
Mugil cephalus	*Centropomus undecimalis*
Elops saurus	*Diapterus plumieri*
Trinectes maculatus	*Adinia zenica*
Lophogobius cyprinoides	*Eucinostomus argenteus*
Gobiosoma bosci	
2. Sporadic invasion, probably for brief periods.	
Cyprinodon variegatus	*Fundulus similis*
Lucania parva	*F. grandis*
Fundulus confluentus	
D. Marine species. Occasionally entering waters of moderate to low salinity.	
Diapterus olisthostomus	

to live in fresh water, and breed there, according to Darnell (1962). None were collected at intermediate salinities here, but three were taken at 0.0 and 8.9 ppt. Two of these three specimens had gravid ovaries, as, however, did a specimen from the laboratory's seawall, salinity 35.3 ppt. *Gobiosoma bosci, Eucinostomus argenteus, Diapterus olisthostomus, D. plumieri* and *Adinia zenica* are additional marine or brackish species taken only at low salinities at station 9. All are known for their wide salinity tolerances, and their absence here at higher salinities may be only apparent and due to relatively low numbers or a patchy distribution within the canal. Also taken in this study at lower salinities were juvenile snook, *Centropomus undecimalis,* from 30-51 mm, and juvenile tarpon, *Megalops atlantica,* were observed leaping over the barrier net on one occasion.

As a result of the difficulty of recovering all or even most specimens when rotenoning at station 9, only generalizations are possible regarding relative numbers of the species. At all salinities, *Gambusia affinis, Menidia beryllina* and *Poecilia latipinna* were the most abundant species, numbering in the several thousands each. *Fundulus confluentus* was nearly as plentiful at 0.0, 12.8 and 39.3 ppt salinities, but reached its greatest abundance at 8.9 ppt on 2 November 1972. At 4.9 ppt on 24 November 1971, however, only a few were taken. From 0.0 to 12.8 ppt, *Lucania parva* and *Jordanella floridae* were the next most abundant species, generally numbering in the hundreds. Few were present at 39.3 ppt. All other species were present in relatively low numbers, from one or a few to a few score. Of the less common fish, *Microgobius gulosus* and *Lophogobius cyprinoides* were the most numerous at all salinities, and *Cyprinodon variegatus* at intermediate salinities.

In the August 1972 collection, fourteen young adult snook from 225-485 mm were taken. These had probably moved upstream from the mangrove estuary and were using the area as a feeding ground. Most of the stomachs of these fish were empty, as is often the case with snook, but three contained food—one a freshwater crayfish, and two others had ingested small bluegills, mollies, and mosquitofish.

The greatest proportion of the species taken in this study are euryhaline forms that were found over a wide salinity range, 16 species from 0.0 to 12.8 ppt., and 13 of those from 0.0 to 39.3 ppt. Both the ladyfish, *Elops saurus,* and the striped mullet, *Mugil cephalus,* are commonly found as juveniles and adults far inland (Dahlberg, 1972; Springer and Woodburn, 1960) and were observed or taken at station 9 several times. Other euryhaline representatives of marine families occurring here in all collections are *Trinectes maculatus, Lophogobius cyprinoides, Microgobius gulosus, Menidia beryllina.* Florida spotted gar, *Lepisosteus platyrhincus,* were also taken or observed at all salinities.

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LITERATURE CITED

DAHLBERG, M. D. 1972. An ecological study of Georgia coastal fishes. Fish. Bull. US NMFS 70: 323-54.

DARNELL, R. M. 1962. Fishes of the Rio Tamesi and related coastal lagoons in east-central Mexico. Pub. Inst. Mar. Sci. 8:299-365.

GUNTER, G. 1945. Studies on marine fishes of Texas. Pub. Inst. Mar. Sci. 1: 190 pp.
———. 1956. Some relations of faunal distributions to salinity in estuarine waters. Ecology 37: 616-19.
———. 1957. Predominance of the young among marine fishes found in fresh water. Copeia 1957: 13-16.
———. 1961. Some relations of estuarine organisms to salinity. Limnol. Oceanogr. 6: 182-90.
——— AND G. E. HALL. 1965. A biological investigation of the Caloosahatchee estuary of Florida. Gulf. Res. Rpts. 2(1): 72 pp.
HULET, W. H., S. J. MASEL, L. H. JODREY, AND R. G. WEHR. 1967. The role of calcium in the survival of marine teleosts in dilute sea water. Bull. Mar. Sci. 17: 677-88.
MARSHALL, A. R. 1958. A survey of the snook fishery of Florida, with studies of the biology of the principal species, *Centropomus undecimalis* (Bloch). Fla. State Bd. Cons. Tech. Ser. 22: 37 pp.
ME, M. A., JR. 1972. Movement and migration of south Florida fishes. Fla. Dept. Nat. Res. Tech. Ser. 69:25 pp.
ODUM, H. T. 1953. Factors controlling marine invasion into Florida fresh water. Bull. Mar. Sci. 3: 134-56.
REID, G. K., JR. 1954. An ecological study of the Gulf of Mexico fishes, in the vicinity of Cedar Key, Florida. Bull. Mar. Sci. 4:1-94.
SPRINGER, V. G. AND K. D. WOODBURN. 1960. An ecological study of the fishes of the Tampa Bay area. Fla. State Bd. Cons. Prof. Pap. Ser. 1: 104 pp.
——— AND A. J. MCERLEAN. 1962. Seasonality of fishes on a south Florida shore. Bull. Mar. Sci. 12: 40-60.
WADE, R. A. 1969. Ecology of juvenile tarpon and effects of dieldrin on two associated species. Tech. Pap. U. S. Bur. Sport Fish & Wildl. 41: 85 pp.
WANG, J. C. S. AND E. C. RANEY. 1971. Distribution and fluctuations in the fish fauna of the Charlotte Harbor estuary, Florida. Charlotte Harbor Estuarine Stud. Mote Marine Lab. 56 pp. + appendices.

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Biological Sciences

A NEW RECORD OF *PIPISTRELLUS SUBFLAVUS* FROM FLORIDA

JAMES W. HARDIN

Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, Illinois 62901

ON 13 June 1972 Jack Watson, manager of the Key Deer National Wildlife Refuge, was notified of a bat hanging from the ceiling of a carport in a residential area on Sugarloaf Key, Monroe County, Florida. It was identified as *Pipistrellus subflavus.* The animal had dark brown pelage but, unlike the subspecies *P. subflavus floridanus* described by Davis (1959), there was a slight orangish tone to the hair tips. It was hanging in the open about 9 ft above the ground and had reportedly been using this shelter for at least 2 days. The bat, which used the roost for 2 weeks before disappearing, was not disturbed or collected since its occurrence within the National Wildlife Refuge was unusual. It may have moved into the Keys ahead of a strong cold front which passed the area around 26 May 1972. The closest record of *P. subflavus* is from Basinger, Okeechobee County, Florida (Davis, 1959), which is about 200 miles to the north.

With exception of a bat from Key West, identified as *Artibeus perspicillatus* in 1870 (Maynard, 1883; Allen, 1893), there has been no previous record of bats in the Florida Keys. Since they appear to select habitats used on restrictions posed by their metabolic requirements (Twente, 1955), it is suggested that bats may be precluded from the lower Keys due to temperatures too high to allow hibernation and due to seasonal fluctuations in the number of flying insects, which result in insufficient quantities of available food to sustain a Chiropteran population at certain times of the year. This possibility merits investigation.

Appreciation is expressed to Mr. Jack C. Watson for assisting in locating the animal.

LITERATURE CITED

ALLEN, H. 1893. A monograph of the bats of North America. Bull. U. S. Nat. Mus. 43: 1-198.
DAVIS, W. H. 1959. Taxonomy of the eastern Pipistrel. J. Mamm. 40: 521-531.
MAYNARD, C. J. 1883. The mammals of Florida. Quart. J. Boston Zool. Soc. 2: 17-24.
TWENTE, J. W., JR. 1955. Some aspects of habitat selection and other behavior of cavern-dwelling bats. Ecology 36: 706-732.

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Biological Sciences

CLEARING AND STAINING LARVAL FISHES

DAVID MOOK AND J. ROSS WILCOX

The Harbor Branch Foundation Laboratory, R.F.D. 1, Box 196, Fort Pierce, Florida 33450

STANDARD clearing and straining techniques involve direct manipulation of the specimen (Holister 1934; Taylor 1967). These techniques are often unsuitable because larval fishes are fragile and may be damaged by handling. To minimize damage during clearing and staining, the enzyme method of Taylor (1967) was modified by reducing the number of steps and using a syringe to add and remove solutions from the dishes containing the specimens.

The larvae are placed in 60 mm wide and 15 mm high petri dishes, and the specimens are covered with a weak trypsin solution (0.05% trypsin in distilled water). The dishes are covered and left until the vertebral column is discernible in the posterior part of the specimen (1-5 days, depending upon size). The trypsin solution is then removed from the dish with a syringe and an alizarin red dye (1 g dye in 100 ml distilled water) is added to cover the specimen. When the ossified areas have taken up the dye (1-7 days, depending on specimen size), the dye is removed and a 1% KOH solution is added to rinse the specimen. If the flesh has retained some of the dye, the specimen is left in the KOH until clear. The KOH is removed and replaced with 100% glycerol in which the specimen can be stored or observed.

This method is very effective for small specimens (less than 12 mm). Because the volume of the solution in the petri dish is so great in comparison to the volume of the specimens, it is not necessary to rinse the preservative from the larvae before the clearing process. The concentrations of the clearing and staining solutions are not critical, but should be kept at low levels to reduce the possibility of damage to the specimens.

LITERATURE CITED

Hollister, G. 1934. Clearing and dying fish for bone study. Zoologica 12: 89-101.

Taylor, W. 1967. An enzyme method of clearing and staining of small vertebrates. Proc. U. S. Nat. Mus. 122: 1-17.

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Earth and Planetary Sciences

MEASUREMENT OF WIND-DRIVEN CURRENTS IN A LAGOON

W. K. Schneider, P. S. Dubbelday, and T. A. Nevin

Oceanography Department, Florida Institute of Technology, Melbourne, Florida 32901

Knowledge of the circulation processes and patterns of lagoonal waters is of major importance if their overall biological and physical characteristics are to be more completely understood. In addition, such circulation processes and patterns must be considered in the development of pollution controls.

The Indian River actually is a lagoon since it is separated from the ocean by a narrow strip of land; it is moderately saline and has a limited number of inlets. There is visible movement of these waters; however, no evidence of defined circulation processes or patterns has been found reported in the literature.

The Melbourne-Eau Gallie area of the Indian River lagoonal system is reported to be free of tidal influence (Intracoastal Waterway map 845-SC). The large surface area of the lagoon suggests the possibility of a wind driven circulation. If such circulation does occur, definite patterns should result under specific wind conditions.

Experimental Procedure—The area studied was a section of the Indian River lagoon just south of the Melbourne Causeway (Fig. 1; Chart 845-SC; C & G D S). The lagoon averages 8 ft deep in this area. A spoil island is located 500 yd east of Marker 6 and extends 150 to 200 yd in the 155°-335° direction which is parallel to the channel of the Intracoastal Waterway. The lagoon is almost two miles wide in this area and the channel and Marker 6 are about one mile from either shore. The causeway has small relief bridges at both ends and is open for

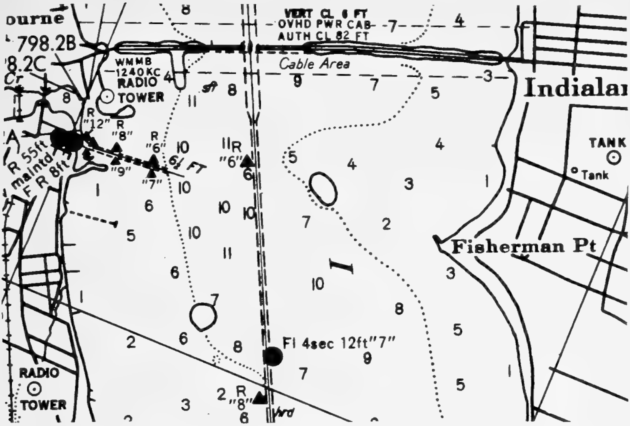


Fig. 1. Area of study, from Intracoastal Waterway Chart 845-SC.

300 yd on either side of the channel. Current crosses were released at Intracoastal Waterway Marker 6 and at the Melbourne Marina sign. The sites are 850 and 1150 yd respectively south of the causeway.

Landmarks and permanent in-water marks used as reference points were the WMMB radio tower, the Melbourne water tank on the east shore, Marker 6, Marker 7, the Melbourne Marina sign, and a radio tower one mile west of Marker 7. Sightings on these points resulted in at least three usable bearings to locate the cross removal points.

Current velocity measurements were made using aluminum crosses. Each of the four wings is 4 in high and 18 in long. They were suspended at selected depths using a measured length of line; a 1-qt plastic bottle half filled with water served as a float.

A boat which was anchored as close to the marker stanchion as possible served as a release platform. The crosses were placed in the water at depths of 0, 2, 4, and 6 ft, and were released approximately 1 min apart to avoid tangling the lines. Care was taken to allow the crosses to settle to the preselected depth before release.

The time was recorded as each float was released. The crosses were allowed to remain in the water as long as the weather and surface conditions permitted but never less than 1 hr. After the crosses had been in the water for a sufficient period, the boat was moved to the new location of the float and anchored. The time was noted, the float and cross were removed from the water, and bearings were taken on preestablished landmarks or in-water marks with a hand bearing compass.

The bearings were plotted on a map of the area to identify the removal point, identified as the point of bearing crossings, or as the center of the triangle formed when the three bearings were plotted. The distance and direction the cross had traveled from the release point to the removal point was then recorded. The speed of the cross was calculated using its travel time from release to pick-up.

Wind data were obtained from the Federal Aviation Agency's Flight Service Station at the Melbourne Municipal Airport, which is approximately three miles from the study area. Data were taken from instruments which recorded wind speed and direction every hour on the hour. The instruments are located on a 20 ft tower. Wind and current directions are both expressed as moving toward a compass heading in order to show their interrelationships more clearly. The readings of wind speed and direction were added vectorially to obtain averages of these quantities for the 24 hr period between current measurements.

Measurements of current speed and direction were conducted on a daily basis from March 22 to April 8 between 8 a.m. and 10 a.m. The wind data recorded with each current profile represent the wind speeds and directions for the 24 hr prior to the current measurement. In order to avoid contributing to the distortion of a shifting wind pattern, consecutive groupings of direction and speed were averaged, permitting an association of directional changes in the prevailing winds during the experimental period with the behavior of the surface water current in the area of study.

The hand bearing compass was graduated in 2° increments. When the water was calm, the instrument could be read accurately to less than $\pm 1°$. However, when the water was choppy the readings were somewhat less accurate. By actual experience, accuracy to within $\pm 2°$ could be obtained routinely even when the water was choppy.

The surface float exerts a drag on the subsurface cross that may produce a slight deviation from the actual value of current speed and direction. However, it is considered small compared to the uncertainty associated with the margin of error in determining the location of release and pick-up points.

Bearings were taken to fix the position of the Melbourne Marina sign since it was not located on the original chart. The sign was located approximately 300 yd south of Marker 6 on a bearing of 165°.

RESULTS—The fig. 2 through 9 show the results in graphic form. The graphs are in parallel projection to show the direction of the current as a function of depth. The wind data depicts the development in time of the wind direction. The wind strength is not shown in these figures.

A. *Surface Currents*: The variation of wind direction and surface current velocity as a function of time for the period of March 27 to March 29 is shown in Fig. 2. During the 48 hr period, the overall surface current change was clockwise from 314° to 355°. The greatest change, from 314° to 347°, occurred in the first 24 hr. The concurrent wind shift was also clockwise from 270° to 100° with an average speed of 6 kn. During the second 24 hr, the surface current shifted from 347° to 355° while the wind swung between 50° and 100° at an average speed of 4.2 kn.

The surface current speed on the 27th, 28th and 29th was 0.24, 0.12 and 0.19 kn. During the 11 hr after the current measurement of the 27th, the average wind direction was 308°. This wind direction tended to maintain the surface current

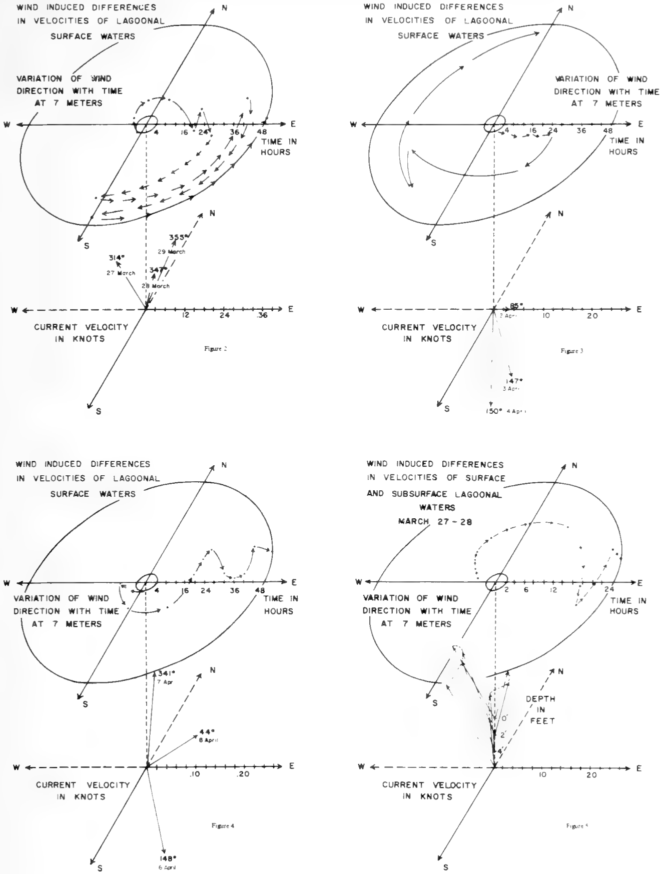


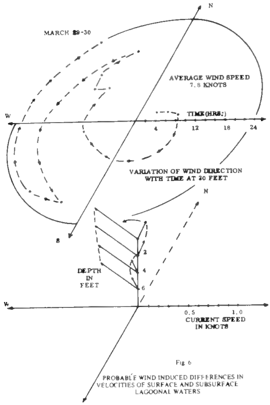
Fig. 2, 3, 4, 5. Wind direction and current velocity data.

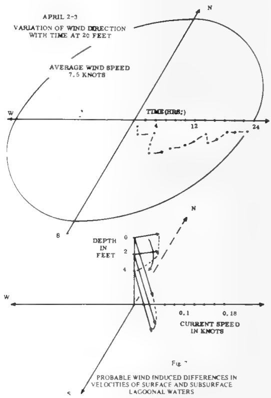
direction and probably contributed to its speed of 0.24 kn. During the next 13 hr of the period, the wind direction shifted to 76°. The current follows this change in direction slightly, and decreases in strength. The wind component probably slowed the surface water current and aids in accounting for the loss of speed noted on the 28th.

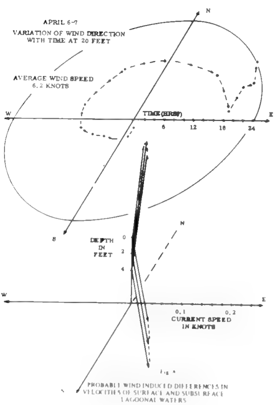
The increase of surface current speed from 0.12 to 0.19 kn, which occurred between the 28th and 29th probably resulted from a small angular difference between the directions of the wind and the surface current for an extended time (60° and 355° respectively). This small angular difference produced a force in the same direction as the current, tending to increase its speed.

The changes of current speed and direction from April 2 to April 4 are shown in Fig. 3. Surface current direction changed from 85° to 159° in a clockwise direction while the speed increased from 0.04 to 0.24 kn during the 48 hr period.

The greatest change in current direction occurred during the first 24 hr of the period. The directional shift (85° to 147°) and the speed increase (0.04 to 0.24 kn)







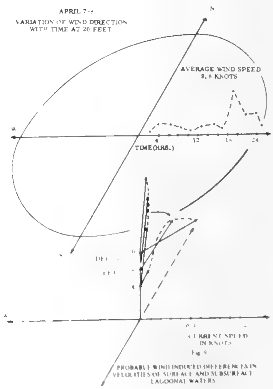


Fig. 6, 7, 8, 9. Wind direction and current velocity data.

of the surface current during these 24 hr correlates well with the predominant wind pattern (130° and 7.5 kn).

The slow shift of the wind pattern from 180° to 360° during the 24 hr from April 3-4 was followed by a further shift in the current direction (147° to 159°) and slight increase in speed (0.17 to 0.24 kn) of the surface current.

Figure 4 depicts the clockwise shift of the surface current, and the predominant winds from April 7-8. The winds during the first 24 hr rotated from 150° to 70°, and were accompanied by a surface current change from 148° to 341°. The current subsequently shifted from 341° to 44° under the influence of a wind moving toward 70° for the next 24 hr.

B. *Velocity versus Depth Profiles*—Figures 5 to 9 show the effect of wind stress on current profiles, and how changes in the wind pattern modify current profiles during 24 hr periods.

Figure 5 shows the effect of a relatively high speed wind (9.8 kn) on a current profile that exhibited constant direction with depth. The current profile at 341° rotated clockwise when a wind with a 70° average direction blew 24 hr. This resulted in a 26° difference in direction of currents between the surface and 4-ft levels.

Rapidly shifting winds may also be associated with a directional difference in the currents of the surface and subsurface waters. The change in the current profile from March 27-28 (Fig. 5) was preceded by a shift of the wind pattern from 308° (11 hr) to 76° (13 hr). This shift in subsurface waters was generally 10° less than that of the surface waters.

The current profiles of March 28-29 suggest that at certain times, the wind speed may be so low that only the direction of the surface and near surface waters shift with the wind while the direction of the deeper water current remains relatively constant.

The changes in current velocity with depth are shown in Fig. 6 for March 29-30, which depicts the counterclockwise shift of the current profiles following a similar shift in wind direction. The variation of current direction with depth noted in the profile of the 29th, changed by the 30th, to a profile of constant direction with depth. This change was probably induced by winds at 335° and 309° at a 7 kn average for a total of 13 hr. Similar changes in current profiles were noted on March 25-26, and April 5-6. There was a general increase in current speed (0.17 to 0.67 kn) from March 29-30 which was also associated with this wind.

Figures 7 and 8 suggest the shift of a profile with no difference in direction between the surface and lower level waters. The clockwise rotation of the profile from April 2-3 was accompanied by a wind headed toward 130° (average direction) at a speed of 7.5 kn. The wind may have produced the constant directional change with depth because of its relatively high speed.

Summary—It is reasonably evident in the data presented that the overall circulation pattern in the study area of the lagoon is variable and depends primarily on the wind as its driving force. Current velocity data obtained from March 22 to April 8, 1972, were correlated with wind velocity data for the same

period. This comparison showed that the movements of water in the lagoon were easily related to wind speed and direction. During the period of study, the wind changes generally progressed in a clockwise direction and similar current changes followed. At times, definite differences were noted in current direction of water at different depths; at other times, the current at all depths was aligned with the wind. Experimental data indicate that the difference of direction between the deeper water currents and the concurrent wind is related to wind velocity and duration. The observed current patterns are probably a superposition of drift currents and slope currents, while currents due to astronomical tides play a minor role. More data would be needed to make a definitive confirmation and to establish pertinent time constants.

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BEHAVIORAL RESPONSES TO VISUAL STIMULATION IN THE SCALLOP (*AEQUIPECTEN IRRADIANS*)[1]

JACQUELINE LUDEL

Division of Natural Sciences and Mathematics,
Stockton State College, Pomona, New Jersey 08240

ABSTRACT: *In a series of experiments, the scallop's shell closure responses to visual stimulation were studied. Recordings were made of the animal's responses to repeated offsets of illumination. The findings indicated that the responses declined in amplitude over a series of offsets. The decline in responding increased as the length of the interval between offsets decreased. It was found that the decline in responding could not be attributed to either an effector or receptor mechanism. It was therefore concluded that the decline was due to a central process. The investigation also revealed that the amplitude of the response to the first offset was found to depend upon both the duration and the intensity of the light.*

THE SCALLOP has long been noted for the two rather unusual characteristics: it has an impressive array of eyes and it is capable of active swimming. The animal's numerous eyes are located on the tips of short stalks found along both shell halves. Each eye contains a large lens and a mass of sense cell material. The sense cells form two distinct retinae, one in front of the other, but the two retinae do not appear to have any functional or anatomical connections between them (Barber, Evans and Land, 1967; Schoepfle and Young, 1936). Each gives rise to its own branch of the optic nerve and the two branches join several mm behind the eye. The branch arising from the proximal retina (nearest the back of the eye) responds when the eye is illuminated; the branch arising from the distal retina responds to

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the offset of illumination (Hartline, 1936; 1938). The large lens does not appear to form an image within the eye (Land, 1965). Any image that is formed within the eye occurs as a result of a reflecting layer, the argentea, which lines the back of the eye (Land, 1966b). The image thus formed falls only on the distal retina.

In the relaxed condition, the scallop shell gapes open (1-2 cm at the point opposite the hinge line). The animal is able to swim by repeatedly clapping its shell halves together thereby forcing water out of the shell cavity. Swimming may occur seemingly spontaneously or in the presence of a starfish (Dakin, 1910). The scallop is also able to simply bring the shell halves together once. It has long been noted that such simple closures may occur when the substrate is disturbed or when the illumination is suddenly decreased (e.g., Dakin, 1910). The simple closure response often does not result in a complete closure of the shell; the shell halves are not brought in contact with each other but the gape is reduced.

Considerable information is now available concerning the structure and electrophysiology of the scallop's eyes (Gorman and McReynolds, 1969; Graziadei and Metcalf, 1970; Land, 1966a; McReynolds and Gorman, 1970a; 1970b; Miller, 1958). However, only sparse information is available concerning the animal's behavior in response to visual stimulation. The present research was an attempt to examine systematically this unusual animal's responses to visual stimulation.

METHODS—A total of 12 animals was used in the course of the experiments. The animals were obtained from the northeast (*Aequipecten irradians irradians* Lamarck) and from the Gulf Coast of Florida (*Aequipecten irradians concentricus* Say). They were housed in a 35 gal aquarium filled with artificial sea water (temperature 20-25° C.; density 1.025) and fed newly hatched brine shrimp every 1-2 days.

For testing purposes, the animal was held in a circular Pyrex dish (170 × 90 mm) which was filled for each run with a fresh quantity of sea water taken from the tank in which the animals were housed. A plexiglass false bottom was placed in the dish. In the center of the false bottom there was a small slot and nylon screw arrangement which served as a clamp to hold the animal in position.

A small plexiglass rectangle was affixed to the right shell half (bottom half) of the animal with dental cement. The rectangle was slipped into the slot of the false bottom and clamped in place. A short length of rubber tubing was cemented to the left shell half (upper half). The second of two lever arms which connected to a potentiometer was slipped into the rubber tubing. A 380 V power supply, of which only 30 V were used in the excursions of the lever arms, was attached to the potentiometer. The potentiometer was connected to a single channel magnetic pen-writer. Movements of the left shell half therefore created displacements of the lever arms which, in turn, rotated the potentiometer shaft and resulted in deflections of the pen.

Since the precise locations of the plexiglass rectangle and rubber tubing and the sizes of the animals varied, pen deflections were calibrated for each animal. After the experiments with each animal, the animal was stripped free of the shell. The cleaned shell was then clamped in the dish, the lever arms were placed in position, and a micromanipulator drive with a thin metal attachment was used to move the left shell half in 2 mm steps. Using the records obtained in this manner, the data were converted from the arbitrary pen-deflection units to mm of closure.

Throughout the testing, the pen-writer was placed on its own table, separate from the surface on which the animals were placed. To further minimize any vibrations of the substrate, a 0.5 in thick felt pad was placed under the wooden structure which held the dish, potentiometer, and lever arms.

The animals were tested in a darkroom and the entire structure holding the animal and potentiometer was covered save for a 2 × 2 in opening through which the animal viewed the light. At the level of the opening and 11 in away from the wall of the dish which held the animal was a single high intensity bulb (GE 1133 HI) run by a 6 volt transformer. The bulb provided an illuminance of 715 lu/m^2 at the plane of the opening. Reductions in illumination were achieved by placing neutral density filters over the opening. Four different intensities were employed during the experiments: 0 log (i.e., 715 lu/m^2), –2 log, –2.5 log and –3 log.

At the beginning of each testing session, the animal was clamped in the dish and the dish was filled with a fresh supply of sea water. The lever arms were positioned and the animal was left, undisturbed, in darkness, for 30 min. This quiescent period insured that the animals were all in the same state of visual adaptation regardless of the illumination of the tank in which they were housed. In addition, it provided time for the animals to assume the normal, relaxed gape after the firm and prolonged closure which characteristically occurred as the animals were clamped in the dish.

To evaluate the effects of prolonged testing sessions, animals were placed in the apparatus and tested aperiodically over, in one case, 5 hr and, in another, 6 hr. These prolonged sessions were longer than any of the testing sessions which occurred in the course of the experiments. During the prolonged sessions, no appreciable decrement in responding was noted and no appreciable increase in water temperature occurred.

Experiment *1*—In an attempt to examine the properties of the shell closure response to light offset, repeated trials consisting of 2 sec periods of darkness were run. The length of time between the periods of darkness was varied: this intertrial interval (ITI) was 30 sec, 1 min, 2, 5, 10, or 20 min. The intensity of the illumination was varied over three log units.

Procedure: A testing session was run as follows: an animal was placed in the dish and following the 30 min quiescent period, the bulb was turned on for 10 min regardless of the subsequent ITI (there was one exception to this: if the 20 min ITI sequence were to be run, the bulb remained on for 20 min prior to the first trial). Thus the first trial always occurred, with the noted exception, after a 10 min light period. Nine additional trials were then run at 1, 2, 5, 10, or 20 min intervals. When the 30 second ITI sequence was run, 29 trials spaced 30 sec apart were run.

The 0 log series was run first on all the animals. This was followed by the –2 log series, then the –2.5 log series and finally, the –3 log series. Within each series, the order in which the various ITI sequences were run was varied.

Results: Figure 1 contains the average size of the shell closure responses for all ITI sequences and all intensity series for trials 1 through 10. The data indicate that

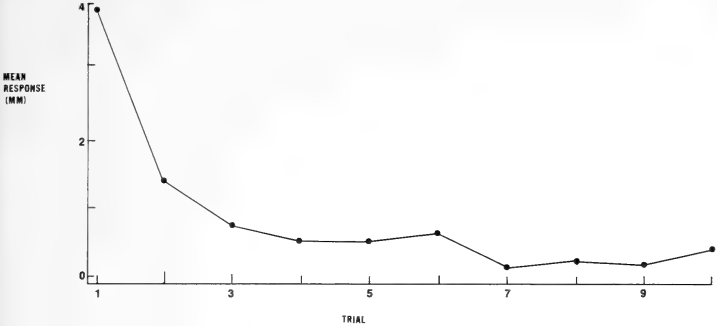

Fig. 1. Mean response for each of the first 10 trials.

there was a clear decrement in the size of the response as the trials proceeded. It may be noted in Fig. 2 that the decrement occurred in each of the intensity series. Furthermore, the decrements in responding varied as a function of the ITI: there was a strong tendency in trials 2 through 10 for larger responses to appear when the ITI was lengthened. Figure 3 contains the average responses for trials 2 through 10 for the 2, 5, and 10 min ITI sequences. The relationship between the response and the ITI may be illustrated in another way: if the number of trials on which *any* response occurred is counted, it appears that there was a strong tendency for more responses to occur as the ITI was lengthened. The graphs of Fig. 4 indicate that there was a consistent increase in the number of responses which occurred as the ITI increased.

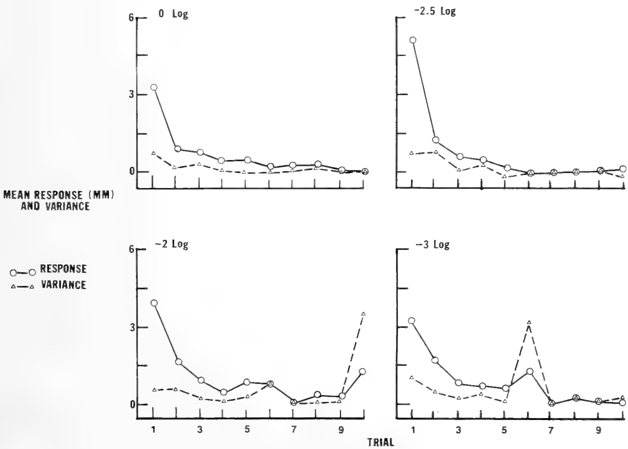

Fig. 2. Mean response and variance for each of the first 10 trials in each intensity series.

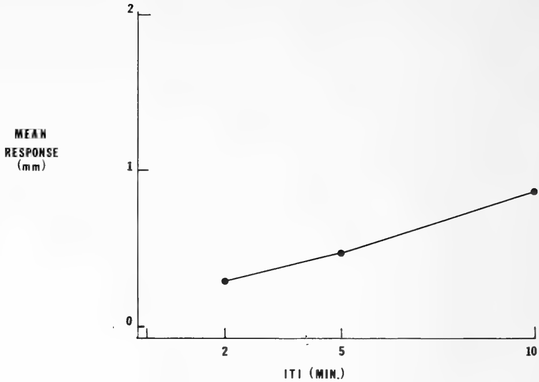

Fig. 3. Mean response on trials 1 through 10 for the 2, 5 and 10 min ITIs.

There was no indication that either the size of the response or the number of responses varied as a function of the light intensity. Further discussion of this finding is presented in Experiment 3.

Discussion: In general, a decrement in the size and the probability of the responses occurred over the course of a series of trials regardless of the ITI sequence or the intensity series. The rate at which the decrement occurred appeared to depend on the ITI sequence. Several hypotheses may be entertained concerning the nature of the decrement.

The first hypothesis to consider is that the animals closed their shells completely in response to each light offset but that they re-opened more slowly following each successive closure. Thus, the decrement would occur as the trials proceeded and the decrement would be more pronounced as the ITI decreased. If this were the case, there should be a high positive correlation between the gape prior to the trial (baseline) and the amplitude of the response.

Table 1 summarizes the results of analyses of the relationship between the response amplitude and the baseline for all non-zero responses. Spearman rank-

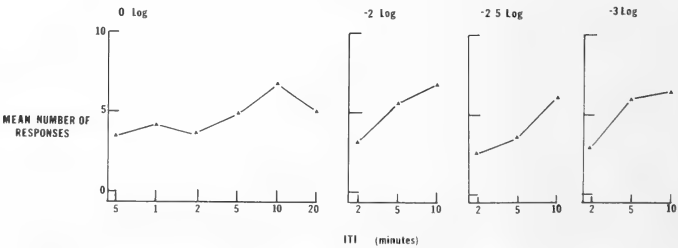

Fig. 4. Mean number of responses as a function of the ITI for each intensity series.

order correlations, corrected for ties, were employed to determine the degree of the relationship for each animal under each intensity series. The student's *t* test was used to evaluate the probability of each correlation. It is clear that the amplitude of the response was not primarily dependent on the baseline opening achieved prior to the trial. Most of the correlation values are quite low; some correlations are positive while others are negative. Only one of the 12 correlations reaches a significance level of .05. These findings generally conform to those that would be expected if the two variables were unrelated and therefore the first hypothesis must be discarded.

TABLE 1. Relationship between the amplitude of the response and the baseline.

	Animal	R_s	T	DF	Probability (two-tailed)
0 log series:	#4	.393	1.956	31	< .10
	#5	.307	1.118	12	> .20
	#6	.366	1.496	20	< .20
	#7	.016	< 1		
	#8	-.224	1.259	30	> .20
-2 log series:	#6	-.061	< 1		
	#7	-.155	< 1		
	#8	.282	1.14	15	> .20
-2.5 log series:	#7	-.342	1.15	10	> .20
	#8	.657	2.756	10	< .05
-3 log series:	#7	.122	< 1		
	#8	.975	< 1		

The second hypothesis to consider is that the large adductor muscle which closes the shell halves became fatigued over the course of a series of trials. Longer ITI sequences would permit a longer recovery period and therefore the longer the ITI, the less pronounced the decrement would be. However, the possibility that an "effector fatigue" accounts for the decrement is unlikely: at the conclusion of each testing session, the table upon which the animal and dish rested was gently rapped. The animals always responded to this vibration with a brisk and large response; even in those cases in which the animal had not responded to the final three or four light offsets, the vibration resulted in an immediate response. Such a response would not be expected if muscle fatigue were the source of the decrement. Further evidence discounting this hypothesis is presented in Experiment 2.

A third hypothesis to consider is that the decrement was somehow related to "sense cell adaptation effects". However, in the experiment, animals were placed in darkness for 30 min prior to the beginning of testing. Following the quiescent period, the animals were exposed to a 10 min light period (in the case of the 20 min ITI, a 20 min light period). That is, regardless of the ITI, the first trial always occurred after at least 10 min in the light. Under these circumstances, it would not be unreasonable to assume that by the time the trials had begun, sense cell adaptation had stabilized. Further treatment of this topic is presented in Experiment 3.

Since the decrement did not appear to be the result of effector or receptor mechanisms, the decrement can perhaps best be attributed to a central process (e.g., habituation).

EXPERIMENT 2—In an attempt to evaluate more carefully the possible role of fatigue effects, the responses of animals to repeated vibrations of the substratum were investigated.

Procedure: The vibration was caused by dropping a 670 g weight on the table 15 in behind the animal. The recording apparatus was identical to that previously described.

The animals were run for 29 trials at a 30 second ITI and for 9 trials at 1, 2, 5, 10, or 20 min ITIs for each of two intensity series. In one intensity series, the weight was dropped from a height of 2 in. In the other series, the weight was dropped from 4 in. The initial trial always followed a 30 min quiescent period regardless of the subsequent ITI. Throughout the quiescent period and the trials, the high intensity bulb remained on.

Results and Discussion: The data indicate that the animals responded to the repeated vibrations with large closures. Figure 5 contains the mean response for each of the trials in the two intensity series.

Once again, there was a decrement in the size of the response as the trials proceeded. Overall, the responses in the vibration series was considerably larger than those found in the various light series.

The vibration series results indicate that the animals were capable of responding at considerably higher rates than had been indicated in the first experiment. Table 2 contains the number of responses made by each animal in each sequence and series.

TABLE 2. Number of responses made in each ITI sequence in the vibration series.

		ITI					
	Animal	30 sec	1 min	2 min	5 min	10 min	20 min
2 in series:	#4	30	10	10	10	10	10
	#6	30	10	10	10	10	10
4 in series:	#4	10	9	5	7	10	10
	#6	30	10	10	10	10	10

Response rates as high as 30 closures within a period of 15 min occurred when the trials were separated by 30 sec intervals. Such high rates of responding suggest that the failures to respond noted in Experiment 1 could not have been due to muscle fatigue.

EXPERIMENT 3—In an attempt to examine the shell closure following several different durations of exposure to light, animals were exposed to various periods of light prior to a 2 sec period of darkness. The light period (ITI) was varied from 10 sec to 10 min.

Procedure: The recording equipment, stimulus arrangement and method of securing the animal were identical to those employed in Experiment 1.

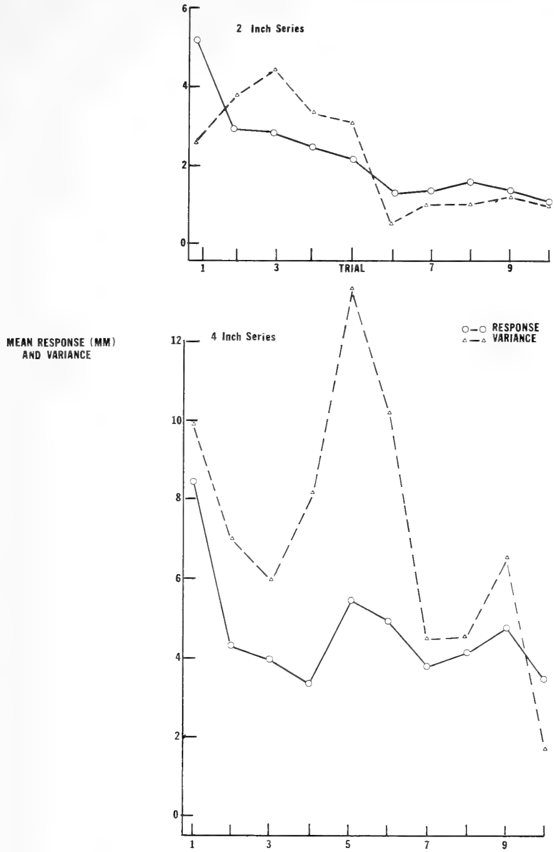

Fig. 5. Mean response and variance for each of the first 10 trials in each intensity series.

Following a 30 min dark, quiescent period, the animals were exposed to the light for a period of either 30 sec, 1, 2, 5, or 10 min prior to the first 2 sec trial. The sequence of light periods and trials was repeated until the animal had been exposed to the light for a total of 10 min. Thus, for example, an animal in the 2 min ITI sequence would, following a 30 min quiesscent period, receive five successive 2 min exposures to light. The major difference between the procedures of Experiment 1 and the present experiment was the elimination of the initial 10 min period of light which always preceded the first trial in Experiment 1.

The ITI sequences were run at 0 log, –2 log, –2.5 log, and –3 log. In addition, in the 0 log series, animals were run at ITIs of 10 and 15 sec for a total of 20 trials in each sequence.

Results and Discussion: Figure 6 contains the mean response made in each time sequence. The responses are plotted as a function of the total amount of time during which the animals had been exposed to the light prior to the trial. Figure 7 separates the data on the basis of intensity and ITI. In both figures, it is clear that there was a decrement in responding as the trials proceeded.

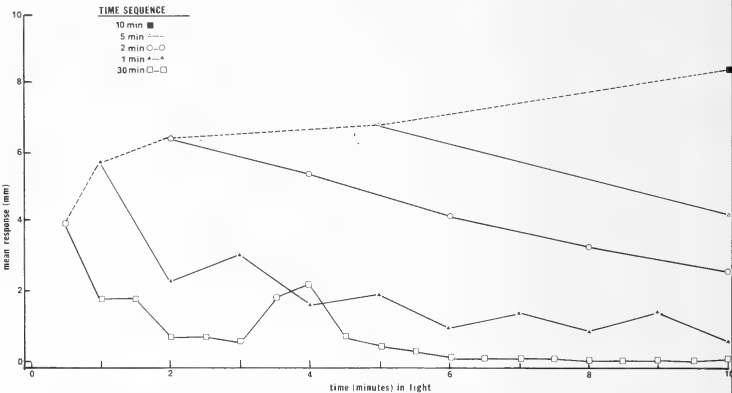

Fig. 6. Mean response in five time sequences. The dashed curve makes it clear that the amplitude of the initial response increased with the amount of time the animals had been in the light prior to the trial.

Several findings emerge from an examination of Fig. 7. The first result has to do with the assumption in Experiment 1 that the decrement in responding could not reasonably be attributed to sense cell adaptation. That assumption was based on a large literature showing that light adaptation is essentially stabilized within 10 min. The present experiment indicates that following a fixed exposure to light, there was a substantial decrement in responding depending on the previous number of trials. Stated differently, test trials that were preceded by visual stimulation of the same intensity and of the same duration of 10 min yielded responses that ranged markedly in amplitude depending on the number of previous test trials. This can be seen most clearly by examining the 0 log series in Fig. 7. All of the points plotted at 10 min represent trials preceded by an equal amount of light energy. These data are replotted in Fig. 8. Whether or not sensory adaptation was complete at this point in time, it must have been the same for all ITIs. The same observation can be made with reference to the –2 log series; the same trend is shown in the –2.5 log and –3 log series with the exception that there is one inversion in each of these series. In Fig. 6, again it is clear that the average response amplitude depended upon the number of previous test trials. These results strengthen the rejection of the hypothesis that the decrement in responding was due to a sense cell adaptation effect.

A second result shown in Fig. 7 is also related to Experiment 1: there seemed to be little, if any, effect of intensity in Experiment 1 over a range of three log units. An inspection of Fig. 7 clarifies those findings: consider only the first trials in any of the series so that no decremental responding is involved. An examination of the 10 min ITI data (the solid squares of Fig. 7) reveals that there was little change over the four intensity levels studied. These experimental points essentially represent a replication of the initial responses for all conditions in Experiment 1, in which the procedure involved 30 min of dark adaptation and 10 min of light adaptation. As in Experiment 1, the magnitude of the response after 10 min of light adaptation was not dependent upon the level of the light intensity.

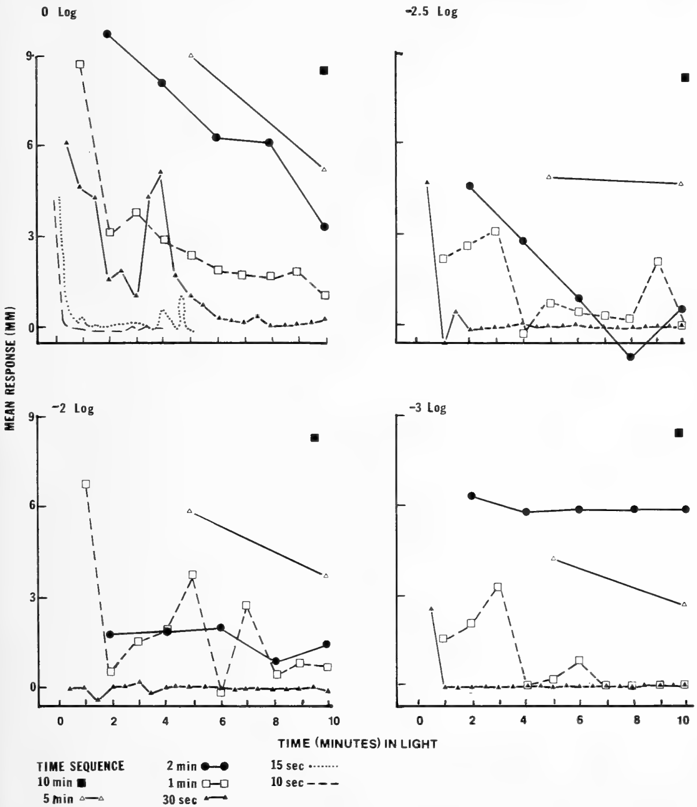

Fig. 7. Mean response in each intensity series. The data point which falls below the horizontal axis indicates an increase in the shell opening rather than a shell closure.

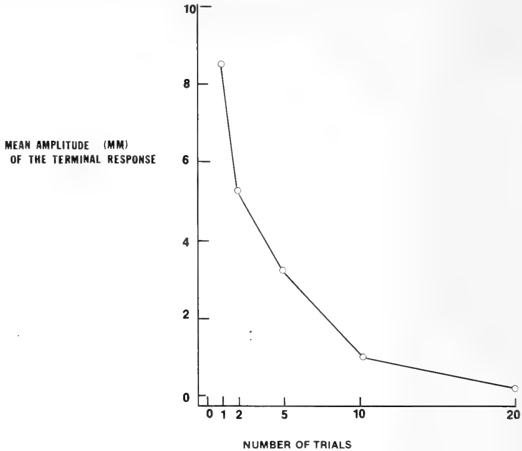

Fig. 8. Mean amplitude of the terminal response as a function of the number of test trials for the 0 log series.

This independence could be expected to break down as the intensity approached or reached the absolute threshold for the visual system of this species.

The analysis may be extended by examining the 0 log series data. In this series, there seemed to be little change in the magnitude of the response with changes in duration of light exposure ranging from 1 min to 10 min. This is not true for any other intensity series. The problem may be quantitatively explored by examining

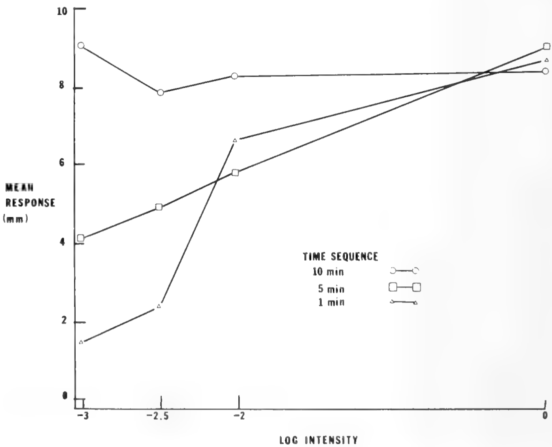

Fig. 9. Mean response on the first trial at each intensity for three time sequences.

the magnitudes of the first responses (once again eliminating the problem of the decrement in responding) following light exposures of 1, 5, and 10 min at each of the four intensities. These times were chosen because their first trial values at 0 log were essentially the same. Figure 9 contains the average response, after light exposures of 1, 5, and 10 min for each of the four intensity levels. It appears that following exposures of 5 min and 1 min, the amplitude of the shell closure response to a brief cessation of light was dependent upon the intensity of the light.

A third feature of the results shown in Fig. 7 is that the relation between the intensity and the duration of light exposure is a complex one. An examination of the data from the 0 log series shows that there was a very regular and orderly function relating the amplitude of the first response to the duration of the prior stimulus. This function rises rapidly from 10 sec to 1 min, seems to peak at 2 min and decline slightly thereafter. The function is shown as the top curve in Fig. 10.

The data for the other intensity series are more variable and they have been averaged in Fig. 10 in an attempt to illustrate the complex interrelation between intensity and duration.

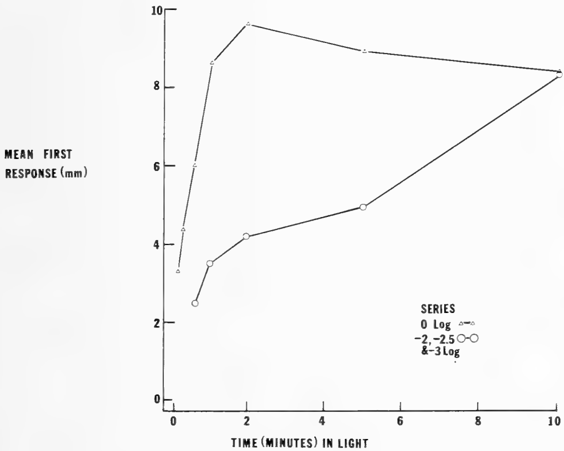

Fig. 10. Mean of the first response for the 0 log series and the average of the -2 log, -2.5 log, and -3 log series.

Conclusions and Summary—The present study involved an examination of the scallop's responses to repeated visual stimulation (light offsets). The initial findings indicated that the shell closure response declined in amplitude over a series of trials and that the decline decreased as the intertrial interval was lengthened.

Three possible causes of the decline in responding were investigated:

1. It was shown that the decline did not occur as a result of the animal returning to its resting, gaped position more slowly with each successive trial.

2. It was shown that muscle fatigue did not account for the decline: in a series of studies involving the animal's responses to vibrations of the substratum, it was found that the animal could respond with greater amplitude and frequency than had been evidenced in the studies of responses to visual stimulation.

3. It was shown that sense cell adaptation did not account for the decline: an investigation revealed that the amplitude of the response to light offset after a 10 min period in the light depended upon the number of trials which occurred during the light period. If the response depended only on the state of adaptation, responses which occurred after equal amounts of light energy should have been the same regardless of the number of intervening trials.

Since the decline in responding could not be attributed to effector or receptor mechanisms, it must have occurred as a result of a central mechanism (e.g., habituation).

An analysis of the effects of changes in the intensity (over a three log unit range) on the amplitude of the response to the first light offset indicated that at exposures briefer than 10 min, the response amplitude increased as the intensity increased. When the exposure period was 10 min, the response amplitudes were the same regardless of the intensity employed. The function relating the amplitude of the first response to the duration of the prior stimulus was a rather complex one.

LITERATURE CITED

Barber, V. C., E. M. Evans, and M. F. Land. 1967. The fine structure of the eye of the mollusc *Pecten maximus*. Zeits. Zellforsch. 76:295-312.

Dakin, W. J. 1910. The visceral ganglion of *Pecten*, with some notes on the physiology of the nervous system, and an inquiry into the innervation of the osphradium in the Lamellibranchiata. Mitt. Zool. Sta. Neapel 20:1-40.

Gorman, A. L. F. and J. S. McReynolds. 1969. Hyperpolarizing and depolarizing receptor potentials in the scallop eye. Science 165:309-310.

Graziadei, P. P. C. and J. F. Metcalf. 1970. Ultrastructure of the retina in the scallop's eye. Federation Proc. 29:834.

Hartline, H. K. 1936. The discharge of impulses in the optic nerve fibers of the eye of *Pecten irradians*. Biol. Bull. 71:403.

———. 1938. The discharge of impulses in the optic nerve of *Pecten* in response to illumination of the eye. J. Cell. Comp. Physiol. 11:464-478.

Land, M. F. 1965. Image formation by a concave reflector in the eye of the scallop, *Pecten maximus*. J. Physiol. 179:138-153.

———. 1966a. Activity in the optic nerve of *Pecten maximus* in response to changes in light intensity, and to pattern and movement in the optical environment. J. Exper. Biol. 45:83-99.

———. 1966b. A multilayer interference reflector in the eye of the scallop, *Pecten maximus*. J. Exper. Biol. 45:433-447.

McReynolds, J. S. and A. L. F. Gorman. 1970a. Photoreceptor potentials of opposite polarity in the eye of the scallop, *Pecten irradians*. J. Gen. Physiol. 56:376-391.

——— and ———. 1970b. Membrane conductances and spectral sensitivities of *Pecten* photoreceptors. J. Gen. Physiol. 56:392-406.

Miller, W. H. 1958. Derivatives of cilia in the distal sense cells of the retina of *Pecten*. J. Biophys. Biochem. Cytol. 4:227-228.

Schoepfle, G. and J. Z. Young. 1936. The structure of the eye of *Pecten*. Biol. Bull. 71:403.

Florida Sci. 37(2):78-90. 1974.

SOME ASPECTS OF THE HEMATOLOGY OF *CLARIAS BATRACHUS* (LINN.)

James W. Ward[1] and H. C. Davis

Department of Anatomy, University of South Florida College of Medicine, Tampa, Florida 33620; Aquarium Supply Company, Tampa

Abstract: *Hematological and ecological studies have been conducted upon an amphibious catfish originating from Africa and Madagascar. Hemopoetic centers and peripheral blood cells are discussed. The mesonephros was determined to be the principal hemopoetic center. All types of leucocytes were identified in the peripheral circulation. Natural history of the species is discussed briefly.*

Hematological studies in fishes have attracted the attention of a number of investigators. The classical works of Parker (1892), Bryce (1904), Drzewina (1911), Jordan (1938), Jordan and Speidel (1923), Downey (1938), and Jakowska (1956) are the foundations of piscine hematology.

Drury (1915) employed vital staining methods on 17 species of marine and freshwater fishes and reported eosinophilic granules to be stable after removal from the fish in eight species, unstable in eight others, and intermediate in one species.

Jordan and Spiedel (1923) made an extensive study on the lymphocytes and hemopoiesis of a number of freshwater fishes. They reported that both lymphoid and myeloid tissues are contained in the same organs in both fishes and amphibians. They stated that the spleen is the main hemopoietic organ in elasmobranchs and that the mesonephros is the principle hemopoietic organ in teleosts. They determined that cellular elements of fish blood included all known types of hemal elements and that these are derived from a common stem cell indistinguishable from lymphocytes.

Duthie (1939) determined that the blood of a number of marine teleosts contained all the usual granulocytes, lymphocytes and thrombocytes. He concluded that the lymphoid hemoblast is the stem cell of all leucocytes and that the coarse granulocytes are identical in both blood and tissue, and that the lymphoid hemoblast is the stem cell of all leucocytes including those in the connective tissue.

Saunders (1966a, 1966b) made extensive studies on the blood of marine fishes. In 1966(a) she conducted studies on the blood of ten species of elasmobranchs and reported finding neutrophils in three species and thrombocytes as the most prevalent type of leucocyte. In one species examined she found thrombocytes to make up 76% of the leucocytes and one species as having no lymphocytes and no thrombocytes. In 1966(b) she also reported her findings from studies on 121 species of marine fishes from Puerto Rico. She found the usual types of cells including macrophages in elasmobranchs. Also, of particular interest, was the

[1]Present Address: Department of Anatomy, College of Medicine, University of South Alabama, Mobile, Alabama 36688.

finding of so-called ring cells in one species, basophils in five species of teleosts, eosinophils in 70 species of fishes and thrombocytes in the greatest numbers.

Patterson (1968, personal communication) made differential counts on blood of two freshwater teleosts; namely, the grass pickerel, *Esox americanus vermicularis* Lessuerur, and the green sunfish, *Lepomis cyanellus* Rafinesque. For the pickerel she reported a differential count as follows: lymphocytes 42, thrombocytes 21, eosinophils 15, basophils 7, neutrophils 11, monocytes 4. For the green sunfish she found the following percentages: lymphocytes 34, monocytes 5, thrombocytes 22, eosinophils 20, neutrophils 11, and basophils 8.

Ward et al. (1965, 1966, 1967) studied peripheral blood and hemopoiesis in marine fishes. He reported results from studying peripheral blood and hemopoietic centers in 46 species of marine fishes from the Biloxi, Mississippi, Bay. He reported representative white cell counts to range from 75,000/mm in *Arius felis* to 280,000 in *Mugil cephalus*. Red cell counts were found to range from 1,600,000 in *Lepososteus ferox* to 3,633,000 in *Rachycentrom canadum* and clotting time as 21.5 sec in *Cyniscion* sp. to 58.6 sec in *Eleotris pisonis.*

Ward (1969) reported that *Neoceratodus forsteri* has all the usual types of leucocytes and that small eosinophils make up 69% of the leucocytes.

In recent years, a clariid catfish has become established in freshwater channels, lakes and ponds of the state of Florida. *Clarias batrachus,* the so-called walking catfish, has been collected by one of us (H.C.D.) from several ponds in Central and South Florida. Newspaper articles have heralded this immigrant as a menace to several species of plant and animal life in Florida waters. It has a voracious appetite and is omnivorous in its feeding habits. It has a high reproductive potential in Florida waters and has the ability to depart from its aquatic habitat and make short excursions on land as well as to survive drought in a state of aestivation by encasing its body in mud balls and respiring through a special branchial accessory organ until sufficient moisture is available.

The natural habitat of *Clarias* is from Ceylon through eastern India to Malay. It is said to have been imported into Florida by tropical fish dealers and sold as a home aquarium fish. It is presumed that the fish were released into an outside aquatic environment after becoming too aggressive and too large for the home aquarium. This unwelcome species has evidently become established in Florida waters. Its import and sale in the state is now prohibited.

Materials and Methods—Adult living specimens of *Clarias batrachus* were collected by one of us (H.C.D.) and transported to the laboratory where they were placed in aquarium water at the same temperature as the water in which they were transported. Blood smears were prepared by taking intracardiac samples with a 27.5 in Jelco disposable syringe. Previously, the needle and barrel had been coated with anticoagulant, EDTA (potassium ethylenediaminetetraacetate). Smears were allowed to air dry and were then fixed in absolute methyl alcohol. The following day they were stained in Wright's blood stain, allowed to dry, and cleared in xylene before the cover glass was applied. Studies were made under the oil emersion lens of a Bausch and Lomb compound binocular microscope. Differential cell counts were made of the erythrocyte series by counting the first 100 red cells encountered so as to ascertain the percentage of erythrocytes and erythroblasts. Likewise, a white series was compiled by counting the first 200 leucocytes and enumerating under the conventional white series types; namely, neutrophils, eosinophils, basophils (heterophils), lymphocytes, macrophages (monocytes) and thrombocytes.

In order to determine the hemopoietic centers parts of all organs were fixed in Lavdowsky's solution, embedded in paraffin, sectioned and stained in hematoxylin and eosin. Cell measurements were made with the stage micrometer, under the oil lens. Photographs were made of representative cell types with a Wild-Heerbrugg microscope equipped with a photo automatic camera.

RESULTS—The mesonephros was found to be the principal hemopoetic organ for both leucocytes and erythrocytes. Lesser centers were identified in the spleen, branchial tissue, intestinal submucosa, skeletal muscle and dermis of the skin. Differential counts and cell measurements are shown in Table 1.

TABLE 1. Differential blood cell counts of *Clarias batrachus* (Linn.).

Type	Percentage per 100 Cells Counted	Measurements in Micra
Erythrocytes	97	19
Erythroblasts	3	21
Hemocytoblasts	2	23
Lymphocytes, small	27	12
Lymphocytes, large	12	19
Macrophages (Monocytes)	2	20
Thrombocytes	44	6
Neutrophils	9	18
Eosinphils	2	13
Basophils (Heterophils)	2	12

DISCUSSION—In studying the results obtained from cell enumeration of this species it will be noted all types of leucocytes were identified.

It was also determined that lymphocytes were the most prevalent type of leucocytes present and thrombocytes were next in order. So far as can be ascertained from the literature no previous hematological studies have been conducted on any member of the family Claridae; therefore, no close comparisons can be made.

The blood cells and hemopoietic tissue of two species of the related family Arridae, namely, *Arius felis* and *Barge marinus*, have been studied (Ward, 1966, 1967). The white cell count percentages in *Arius felis* were found to be 32 lymphocytes, 51 thrombocytes, 7 eosinophils, 3 basophils and 7 neutrophils. The percentages of white cells in *Barge marinus* were found to be 30 lymphocytes, 45 thrombocytes, 13 eosinophils, 10 neutrophils and 2 basophils. Ward et al. (1966) determined the mesonephros to be the principal hemopoietic organ in *Arius felis* and erythrocyte count to be 3,633,000 per mm^3.

Oria, 1933, noted that the erythrocytes in some members of the siliroids are frequently round rather than circular.

LITERATURE CITED

Bryce, T. H. 1904. The histology of the blood of the larva of *Lepidosiren paradoxa.* Part II. Hematogenesis. Trans. Roy. Soc. Edinburgh 41:291-302.

Downey, H. 1938. Handbook of Hematology. Volume II. Paul B. Hoeber, Inc. New York.

Drury, A. N. 1915. The eosinophil cell of teleostean fish. J. Physiol. 49:349-366.

Drzewina, A. 1911. Contribution a Petude des leucocytes granuleux du sang des poissons. Arch. Anat. Mier. 13, 319-376.

Duthie, E. S. 1939. The origin, development and function of the blood cells in certain marine teleosts. Part I. Morphology. J. Anat. 73:396-412.

Jakowska, S. 1956. Morphologie et nomenclature des cellules du sang des Téléostéens. Rev. Hematol. 11:519-539.

Jordan, H. E. 1938. Comparative hematology. *In* Downey, H. (ed.) Handbook of Hematology 2:703-862. Paul B. Hoeber, Inc. New York.

________ and Speidel, C. C. 1923. Studies on lymphocytes. II. The origin, function and fate of the lymphocytes in fishes. J. Morph. 38:529-549.

Oria, J. 1933. On the figurative elements of the circulating blood of some Brazilian fluvial téléostéens. Anat. Rec. 55:369-376.

Parker, W. N. 1892. On the anatomy and physiology of *Protopterus annectens.* Trans. Roy. Irish Acad. Dublin 39:109.

Saunders, D. C. 1966a. Elasmobranch blood cells. Copeia 2:348-351.

________. 1966b. Differential blood cell counts of 121 species of marine fishes of Puerto Rico. Trans. Amer. Microscop. Soc. 85:427-449.

Stebra, G. 1962. Freshwater fishes of the world. The Pet Library, Ltd. New York.

Ward, J. W. 1969. Further blood studies on the Australian Lungfish, *Neoceratodus forsteri.* Copeia 3:633-635.

________, C. L. Dodgen and L. L. Sulya. 1965. Morphological studies on peripheral blood cells of 29 species of marine fishes. Anat. Rec. 151:496.

________ and G. H. Ezell. 1967. Further blood studies in marine fish. Anat. Rec. 157:337-338.

________, L. L. Sulya and C. L. Dodgen. 1966. Hemopoiesis in 46 species of marine fish. Anat. Rec. 154:505.

________, 1974. Leukocyte Counts: Vertebrates other than Man. Part II. Fishes. Biology Data Book, 2nd Edition, Volume III. Federation of American Societies for Experimental Biology. 1859-1860.

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Biological Sciences

BACTERIA ASSOCIATED WITH SOOTY MOLD FUNGI ON CENTRAL FLORIDA CITRUS

Robert N. Gennaro

Department of Biological Sciences, Florida Technological University, Orlando, Florida 32816

Abstract: *The occurrence and frequency of* Azotobacter *spp. present on leaf surfaces of central Florida citrus trees bearing sooty mold fungi and in soil in which the trees grew were determined.* Azotobacter chroococcum, Azotobacter beijerinkii *and an unidentified* Azotobacter *sp. which produces a large mucoid colony were evenly dispersed in the canopy. The dispersion of the mucoid colony producing* Azotobacter *sp. in the soil was uneven and was not in the control soil devoid of citrus trees. This study indicates that nitrogen-fixing* Azotobacter *spp. may be regularly associated with the sooty mold colony on citrus leaves in Central Florida.*

Sooty mold fungi occupy a distinct niche in a microenvironment defined by Ruinen (1971) as the phyllosphere. The sooty mold colony is formed by predictable associations of entomcoprophyllous Ascomycete and Deuteromycete fungi with common morphological features which enable them to thrive under the selective pressures existing at the epiphyllous surface (Reynolds, 1971). While studying the establishment of sooty mold fungi on citrus leaf surfaces in Florida, bacteria were found which may be a regular component of the sooty mold colony. *Azotobacter* spp. were isolated with high frequency in central Florida citrus groves. The aim of this investigation was to determine the occurrence and frequency of nitrogen-fixing bacteria present on leaf surfaces of central Florida citrus trees bearing sooty mold fungi and in the soil in which these trees grow.

METHODS—Sampling was done in July and November 1972. Soil samples were collected at one ft intervals from a depth of approximately 2 in along a line extending from the base of the tree to the center of the open cultivation accessway between the rows of trees. Control sampling was done in a nearby area where no citrus trees were growing. Dilutions were made using standard methods. The medium used for isolation and enumeration was Burk's nitrogen free agar (Jensen, 1954). The agar plates were incubated at 30°C for 48-72 hr. The mature trees in the grove used for this study had a canopy that was open near the trunk. Large branches extended outward from the trunk and branched regularly in the outer 5 to 8 ft in the dome shaped canopy where the major portion of the leaf bearing twigs occurred. The flow of water during a rain, or particularly during a slow drip resulting from fog that often occurs in the area, caused a drip zone immediately beneath the outer denser leaf laden portion of the canopy. Citrus leaves were sampled at breast height at tree center, Area I (0-2 ft); in the middle of the canopy, Area II (3-5 ft); and in the outer tree canopy where the drip line formed, Area III (6-8 ft). Two 1.0 cm^2 plugs were cut from each leaf with a cork borer and emaciated with a tissue grinder in 2.0 ml of sterile saline solution. Dilutions were made using standard methods. The medium and incubation were the same as that described for the soil sample processing. Measurements of pH were made by allowing 10 g of soil to equilibrate with 90 ml of distilled water for 2 hr before measurement with a pH meter. The methods described by Jensen (1954) were used to identify the bacterial isolates.

RESULTS—*All of the isolated nitrogen-fixing bacteria belonged to the genus Azotobacter; A. chroococcum, A. beijerinkii* and an unidentified *Azotobacter* sp. comprise the species present in our samples. The unidentified *Azotobacter* sp. produces a large mucoid colony and will be referred to as the "mucoid type". The mucoid type *Azotobacter* does not conform to any of the presently recognized species within the genus; it resembles *A. vinelandii,* but lacks cysts and is achromogenic. The total count of nitrogen-fixing bacteria in the soil remained relatively constant from Area I at the base of the tree trunk to Area III which included the canopy edge at 8 ft (Table 1). A 10-fold increase was observed from 7-8 ft in Area III in the edge of the canopy. The canopy of the tree extended approximately 8 ft beyond the trunk in our sampled grove. From the edge of the canopy in Area III to the 12 ft sample in the accessway between the tree rows, another 10-fold increase in bacterial frequency was observed. The frequency of bacteria recorded in the grove samples represents a 100-fold increase in the nitrogen-fixing bacterial population when compared to the abundance of bacteria recorded from the control sample from the uncultivated soil. The number of nitrogen-fixing bacteria per cm^2 of citrus leaf was 4×10^5 in Area I (0-2 ft), 1.5×10^5 in Area II (3-5 ft) and 5×10^4 in Area III (6-8 ft).

Discussion—Several excellent reviews on the *Azotobacteriaceae* are available (Alexander, 1961; Dobereiner, 1953; Kyle and Eisenstark, 1951). The population density of *Azotobacter* in the soil ranges from a few organisms per g to as high as 2.8 millions per g (Dobereiner, 1953; Vancura and Macura, 1960). Ruinen (1956, 1961) isolated *Beijerinkia* spp. and *Azotobacter* spp. as part of the normal microflora of various plants in Indonesia and Surinam. The population density of these two genera of nitrogen-fixing bacteria on mature cacao leaves was reported as 12.5 millions per cm^2. *Azotobacter* was reportedly the most prevalent nitrogen-fixing organism on citrus (Ruinen, 1961). *Azotobacter* can be experimentally established on the leaves of the mulberry plant following artificial inoculation (Vasantharajan and Bhat, 1968). The most striking observation made from our citrus grove sampling was the distribution pattern of the mucoid type *Azotobacter.* This species was found in soil at the tree center (Area I) and reappeared again at 8 ft at the same density (Area III) (Table 1). The mucoid type increased in frequency in the soil from 9 ft to the center of the open cultivation row at 12 ft (Area IV). The mucoid type was not observed in the soil under the main portion of the tree canopy from 2 to 8 ft. The uncultivated soil did not contain any of the mucoid type *Azotobacter.* The lower numbers of *Azotobacter* in the uncultivated soil is in agreement with the work of Krasil'nikov (1958). The absence of the mucoid type from the uncultivated soil supports the apparent relationship between the citrus tree and this bacterium. No specific data exist which explain the absence of the mucoid type *Azotobacter* in the soil under the major portion of the tree canopy. One may speculate that its absence is the result of a lack of a growth promotion factor in the soil.

The bacteria present on the leaf surface were similar to those found in the grove soil except that the mucoid type was found to be evenly dispersed in the canopy. The occurrence of all three species of *Azotobacter* on the leaves would indicate that no inhibition occurs on the leaf surface. The total numbers of nitrogen-fixing organisms present on the leaf surface show a distinct variance within the canopy. The leaves of the tree canopy edge (Area III) have the lowest number of nitrogen-fixing bacteria and the leaves of the tree center near the trunk (Area I) have the highest number. The 10-fold difference between the bacteria on the leaf surfaces in the canopy edge (Area III), middle (Area II) and center (Area I) regions of the canopy may be due to mechanical washing, i.e. from rain, or other environmental factors such as available moisture or solar radiation differential. The mucoid type *Azotobacter* is either predominately leaf occurring because of the favorable microenvironment created by the presence of the sooty mold fungi or soil occurring due to growth related factors contributed from the phyllosphere.

Carbonates from the citrus leaf leachates would explain the basic pH of the soil under the canopy. The difference in the *Azotobacter* species in the soil is not caused by the pH; the soil pH values, as indicated in Table 1, are within the growth pH range of this group of bacteria. However, the possibility for differences within the microenvironment of the soil should not be precluded.

Neither the role of the free living nitrogen-fixing bacteria with respect to the ecology of the leaf surface nor their effect on the plant has been determined. Ruinen (1961) suggested that metabolic and decomposition products of oligotrophic bacteria accumulated on leaf surfaces were absorbed by the plant. Reports of amino acid and gibberillin production by the heterotrophic nitrogen-fixing bacteria (Vancura, 1961; Vancura and Macura, 1960) further suggest interaction between them and the supporting plant. We may speculate that these bacteria are supplying some of the growth requirements for sooty mold fungi in addition to those possibly available from the plant (Vancura, 1961) and from insect excreta. Insect excreta provide ample carbon sources for both the bacteria and the sooty mold fungi.

TABLE 1. Results from soil samples taken from a central Florida grove.

Sample Area	Distance in Feet	Total Count[1] per Gram Soil	Mucoid Colonies per Gram Soil	Soil pH
	0	24×10^4	20×10^2	
I	1	21×10^4	10×10^2	7.79
	2	20×10^4	0	7.43
	3	21×10^4	0	7.30
II	4	20×10^4	0	7.41
	5	29×10^4	0	7.03
	6	15×10^4	0	7.18
III	7	30×10^4	0	7.43
	8*	20×10^5	20×10^2	7.21
	9	60×10^5	19×10^3	6.68
IV	10	10×10^6	20×10^3	7.15
	11	11×10^6	30×10^3	6.73
	12	9×10^6	20×10^3	6.68
	Control	3×10^4	0	6.68

*end of canopy of tree (drip line)
[1]includes mucoid type

The insect excretum known as "honeydew", which is produced by certain insects such as soft scales and white flies, is the most apparent nutrient source for the sooty mold fungi. The sooty mold fungi in central Florida develop only when this food source is present. Way (1963) indicated that glucose, sucrose and many common amino acids are normal components of the honeydew. *Azotobacter* spp. utilize glucose and sucrose as carbohydrate sources (Jensen, 1954). Some sooty mold fungi have been found to utilize glucose in artificial culture media.

The relationship of the nitrogen-fixing bacteria and the sooty mold colony has not been determined at this time. Certain sooty mold fungi have been observed in vitro by the author to proliferate on nitrogen free medium adjacent to nitrogen-fixing bacteria. Whether crossfeeding takes place in nature, as Ruinen (1961, 1971) suggests, has not yet been determined.

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LITERATURE CITED

ALEXANDER, M. 1961. Introduction to Soil Microbiology. John Wiley & Sons. New York.

DOBEREINER, J. 1953. Azotobacter em Solos Acidos. Bol. Inst. Ecol. Exp. Agr. Rio de Janeiro. 31 p.

JENSEN, H. L. 1954. The Azotobacteriaceae. Bact. Rev. 18:195-214.

KRASIL'NIKOV, N. A. 1958. Soil Microorganisms and Higher Plants. Academy of Sciences, U.S.S.R. Moscow.

KYLE, T. S. AND A. EISENSTARK. 1951. The genus *Azotobacter*. Bull. Okla. Agr. Mech. Coll. 48(16):1-49.

RUINEN, J. 1956. Occurrence of *Beijerinkia* in the phyllosphere. Nature (London) 177:220.

———. 1961. The phyllosphere. I. An ecologically neglected milieu. Pl. & Soil. 11:81-109.

———. 1971. The grass sheath as a site for nitrogen fixation. Pp. 567-580. *In* PREECE, T. F. AND C. H. DECKINSON, eds. Ecology of Soil Microbiology. Academic Press. New York.

REYNOLDS, D. R. 1971. On the use of hyphal morphology in the taxonomy of sooty mold Ascomycetes. Taxon 20:759-768.

VANCURA, V. 1961. Detection of gibberelic acid in *Azotobacter* cultures. Nature (London) 192:88-89.

——— AND J. MACURA. 1960. Indole derivatives in *Azotobacter* cultures. Folia Microbiol. 5:293-297.

VASANTHARAJAN, V. N. AND J. V. BHAT. 1968. Interrelations of microorganisms and mulberry. II. Phyllosphere microflora and nitrogen fixation in leaf and root surfaces. Pl. & Soil. 18:258-267.

WAY, M. J. 1963. Mutualism between ants and honeydew—producing Homoptera. Amer. Rev. Entom. 8:307-344.

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Biological Sciences

OCCURRENCE OF SNOOK ON THE NORTH SHORE OF THE GULF OF MEXICO[1]

NELSON R. COOLEY

U. S. Environmental Protection Agency, Gulf Breeze Environmental Research Laboratory, Sabine Island, Gulf Breeze, Florida 32561

ABSTRACT: *The known range of snook is extended about 100 miles westward to Santa Rosa Sound.*

THE geographical range of *Centropomus undecimalis* (Bloch) has been reviewed by Marshall (1958) and Martin and Shipp (1971). Snook are found in tropical and subtropical estuarine waters of the eastern coast of the Americas. In the United States, snook have been reported as far north as Georgia (Dahlberg, 1972) and the Carolinas (Lunz, 1953; Martin and Shipp, 1971), but are abundant only in Texas and peninsular Florida. In Texas, the range rarely extends north of Port Aransas, although Jordan and Gilbert (1882) reported the species from the vicinity of Galveston. On the east coast of Florida, Marshall (1958) placed the

[1]Contribution No. 192 from Gulf Breeze Environmental Research Laboratory, Associate Laboratory of the National Environmental Research Center, Corvallis, Oregon.

northern limit in the vicinity of Volusia County, noting that the species is occasionally taken in Duval County and in the St. John's River. On the west coast of Florida, he noted that the northern limit was in the vicinity of Hernando County, the species appearing to be absent from the north shore of the Gulf of Mexico. Subsequently, Yerger (1961) reported a single adult from the Gulf off Alligator Harbor, Franklin County, Florida, but the first record from a northern Gulf coast estuary appears to be a 351-mm snook caught in St. Andrew Bay, Bay County, Florida in August 1963 (Vick, 1964). Vick also noted that local commercial fishermen told him that two or three snook were caught in that bay each year, usually in August.

This report extends the known range of the species approximately 100 miles westward along the northern Gulf coast of Florida into a second estuary. I identified an adult snook, 395 mm standard length, that was caught on 3 November 1973 in a gill net in Santa Rosa Sound off Woodlawn Beach, Santa Rosa County, Florida by Mr. J. A. Briggs, a commercial fisherman. The specimen was deposited in the museum of the Gulf Breeze Environmental Research Laboratory as GBERL-1911. Water temperature and salinity were not taken at the collecting site, but should have been similar to those recorded that day in the Sound at Sabine Island, 10 miles west of Woodlawn Beach, namely, 21.0° to 22.0°C and 29.5 to 30.0‰.

The scarcity of snook along the northern Gulf coast is probably related to their known sensitivity to cold (see Marshall, 1958, for review of temperature tolerance). Nevertheless, during warm seasons, isolated specimens from endemic populations along the southwestern coast of Florida could move out of their nominal range into localities along the northwestern coast of the state.

LITERATURE CITED

Dahlberg, M. D. 1972. An ecological study of Georgia coastal fishes. U. S. Dept. Commer., Natl. Mar. Fish. Serv., Fish. Bull. 70:323-353.

Jordan, D. S., and C. H. Gilbert. 1882. Notes on fishes observed about Pensacola, Florida, and Galveston, Texas, with descriptions of new species. Proc. U. S. Natl. Mus. 5:241-307.

Lunz, G. R. 1953. First record of the marine fish *Centropomus undecimalis* in South Carolina. Copeia 1953:240.

Marshall, A. R. 1958. A survey of the snook fishery of Florida, with studies of the biology of the principal species, *Centropomus undecimalis* (Bloch). Florida State Bd. Conserv. Tech. Paper 22, 37 p.

Martin, J. R., and R. L. Shipp. 1971. Occurrence of juvenile snook, *Centropomus undecimalis*, in North Carolina waters. Trans. Amer. Fish. Soc. 100:131-132.

Vick, N. G. 1964. The marine ichthyofauna of St. Andrew Bay, Florida, and nearshore habitats of the northeastern Gulf of Mexico. Texas A. & M. Res. Found., A. & M. Proj. 286-D, 77 p.

Yerger, R. W. 1961. Additional records of marine fishes from Alligator Harbor, Florida, and vicinity. Quart. J. Florida Acad. Sci. 24:111-116.

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Physical Sciences

1971 PHOTOELECTRIC OBSERVATION OF BETA LYRAE

R. M. Williamon, T. H. Morgan, D. H. Martins,
T. F. Collins, and H. R. Miller

Rosemary Hill Observatory[1], Department of Physics and Astronomy,
University of Florida, Gainesville, Florida 32611

As part of the Second Coordinated Program for the Observation of β Lyrae sponsored by Commission 42 of the International Astronomical Union, narrow-band photoelectric observations were made on several nights in July and August 1971 at the Rosemary Hill Observatory of the University of Florida. The next section discusses the equipment employed in the observations, and the final section presents the data.

Equipment—The observations were made with the Astro-Mechanics dual-channel photoelectric photometer attached to the Cassagrain focus of the 76 cm reflector at Rosemary Hill. This photometer employs a dichroic filter to reflect 95% of the incident light between 3500 and 6000 Å while transmitting 80% above 6500 Å. A transmitted beam was directed to an EMI 9558B (S20 photocathode) photomultiplier driven at -1000 VDC, while the reflected beam was measured by an EMI 6256 (S11), also driven at -1000 VDC. Both photo-multipliers were refrigerated to dry ice temperature. Aperture size was either 25 or 32.5 seconds of arc, depending on sky conditions.

Each channel was equipped with three narrow band filters, selected following the recommendation of Dr. A. Batten, the Campaign Coordinator; these filters were manufactured by Thin Film Products, Waltham, Massachusetts. The center

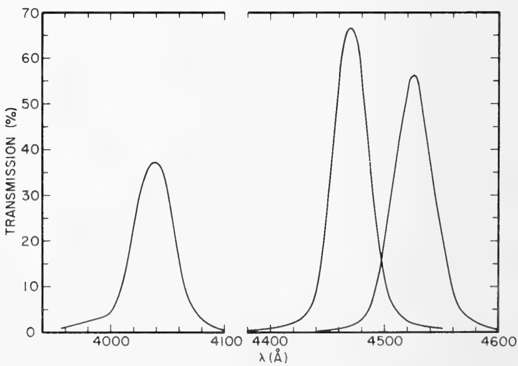

Fig. 1. Transmission curves for the blue filters.

[1]Contribution No. 39.

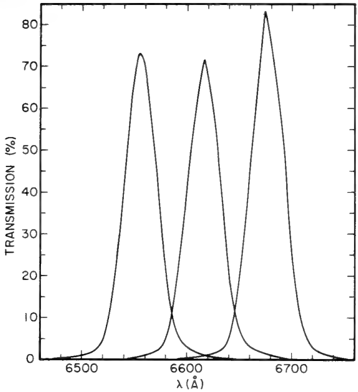

Fig. 2. Transmission curves for the red filters.

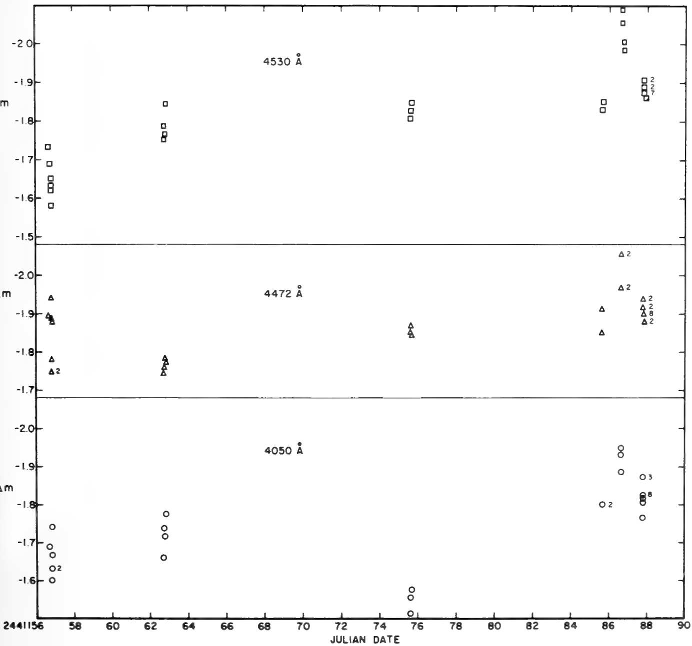

Fig. 3. Blue-channel observations.

wavelengths chosen were 4050, 4472, 4530, 6563, 6620, and 6678 A, and the transmission curves, given in Fig. 1 and 2, were measured with the Perkin-Elmer E-1 monochromator at the Department of Mechanical Engineering, University of Florida.

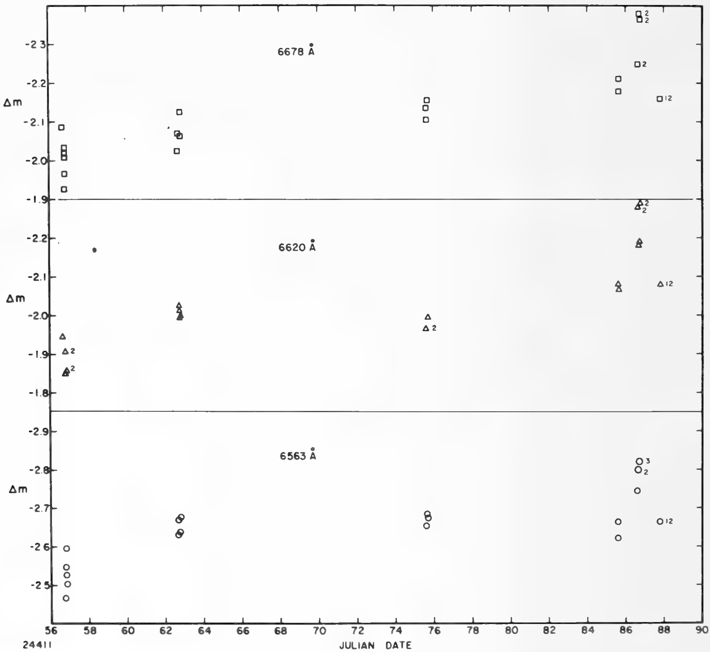

Fig. 4. Red-channel observations.

The data gathering system consisted of two identical, calibrated DC amplifiers twin voltage-frequency converting scaling devices with visual readout controlled by an adjustable timer which is accurate to at least ±0.001 second, and a Honeywell dual channel chart recorder connected directly to the amplifier outputs. The Universal Time for each observation was recorded simultaneously with the integration. Although originally intended for use as a sky monitoring device for this program, the chart recorder proved to be very useful when trouble was detected in the integration system during data reduction. Many of the data presented here were obtained from the strip chart records.

OBSERVATION—The comparison star for the photoelectric observations was HR 6997, and the check star was 9 Lyrae. The reduction to differential magnitudes was performed on the RCA SPECTRA 70/47 at Georgia State University.

Six-filter data were obtained on six nights; these were: July 23-24, 29-30, August 11-12, 21-22, 22-23, and 23-24. In addition, single-channel observations (through the three blue filters) were made on July 17-18. Differential magnitudes corrected for atmospheric extinction are listed in Table 1 (blue filters) and Table 2 (red filters). These magnitudes for each night on which six-filter data are available are plotted against heliocentric Julian date in Fig. 3 (blue filters) and Fig. 4 (red filters).

TABLE 1. Blue Channel Observations.

4050 Å		4472 Å		4530 Å	
J.D. Hel. 2441100+	Δm	J.D. Hel. 2441100+	Δm	J.D. Hel. 2441100+	Δm
50.7742	-1.205	50.7752	-1.297	50.7765	-1.251
.7863	-1.188	.7871	-1.283	.7879	-1.236
.7968	-1.184	.7974	-1.286	.7981	-1.229
.8052	-1.181	.8059	-1.280	.8064	-1.232
.8126	-1.169	.8132	-1.266	.8138	-1.223
.8207	-1.138	.8220	-1.245	.8225	-1.190
.8301	-1.148	.8308	-1.236	.8315	-1.184
.8365	-1.146	.8371	-1.249	.8378	-1.195
.8440	-1.155	.8447	-1.255	.8453	-1.180
.8619	-1.095	.8627	-1.206	.8633	-1.162
56.7101	-1.689	56.7110	-1.895	56.7117	-1.733
.8184	-1.602	.8191	-1.889	.8198	-1.691
.8304	-1.741	.8314	-1.948	.8322	-1.638
.8408	-1.633	.8418	-1.749	.8427	-1.620
.8500	-1.663	.8508	-1.779	.8519	-1.650
.8608	-1.629	.8619	-1.753	.8631	-1.582
62.7289	-1.665	62.7304	-1.746	62.7314	-1.756
.7394	-1.739	.7401	-1.761	.7409	-1.789
.7711	-1.719	.7723	-1.786	.7731	-1.766
.8101	-1.779	.8109	-1.777	.8116	-1.845
75.6067	-1.557	75.6075	-1.871	75.6082	-1.832
.6155	-1.515	.6163	-1.855	.6171	-1.806
.6914	-1.576	.6922	-1.844	.6930	-1.850
85.6264	-1.804	85.6274	-1.852	85.6281	-1.833
.6367	-1.798	.6375	-1.915	.6382	-1.851
86.6399	-1.905	86.6392	-1.965	86.6385	-1.949
.6687	-2.089	.6681	-2.050	.6674	-1.882
.6762	-2.057	.6755	-2.062	.6749	-1.934
.7378	-2.009	.7372	-2.077	.7365	-1.947
.7410	-1.980	.7405	-2.034	.7399	-1.935
87.7410	-1.821	87.7417	-1.893	87.7422	-1.854
.7441	-1.826	.7447	-1.908	.7453	-1.867
.7509	-1.863	.7516	-1.950	.7526	-1.912
.7549	-1.873	.7554	-1.940	.7560	-1.907
.7618	-1.818	.7625	-1.908	.7631	-1.886
.7651	-1.873	.7657	-1.925	.7663	-1.892
.7769	-1.765	.7775	-1.886	.7781	-1.863
.7799	-1.807	.7805	-1.911	.7811	-1.891
.7989	-1.838	.7994	-1.911	.8000	-1.881
.8017	-1.839	.8023	-1.891	.8028	-1.865
.8090	-1.818	.8101	-1.880	.8102	-1.850
.8130	-1.840	.8136	-1.884	.8142	-1.871

TABLE 2. Red Channel Observations.

6563 Å		6620 Å		6678 Å	
J.D. Hel. 2441100+	Δm	J.D. Hel. 2441100+	Δm	J.D. Hel. 2441100+	Δm
56.7101	-2.542	56.7110	-1.941	56.7117	-2.082
.8184	-2.463	.8191	-1.853	.8198	-2.033
.8304	-2.594	.8313	-1.902	.8322	-2.008
.8408	-2.544	.8418	-1.908	.8427	-2.019
.8500	-2.527	.8508	-1.844	.8519	-1.965
.8608	-2.505	.8619	-1.859	.8631	-1.926
62.7289	-2.628	62.7304	-2.014	62.7314	-2.025
.7394	-2.660	.7401	-2.029	.7409	-2.071
.7711	-2.635	.7723	-1.997	.7731	-2.063
.8101	-2.680	.8109	-2.002	.8116	-2.128
75.6067	-2.660	75.6075	-2.065	75.6082	-2.135
.6155	-2.685	.6163	-2.070	.6171	-2.106
.6914	-2.676	.6922	-2.095	.6930	-2.157
85.6264	-2.661	85.6274	-2.082	85.6281	-2.214
.6367	-2.622	.6375	-2.069	.6382	-2.177
86.6385	-2.800	86.6392	-2.190	86.6399	-2.253
.6424	-2.746	.6432	-2.194	.6443	-2.247
.6674	-2.826	.6681	-2.285	.6687	-2.373
.6749	-2.798	.6755	-2.284	.6762	-2.374
.7365	-2.819	.7372	-2.290	.7378	-2.365
.7399	-2.827	.7405	-2.282	.7410	-2.361
87.7410	-2.670	87.7417	-2.075	87.7422	-2.148
.7441	-2.661	.7447	-2.085	.7453	-2.147
.7509	-2.652	.7516	-2.059	.7526	-2.131
.7549	-2.662	.7554	-2.052	.7560	-2.124
.7618	-2.663	.7625	-2.102	.7631	-2.173
.7651	-2.683	.7657	-2.104	.7663	-2.171
.7769	-2.623	.7775	-2.079	.7781	-2.144
.7799	-2.670	.7805	-2.109	.7811	-2.185
.7989	-2.674	.7994	-2.110	.8000	-2.183
.8017	-2.677	.8023	-2.099	.8028	-2.182
.8090	-2.657	.8101	-2.091	.8102	-2.166
.8130	-2.667	.8136	-2.081	.8142	-2.172

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TROPICAL MARINE FISHES FROM PENSACOLA, FLORIDA

KEITZ HABURAY (1), ROBERT W. HASTINGS (2), DOUG DEVRIES (3), JIM MASSEY (3)

(1) Biology Department, Pensacola Junior College, Pensacola, Florida 32504;
(2) Biology Department, Rutgers University, Camden, New Jersey 08102;
(3) Biology Department, University of West Florida, Pensacola, Florida 32504

ABSTRACT: Corniger spinosis *is newly reported for the Gulf of Mexico;* Pomacentrus fuscus, P. partitus, Pomacanthus arcuatus, *and* P. paru *are new to Pensacola. Pearlfish-sea cucumber symbiosis occurs frequently in the area.*

THE present list of fishes is a supplement to an earlier paper on tropical marine fishes from Pensacola, Florida (Haburay, et al., 1969). Included are notes on the symbiotic association between *Carapus bermudensis* and *Theelothuria princeps* in the northeastern Gulf of Mexico.

New locality records in the northeastern Gulf of Mexico are reported for the following species: *Pomacentrus fuscus, Pomacentrus partitus, Pomacanthus arcuatus,* and *Pomacanthus paru.* The collection of *Corniger spinosus* is apparently a new record for the Gulf of Mexico. The present additions to the tropical fauna of the northern Gulf of Mexico will aid investigators engaged in zoogeographic studies of Western North Atlantic marine fishes.

Unless otherwise stated, all the Pensacola specimens were collected by SCUBA divers using leaded nets and plastic bags. The specimens recorded in this paper were deposited in the Pensacola Junior College Marine Collection (PJCMC—no catalog numbers) with the exception of the specimen of *Corniger spinosus* which was deposited in the fish collections of the U. S. National Museum (USNM—uncat.).

All measurements refer to standard length in millimeters.

All common and scientific names used in this paper conform with the list published by the American Fisheries Society (Bailey, et al., 1970).

FAMILY HOLOCENTRIDAE

Corniger spinosus Agassiz. 1, 141 mm (USNM—uncat.), Gulf of Mexico, 29° 56′N, 87° 11′W, May 7, 1970, coll. James Stewart. The fish was hooked on a bottom rig baited with cut mullet approximately 24 nautical miles (44 km) south-southeast from the entrance of Pensacola Bay at a depth of 53 m.

Howell-Rivero (1941) reported this species as occurring from the coast of Brazil and Cuba north of Havana. Anderson and Gutherz (1964) collected a specimen off Cape Romain, South Carolina (R/V SILVER BAY, Station 1393), and reported a range extension of about 650 nautical miles (1200 km) northward from Cuba, along the Atlantic coast of the United States. Struhsaker (1969) also listed the species as occurring along the shelf edge and in reef habitats in that area.

We found no references to its occurrence in the Gulf of Mexico. Apparently the Pensacola specimen constitutes the first record of its presence in these waters. The range extension of this species is some 510 nautical miles (945 km) into the Gulf of Mexico northward from Cuba. The species could be more widely distributed in the Gulf of Mexico but only rarely collected, as it is throughout its range, since it normally occurs at depths greater than 90 m (300 ft—Randall, 1968).

FAMILY CHAETODONTIDAE

Pomacanthus arcuatus (Linnaeus). Gray angelfish. 1, 32.6 mm juvenile (PJCMC), rock piles below Santa Rosa Sound Bridge (State Highway 399) water depth 1.5 m, 22 June 1971, coll. Jim Massey. 1, 35.41 mm juvenile (PJCMC), abandoned pipeline 1600 m east of Pensacola Bay Lighthouse, water depth 1.5 m, 25 June 1971, coll. C. F. Crooke.

Bohlke and Chaplin (1968) listed this angelfish as occurring from New England to southeastern Brazil, including the Gulf of Mexico. However, the species is not common in the Gulf and records of its occurrence there are few. Springer and Woodburn (1960) and Moe et al. (1966) reported it from off Tampa Bay, Florida (listed as *P. aureus* by Moe et al. but reidentified as *P. arcuatus* following Feddern (1968); fide Robert W. Topp, personal communication).

Caldwell (1963) recorded two specimens (70 and 107 mm SL) of the gray angelfish from off Fort Walton Beach, Florida. Briggs et al. (1964) reported one specimen (104.4 mm) collected on Stetson Reef at a depth of 56 m off the coast of Texas on 26 April 1963 and Bullis and Thompson (1965) reported one collection of this species at R/V SILVER BAY Station 10 (28° 08′N, 94° 35′W) on 29 June 1957, also off the coast of Texas at a depth of 56 m. The Pensacola specimens, collected in shallow bay waters 1.5 m in depth, constitute a new locality record for *Pomacanthus arcuatus* in the northeastern Gulf of Mexico.

Pomacanthus paru (Bloch). French angelfish. 1, 17.5 mm (PJCMC), Fort Pickens rock jetty at mouth of Pensacola Bay, water depth 4 m, 8 June 1971, coll. Doug DeVries. The following were collected by Jim Massey at the Santa Rosa Sound Bridge (State Highway 399) during the summer of 1971: 1, 17.5 mm (PJCMC), 17 June; 1, 30.0 mm (PJCMC), 20 June; 1, 28.8 mm (PJCMC), 22 June; 1, 41.9 mm (PJCMC), 16 July.

Specimens of *P. paru* were collected and observed in the Pensacola Estuary throughout the summer and fall of 1971 at the abandoned pipeline, 1.6 km east of Pensacola Bay Lighthouse, and at the Santa Rosa Sound Bridge. The authors collected four additional specimens and maintained them in aquaria—two of them for 12 months. Observation of the growth rate of one individual in the natural environment during the collection period was also noted. Although the fish was not tagged, the authors feel certain that repeated observations of a particular individual were in fact carried out because of the territorial nature of the species. Massey noted that each individual at the Santa Rosa Sound Bridge collection site remained in a rather well defined area in water 0.6-3.6 m deep. Based on this premise the specimen (17.5 mm) captured 17 June, 1971, but released at the site of capture, grew approximately 9.9 mm per month until its subsequent capture on 12 December, 1971, (86.8 mm).

The authors noted the following dominant invertebrates and algae at the Santa Rosa Sound Bridge site: Invertebrates: orange sponge, *Cliona* sp.; coral, *Astrangia solitaria*; encrusting bryozoan, *Membranipora* sp.; annelid, *Eupomatus dianthus*; mollusks, *Murex fulvescens* and *Fasciolaria hunteria*; barnacle, *Balanus eburneus*; echinoderm, *Arbacia punctulata*.

Algae: brown algae—*Sargassum filipendula*; red algae—*Digenea simplex*, *Laurencia poitei*.

Bohlke and Chaplin (1968) recorded the range of this species as both sides of the Atlantic; in the West Atlantic, from the Bahamas and Florida to southeastern Brazil.

Springer and Hoese (1958) reported a single specimen (67 mm SL) from Aransas Bay, Texas, and Bullis and Thompson (1965) listed the species at R/V SILVER BAY Station 726 off the west Florida coast near Venice (27° 12′N, 83° 14′W).

A few specimens of *P. paru* have been collected off Horn Island in Mississippi Sound. One juvenile specimen (51 mm) was collected in August, 1971, near a sunken barge in the "Horseshoe" area of Horn Island by the Marine Vertebrate Class, Gulf Coast Research Laboratory, Ocean Spring, Mississippi, and examined by the senior author.

FAMILY POMACENTRIDAE

Pomacentrus fuscus (Cuvier). Dusky damselfish. 1, 32.5 mm (PJCMC), abandoned pipeline. 1.6 km east of Pensacola Bay Lighthouse, water depth 1.5-1.8 m, 23 August 1971, coll. Doug DeVries and Keitz Haburay. 1, 29.9 mm (PJCMC), sunken debris 200 m northeast of Ft. McRee steel jetty, Pensacola Bay, water depth 3-4 m, 28 September 1972, coll. Michael Williams.

Bohlke and Chaplin (1968) listed this damselfish (as *Eupomacentrus dorsopunicans*) as occurring from Bermuda, the Bahamas and Florida through the Lesser Antilles, including the Gulf of Mexico. This species is not at all common in the Gulf of Mexico and is the least common of three species of *Pomacentrus* collected in the Pensacola area (*P. fuscus*, *P. partitus* and *P. variabilis*). In contrast, Cervigon (1966) and Randall (1968) reported *P. fuscus* as one of the most common pomacentrids in the inshore waters of the Caribbean Sea.

The first record of *P. fuscus* north of the Florida Keys was published by Dawson (1962) based upon a single juvenile specimen collected on 20 July 1956 among rocks at Fort Massachusetts, Ship Island, Mississippi. Briggs et al. (1964) reported three specimens (as *Eupomacentrus dorsopunicans*) collected on 17 September 1967 at the jetties at Port Aransas, Texas, and Causey (1969) reported the species (as *E. dorsopunicans*) as a benthic resident at Seven and One-Half Fathom Reef off Padre Island, Texas. In the northeastern Gulf of Mexico, Hastings (1972) recorded *P. fuscus* at the St. Andrew jetties at Panama City, Florida, during the summers of 1967 and 1971.

The Pensacola and Panama City specimens represent the first locality records for the dusky damselfish in the northeastern Gulf of Mexico. It is apparently another of the tropical species carried into the northern Gulf by currents.

Pomacentrus partitus (Poey). Bicolor damselfish. 1, 21.2 mm (PJCMC), Ft. McRee steel jetty, water depth 4 m, 2 July 1971, coll. Doug DeVries. 1, 33.6 mm (PJCMC), abandoned pipeline 1.6 km east of Pensacola Bay Lighthouse, water depth 1.5 m, 25 June 1971, coll. C. F. Crooke. (Dr. Luis Rivas, National Marine Fisheries Service, identified these specimens as *Pomacentrus pictus*. According to Rivas (1960) *Pomacentrus partitus* is a synonym of *P. pictus*).

Bohlke and Chaplin (1968) recorded the range of this damselfish as extending from the Bahamas and Florida through the West Indies. Hastings (1972) recorded *P. partitus* from two localities in the northeastern Gulf of Mexico, the East Pass jetties, at the mouth of Choctawhatchee Bay, Okaloosa County, near Destin, Florida; and the St. Andrew jetties at the west pass of St. Andrew Bay, Bay County, Panama City, Florida; and has subsequently found adults of the species quite numerous on the reefs of the Florida Middleground (28° 32′N, 84° 16′W) at depths of about 24-27 m. Gregory B. Smith (personal communication) has recorded the species as rare at depths of 24-42 m off Tampa Bay.

These northern Gulf records extend the range of this damselfish approximately 797 km into the northeastern Gulf of Mexico from the previous northernmost recorded locality at Tortugas, Florida (Longley and Hildebrand 1941). The records also indicate that *P. partitus* may be a permanent member of the fauna at the Florida Middlegrounds but apparently occurs only as a straggler in other northern Gulf areas.

FAMILY CARAPIDAE

Carapus bermudensis (Jones). Pearlfish. 1, 101.9 mm (PJCMC), Santa Rosa Island (Pensacola Beach), Escambia Co., Florida, 19 November 1969, coll. Keitz Haburay and T. E. Lundy. (Taken from the cloacal chamber of the sea cucumber, *Theelothuria princeps,* collected in shallow water.).

The holothurian, *Theelothuria princeps* (Selenka) is a common species in shallow, sandy areas along the outer beaches of the northeastern Gulf coast. Specimens commonly wash up on the beaches after storms. The authors have collected numerous specimens (85-200 mm long) buried in the sand approximately 100-200 m offshore at depths of about 3-5 m.

Wells and Wells (1961) reported observing thousands of *Theelothuria princeps* in windrows on the outer beach near Fort Walton Beach, Florida. Their examination of the cloacal chamber and respiratory tree of numerous specimens revealed the presence of a previously undescribed species of pinnotherid crab (which they described as *Pinnaxodes floridensis*). The particular sea cucumber noted above as containing the pearlfish was one of three specimens cut open by the senior author to illustrate to an observer the anticipated presence of the commensal crab. Both the crab and a single pearlfish were found co-habiting this single holothurian. The crab *P. floridensis* (female), was taken from the respiratory tree, and the pearlfish, *C. bermudensis,* was taken from the cloacal chamber. This is apparently the first published account of a single holothurian being co-habited by both a crab and a fish (David Pauson, USNM—personal communication), although holothurians are often cited as hosts for such commensal organisms.

Dawson (1971) recently reported several records of *Carapus bermudensis* in the northern Gulf of Mexico. Hastings has seen additional specimens from the St. Andrew Bay, Panama City, area, and also from near the mouth of St. Josephs Bay, Florida. In all cases, the pearlfishes were associated with *Theelothuria princeps.* One additional species of large holothurian, *Isostichopus badionotus* (Selenka), is common in the northeastern Gulf and could serve as a host for *Carapus.* Smith and Tyler (1969) found *Carapus* in *I. badionotus* at depths of 27-33 m in the Bahamas and suggested that this species might be the primary host in deeper waters. This holothurian is common on the jetties at St. Andrew Bay but examination of numerous specimens from this locality has failed to yield any *Carapus.*

Records of the number of *Carapus* found per number of *Theelothuria* examined may give some indication of the abundance of this fish in the northeastern Gulf. Dawson (1971) recorded one *Carapus* from one *Theelothuria* collected off Santa Rosa Island, in January, 1970. Hastings and others collected one *Carapus* from one *Theelothuria* in April, 1966, and one from about 10 *Theelothuria* collected in March, 1968, at the St. Andrew Bay jetties. Camm C. Swift collected two *Carapus* from about 30 *Theelothuria* examined in August, 1968, taken at a depth of about 18 m off the coast of St. Andrew Bay. Hastings found two *Carapus* stranded alive on the beach of Santa Rosa Island in February, 1966, along with numerous *Theelothuria.* Hastings also examined 19 holothurians taken in February, 1969, and 38 taken in March, 1969, at East Pass (at the east end of Santa Rosa Island) near Destin, Florida, but found no *Carapus.* These records indicate that *Carapus bermudensis* may not be common in the northeastern Gulf, but is apparently a permanent resident, found throughout the year, and should be expected wherever *Theelothuria princeps* occurs.

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LITERATURE CITED

ANDERSON, W. D. AND E. J. GUTHERZ. 1964(1965). New Atlantic coast ranges for fishes. Quart. J. Florida Acad. Sci. 27:299-306.

BAILEY, R. M., J. E. FITCH, E. S. HERALD, E. A. LACHNER, C. C. LINDSEY, C. R. ROBINS, AND W. B. SCOTT. 1970. A list of common and scientific names of fishes from the United States and Canada (3rd Ed.) Amer. Fish. Soc. Spec. Publ. 6:149 p.

BOHLKE, J. E., AND C. C. G. CHAPLIN. 1968. Fishes of the Bahamas and adjacent tropical waters. Livingston Publ. Co. Wynnewood, Pa.

BRIGGS, J. C., H. D. HOESE, W. F. HADLEY, AND R. S. JONES. 1964. Twenty-two new marine fish records for the north-western Gulf of Mexico. Texas J. Sci. 16:113-116.

BULLIS, H. R., JR., AND J. R. THOMPSON. 1965. Collections by the exploratory fishing vessels OREGON, SILVER BAY, COMBAT, and PELICAN made during 1956 to 1960 in the south-western North Atlantic. U.S. Fish Wildl. Serv. Spec. Sci. Rpt. Fisheries 510:130 p.

CALDWELL, D. K. 1963. Tropical marine fishes in the Gulf of Mexico. Quart. J. Florida Acad. Sci. 26:188-191.

CAUSEY, B. D. 1969. The fishes of Seven and One-Half Fathom Reef. M. S. Thesis. Texas A & I University. Kingsville, Texas.

CERVIGON, M. F. 1966. Los peces marinos de Venezuela. Tomo II. Fund. La Salle Cien. Nat. Caracas Monogr. 12:439-952.

DAWSON, C. E. 1962. New records and notes on fishes from the northcentral Gulf of Mexico. Copeia 1962:442-444.

———. 1971. Records of the pearlfish, *Carapus bermudensis*, in the northern Gulf of Mexico and of a new host species. Copeia 1971:730-731.

FEDDERN, H. A. 1968. Hybridization between the western Atlantic angelfishes, *Holocanthus isabelita* and *H.* ciliaris. Bull. Mar. Sci. 18:351-382.

HABURAY, K., C. F. CROOKE, AND R. HASTINGS. 1968(1969). Tropical marine fishes from Pensacola, Florida. Quart. J. Florida Acad. Sci. 31:213-219.

HASTINGS, R. W. 1972. The origin and seasonality of the fish fauna on a new jetty in the north-eastern Gulf of Mexico. Ph.D. Dissertation. Florida State Univ. Tallahassee.

HOWELL-RIVERO, L. 1941. "*Corniger spinosus*" Agassiz: nueva especie para Cuba y algunas consideraciones acerca de la misma. Torreia 6:3-7.

LONGLEY, W. H. AND S. F. HILDEBRAND. 1941. Systematic catalogue of the fishes of Tortugas, Florida. Carnegie Inst. Washington Publ. 535:i-xiii; 1-331.

MOE, M. A., P. C. HEEMSTRA, J. E. TYLER AND H. WAHLQUIST. 1966. An annotated listing of the fish reference collection at the Florida Board of Conservation Marine Laboratory. Florida State Bd. Conserv. Mar. Lab. Spec. Sci. Rpt. 10:1-121.

RANDALL, J. E. 1968. Caribbean Reef Fishes. T.F.H. Publ. Inc. Jersey City, New Jersey.

RIVAS, L. R. 1960. The fishes of the genus *Pomacentrus* in Florida and the western Bahamas. Quart. J. Florida Acad. Sci. 23:130-162.

SMITH, C. L., AND J. C. TYLER. 1969. Observations on the commensal relationship of the western Atlantic pearlfish, *Carapus bermudensis*, and holothurians. Copeia 1969:206-208.

SPRINGER, V. G., AND HINTON D. HOESE. 1958. Notes and records of marine fishes from the Texas coast. Texas Jour. Sci. 10:343-348.

———, AND K. D. WOODBURN. 1960. An ecological study of the fishes of the Tampa Bay area. Florida State Bd. Conserv. Marine Lab. Prof. Pap. Ser. 1:104 p.

STRUHSAKER, P. 1969. Demersal fish resources: Composition, distribution and commercial potential of the Continental Shelf Stocks off southeastern United States. U.S. Fish Wildl. Serv. Fish. Ind. Res. 4:261-300.

WELLS, H. W., AND M. J. WELLS. 1961. Observations on *Pinnaxodes floridensis*, a new species of Pinnotherid crustacean commensal in holothurians. Bull. Mar. Sci. Gulf & Caribbean. 11:267-279.

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ECOLOGICAL AND DISTRIBUTIONAL NOTES ON THE FRESHWATER FISH OF SOUTHERN FLORIDA

JAMES A. KUSHLAN AND THOMAS E. LODGE

Department of Biology, University of Miami, Coral Gables, Florida 33124

ABSTRACT: *The freshwater fish fauna is composed of 108 species in 34 families. Only 29% of the fauna belong to obligatory freshwater families. The* Cyprino dontidae *and* Poeciliidae *represent 19% of the native fauna. Eleven exotic species are established. The distribution and habitat of each species are described.*

DESPITE recent interest in the wetlands of southern Florida, the freshwater fish fauna of the region is superficially known and poorly documented. The only published list of freshwater fish known to occur in this region (Kilby and Caldwell, 1955) is derived primarily from limited field collections in and near Everglades National Park. Studies of ecology and life history of southern Florida fish have been limited almost entirely to commercially important species and, with few exceptions such as Hunt (1953), Gunter and Hall (1963a, 1965), and Kushlan (1972a), published studies on the freshwater fish communities of southern Florida are almost nonexistent.

Ecological work has been hampered by the paucity of published distributional information. In addition, it is difficult for workers to judge the significance of new results because the pertinent literature is widely scattered. Information on southern Florida fish fauna is included in previous state lists starting with Evermann and Kendall (1900) and including the important works of Carr and Goin (1955) and Briggs (1958). The latter papers were based primarily on northern Florida specimens and reflected the paucity of information available on southern Florida fish.

The purpose of this paper is to summarize existing published information on the freshwater fishes of southern Florida with the addition of recent data collected by the authors. We have emphasized the gross distribution of each species and have added information on habitat preferences wherever possible. Detailed information on reproduction and other aspects of biology are too little known in most species for inclusion. The paper includes those native species of fish which have been collected in freshwater in Lake Okeechobee, the Caloosahatchee and St. Lucie Rivers, south to the southern tip of the peninsula. This region encompasses the vast freshwater swamps and marshes of the Everglades and Big Cypress Swamp (Fig. 1). The list also includes introduced species which have established populations in the region. Davis (1943) and Craighead (1971) described this region and the ecological communities found within it.

Fig. 1. Map of southern Florida.

Fauna—The freshwater fish fauna of southern Florida is composed of 108 species listed in Table 1. The list is divided into two broad categories of "principally freshwater" and "principally marine" species. Each species is assigned to one of these categories based upon present information on whether or not the species carries out its life cycle in freshwater which we define as having a salinity of less than 0.30% (Gunter and Hall, 1963b). Distinguishing between the two categories becomes somewhat difficult because of the large number of marine species which occur in freshwater in Florida (Carr, 1937; Gunter, 1942; Hubbs and Allen, 1943; Herald and Stickland, 1949; Carr and Goin, 1955; Tagatz, 1968). Over half the species listed in Table 1 are marine. Possible reasons for this phenomenon have been discussed by Odum (1953), Hulet et al. (1967), Martin (1972) and others. Some species classified as principally marine, such as the catadromous American eel (*Anguilla rostrata*) and the tarpon (*Megalops atlantica*), move far into the Everglades and Big Cypress Swamp. Other marine species move inland only short distances from the coast and are generally found in canals and rivers. Some families have both principally marine and principally freshwater members.

TABLE 1. List of the freshwater fishes of southern Florida.

	Principally Freshwater Species	
Lepisosteus osseus	Noturus leptacanthus	Labidesthes sicculus
Lepisosteus platyrhincus	Clarius batrachus[1]	Elassoma evergladei
Amia calva	Hypostomus sp.[1]	Enneacanthus gloriosus
Dorosoma cepedianum	Aphredoderus sayanus	Lepomis gulosus
Dorosoma petenense	Cyprinodon variegatus	Lepomis macrochirus
Esox americanus	Fundulus chrysotus	Lepomis marginatus
Esox niger	Fundulus cingulatus	Lepomis microlophus
Notemigonus crysoleucas	Fundulus confluentus	Lepomis punctatus
Notropis chalybaeus	Fundulus seminolis	Micropterus salmoides
Notropis emiliae	Jordanella floridae	Pomoxis nigromaculatus
Notropis maculatus	Lucania goodei	Etheostoma fusiforme
Notropis petersoni	Belonesox belizanus[1]	Astronotus ocellatus[1]
Erimyzon sucetta	Gambusia affinis	Cichlasoma bimaculatum[1]
Ictalurus catus	Heterandria formosa	Cichlasoma octofasciatum[1]
Ictalurus natalis	Poecilia latipinna	Cichlasoma nigrofasciatum[1]
Ictalurus nebulosus	Xiphophorus helleri[1]	Hemichromis bimaculatus[1]
Ictalurus punctatus	Xiphophorus variatus[1]	Tilapia mossambica[1]
Noturus gyrinus		
	Principally Marine Species	
Carcharhinus leucas	Menidia beryllina	Sciaenops ocellata
Dasyatus sabina	Centropomus ensiferus	Mugil cephalus
Elops saurus	Centropomus parallelus	Mugil curema
Megalops atlantica	Centropomus pectinatus	Mugil trichodon
Anguilla rostrata	Centropomus undecimalis	Dormitator maculatus
Brevoortia smithi	Caranx hippos	Eleotris pisonis
Brevoortia tyrannus	Oligoplites saurus	Gobiomorus dormitor
Anchoa hepsetus	Lutjanus griseus	Gobioides broussonneti
Anchoa mitchilli	Diapterus olisthostomus	Gobionellus boleosoma
Arius felis	Diapterus plumieri	Gobionellus gracillimus
Bagre marinus	Eucinostomus argenteus	Gobionellus hastatus
Strongylura marina	Eucinostomus gula	Gobiosoma bosci
Strongylura notata	Archosargus probatocephalus	Gobiosoma robustum
Strongylura timucu	Lagodon rhomboides	Lophogobius cyprinoides
Adinia xenica	Cynoscion arenarius	Microgobius gulosus
Floridichthys carpio	Cynoscion regalis	Citharichthys spilopterus
Fundulus grandis	Leiostomus xanthurus	Achirus lineatus
Fundulus similis	Micropogon undulatus	Trinectes maculatus
Lucania parva	Pogonias cromis	

[1] introduced species

An analysis of the freshwater fish fauna by families is presented in Table 2. Two of the 36 families listed are considered to be hypothetical because representatives have not been collected in freshwater in southern Florida although they are expected to occur there. Three other families are represented only by introduced species. Each family is classified in Table 2 as belonging to the primary, secondary or peripheral division of fishes. These groupings, based upon the system of Myers (1938) and later authors, classify families as to their physiological adaptation to marine environments and therefore reflect their ability to invade new areas by marine routes.

TABLE 2. Families and number of species of freshwater fish in southern Florida.

Family[1]	Salinity class[2]	Number of verified species	Number of principally freshwater species	Number of principally marine species	Number of established exotic species	Number of hypothetical species[3]
Carcharhinidae	Per	1	0	1	0	0
[Pristidae]	Per	0				2°
Dasyatidae	Per	1	0	1	0	0
Lepisosteidae	Prim	2	2	0	0	0
Amiidae	Prim	1	1	0	0	0
Elopidae	Per	2	0	2	0	0
Anguillidae	Per	1	0	1	0	0
Clupeidae	Per	4	2	2	0	0
Engraulidae	Per	2	0	2	0	0
Esocidae	Prim	2	2	0	0	0
Cyprinidae	Prim	5	5	0	0	0
Catostomidae	Prim	1	1	0	0	0
Ictaluridae	Prim	6	6	0	0	0
Clariidae	Sec	1	0	0	1	0
Ariidae	Per	2	0	2	0	0
Loricariidae	Prim	1	0	0	1	0
Aphredoderidae	Prim	1	1	0	0	0
Belonidae	Per	3	0	3	0	0
Cyprinodontidae	Sec	12	7	5	0	1°
Poeciliidae	Sec	6	3	0	3	1°
Atherinidae	Per	2	1	1	0	0
[Syngnathidae]	Per	0				1°
Centropomidae	Per	4	0	4	0	0
Centrarchidae	Prim	9	9	0	0	0
Percidae	Prim	1	1	0	0	0
Carangidae	Per	2	0	2	0	1°
Lutjanidae	Per	1	0	1	0	1°
Gerreidae	Per	4	0	4	0	1°
Sparidae	Per	2	0	2	0	1°
Sciaenidae	Per	6	0	6	0	1°
Cichlidae	Sec	6	0	0	6	2
Mugilidae	Per	3	0	3	0	0
Eleotridae	Per	3	0	3	0	0
Gobiidae	Per	8	0	8	0	2°
Bothidae	Per	1	0	1	0	0
Soleidae	Per	2	0	2	0	0

[1]Brackets indicate family is based entirely on species of hypothetical occurrence.
[2]Classified as primary (Prim), secondary (Sec), or peripheral (Per) freshwater families. Peripheral families include those elsewhere classified as vicarious, complementary, and diadromous. Classification use follows Myers (1938) and Miller (1966) except for Lepisosteidae which is usually considered to be a secondary family and Clariidae which is usually considered to be a primary family. These follow the suggestion of C. R. Robins (personal communication).
[3]Hypothetical status is due to either (°) euryhaline species of unproven occurrence in freshwater in southern Florida or (‡) freshwater species whose current breeding status is unknown.

Native Fauna: There are 97 species of native freshwater fishes in southern Florida. It is of biogeographic interest that only 9 of the 31 native families found in southern Florida belong to the primary (i.e., obligatory freshwater) division and represent only 29% of the entire native fauna. The affinities of these families are decidedly temperate North American, all having ranges extending at least as far north as the Great Lakes region. Species of primary families occurring in southern Florida are derived from the coastal plain fauna of southeastern North America. Most of the primary families, especially the Catostomidae, Percidae and Cyprinidae experience a reduction in the number of species from north to south in Florida (see Briggs, 1958) despite the existence of continuous freshwater avenues for colonization. It seems most probable that the weak invasion of southern Florida by these families is due to a lack of proper habitat. The catostomids, percids and cyprinids are primarily fish of fast-flowing streams, a habitat missing from central and southern Florida. Species of these families that do occur in southern Florida are those which occupy slow-moving marsh and swamp habitats throughout their range. Two other families of primary freshwater fish, the Ictaluridae and Centrarchidae, are well-represented in southern Florida. While southern Florida ictalurids are found commonly in shallow habitats, the centrarchids are primarily fishes of stable habitats and are presently found in greatest abundance in canals, the most permanent of present-day habitats.

The native southern Florida freshwater fish fauna has two additional biogeographic components corresponding to the peripheral and secondary divisions. Only two native families are members of the secondary division. The Cyprinodontidae with 12 species makes the largest contribution of any family to the fauna. This family and the closely related Poeciliidae, together represent 19% of the total native fauna and one-quarter of the native species considered to be principally freshwater fish. These species, in addition, form the dominant component of the small fish fauna of the freshwater ecosystems of southern Florida. Although both of these families are derived from the neotropics, they have undoubtedly entered southern Florida from the north by both freshwater and marine routes.

Peripheral families comprise 20 of 41 native families and include the two hypothetical families of southern Florida fish. It is notable that peripheral families account for 56 of the 97 species of native fish verified to occur in southern Florida and that 3 of these are considered to be principally freshwater species.

Exotic Fauna: Eleven species of introduced fish are known to be established in freshwater in southern Florida. These comprise the families Clariidae, Loricariidae, Poeciliidae and Cichlidae (Table 2). This fauna has been recently reviewed by Lachner, Robins and Courtenay (1970) and Courtenay and Robins (1973).

Six of the species of exotic fish currently established in southern Florida are members of the tropical secondary freshwater family Cichlidae, a highly diversified group considered to be in many ways the ecological counterpart of the centrarchids. Members of this family are generally well adapted for survival in the Everglades and Big Cypress Swamp due to their ability to withstand drought, their highly developed system of parental care and their general aggressiveness. The Centrarchidae on the other hand comprise a primary freshwater family which reaches the extreme of its range in southern Florida in habitats characterized by seasonal drought to which the family is poorly adapted (Kushlan, 1974). It is anticipated that the spread of cichlids will be at the expense of the native centrarchids. The range expansion of *Cichlasoma bimaculatum*, already widespread throughout southern Florida, was aided by its tolerance of brackish water and its use of the extensive canal system of the interior. The future of both the exotic and native fish fauna of southern Florida should be a matter of concern.

FUTURE STUDY—It is hoped that this paper will serve to stimulate interest in and further research on the freshwater fish of southern Florida. The paucity of published information which compelled us to begin this work was even more apparent in its compilation. We have noted however some especially glaring gaps in current knowledge.

Due to the existence of canals, the correlation between the present distribution of fish and their historical distribution is not exact. It is anticipated that older collections might shed some light on this problem. This paper does not include data from any of the extensive collections of southern Florida fish which exist in various locations. The study of these collections might reveal interesting patterns of changing distribution.

Apparently biogeographic differences exist between the eastern and western parts of southern Florida, the one composed of the Lake Okeechobee-Everglades basin, the other composed of the Big Cypress Swamp, sandy flatwoods and Caloosahatchee river drainage. These patterns cannot be resolved without extensive sampling in and near the Big Cypress Swamp, where few data presently exist.

The extent of the penetration of marine fish into freshwater, especially in canals and rivers, deserves additional study. In this respect the Gobeiidae and the Eleotridae present particularly interesting problems. Of all the families included in this paper we have been most hesitant and tentative in our accounts of the gobies. Study of the ecology, distribution and life history of species in both these families is much desired.

Finally we might take note that intensive ecological studies of southern Florida fish have only recently begun. Much additional work is necessary. The area presents abundant opportunity for significant and rewarding study.

SPECIES ACCOUNTS

The species accounts that follow describe the range and habitat of 108 verified and 14 hypothetical species of freshwater fish. Nomenclature and sequence follows Bailey et al. (1970) wherever possible. Names of introduced fishes follow Courtenay and Robins (1973). All information not credited to other sources are observations or generalizations attributable to the authors. It should be noted that the primary state work, Carr and Goin (1955) credits a number of species to southern Florida which apparently do not occur there. These species which have been excluded from the present paper include the following: Atlantic sharpnose shark, *Rhizoprinodon terraenovae* (Richardson); hickory shad, *Alosa mediocris* (Mitchill); skipjack herring, *Alosa chrysochloris* (Rafinesque); Alewife, *Alosa pseudoharengus* (Wilson); mummichog, *Fundulus heteroclitus* (Linnaeus);

mountain mullet, *Agonostomus monticola* (Bancroft); and frillfin goby, *Bathygobius soporator* (Valenciennes).

Order SQUALIFORMES, Family CARCHARHINIDAE

Carcharhinus leucas (Valenciennes). The bull shark is a euryhaline species (Briggs, 1958) credited to the Florida freshwater fauna by Carr and Goin (1955) who stated that no specimens were recorded. Large rivers such as the Caloosahatchee, St. Lucie and the numerous smaller rivers of the southwest coast such as the Shark, Broad and North Rivers of Everglades National Park provide suitable habitat. Odum (1971) found juveniles in freshwater in North River in 1967.

Order RAJIFORMES, Family PRISTIDAE

Pristis pectinata Latham—hypothetical. The small tooth sawfish is a euryhaline species present along the southwest coast and may ascend the coastal rivers into freshwater.

Pristis perotteti Muller and Henle—hypothetical. The status of the largetooth sawfish is similar to that of the smalltooth sawfish.

Family DASYATIDAE

Dasyatis sabina (Lesueur). The Atlantic stingray ascends both the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965) to freshwater.

Order SEMIONOTIFORMES, Family LEPISOSTEIDAE

Lepisosteus osseus (Linnaeus). Although Carr and Goin (1955) and Briggs (1958) considered the longnose gar to range throughout the state, the species apparently occurs in southern Florida only in Lake Okeechobee (Ager, 1971). The subspecies is *L. o. osseus* (Linnaeus).

Lepisosteus platyrhincus DeKay. The Florida gar is found in all habitats throughout the freshwater swamps and marshes of southern Florida. It is abundant in marsh-lined canals (Hunt, 1953, 1960), ponds, cypress sloughs, mangrove streams and other deep-water habitats. It is not common in canals in developed areas or along agricultural canals in southeast Dade County (Belshe, 1961). It occurs in cypress swamps and sawgrass marshes near canals during high water levels and apparently penetrates into the interior Everglades during prolonged high water. It moves into mangroves during the rainy season (Tabb and Manning, 1961; Odum, 1971).

Order AMIIFORMES, Family AMIIDAE

Amia calva Linnaeus. The bowfin (often called mudfish) is found throughout southern Florida. It is probably most common during high water in shallow communities but becomes abundant in ponds and canals during low water where it is well adapted for survival during drought.

Order ELOPIFORMES, Family ELOPIDAE

Elops saurus Linnaeus. The ladyfish occurs in freshwater in southern Florida in mangrove swamps (Tabb and Manning, 1961), in canals connected to salt water and in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965). It is pelagic in Lake Okeechobee (Ager, 1971).

Megalops atlantica Valenciennes. The tarpon is widespread in freshwater in southern Florida (Carr and Goin, 1955) as both juveniles (Wade, 1962) and adults. It occurs in airboat trails in the southern Everglades, in Taylor Slough during high water, and in canals in the conservation areas, the Big Cypress Swamp, and along both coasts. Large individuals are dependent upon such deep water habitats for dispersal as is shown by the fact that tarpons appeared in Deep Lake after the construction of a canal joining the lake to Barron River Canal (B. P. Hunt, personal communication).

Order ANGUILLIFORMES, Family ANGUILLIDAE

Anguilla rostrata (Lesueur). The American eel is a catadromous species found in most deeper water areas of southern Florida with connections to the ocean. These include mangrove streams, Lake Okeechobee (Ager, 1971) and many canals, including shallow ones, as far inland as the Big Cypress Swamp and Everglades.

Order CLUPEIFORMES, Family CLUPEIDAE

Brevoortia smithi Hildebrand. The yellowfin menhaden occurs in freshwater in Everglades National Park (C. R. Robins, personal communication) and in the St. Lucie River, where the presence of young is dependent upon low salinity (Gunter and Hall, 1963a).

Brevoortia tyrannus (Latrobe). The Atlantic menhaden occurs in freshwater in the Everglades National Park (C. R. Robins, personal communication) and in the St. Lucie River where it spawns (Gunter and Hall, 1963a).

Dorosoma cepedianum (Lesueur). The gizzard shad occurs in lakes and canals in southern Florida. It occurs in the St. Lucie River (Gunter and Hall, 1963a) and is plentiful in and around Lake Okeechobee (Ager, 1971). It is scarcer farther south but ranges through the conservation areas and into Everglades National Park (Phillips, 1971).

Dorosoma petenense (Gunter). The threadfin shad is abundant in Lake Okeechobee and nearby canals (Ager, 1971) and occurs in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965). It is apparently less common south of Lake Okeechobee but occurs in canals as far south as Everglades National Park (Phillips, 1971). The subspecies is *D. p. vanhyningi* (Weed).

Family ENGRAULIDAE

Anchoa hepsetus (Linnaeus). The striped anchovy apparently occurs in freshwater along both coasts (Carr and Goin, 1955) and has been recorded from southern Florida by Ogilvie (1969). However Gunter and Hall (1963a) stated that their record from a salinity of 1.0% in the St. Lucie River is the lowest salinity from which the species has been reported, and Odum (1971) noted it only occasionally strays into North River. The subspecies is *A. h. hepsetus* (Linnaeus).

Anchoa mitchilli (Valenciennes). The widespread and abundant bay anchovy invades freshwater rivers along both coasts (Carr and Goin, 1955) including the St. Lucie (Gunter and Hall, 1963a), Caloosahatchee (Gunter and Hall, 1965), and North Rivers (Odum, 1971). An unidentified species of *Anchoa* was taken in Lake Okeechobee (Florida Game and Fresh Water Fish Commission, 1956). The subspecies is *A. m. diaphana* Hildebrand.

Order SALMONIFORMES, Family ESOCIDAE

Esox americanus Gmelin. The redfin pickerel occurs in marginal areas of Lake Okeechobee (Ager, 1971) and has been found in Conservation Area 3 (Dineen, 1972). It is primarily a fish of shallow marshes. The subspecies is *E. a. americanus* Gmelin.

Esox niger Lesueur. The chain pickerel occurs in vegetated areas of Lake Okeechobee (Ager, 1971), through the Everglades, and into Everglades National Park. Dineen (1968) stated that this species was established in Conservation Area 2 but not Area 3. However, it occurs commonly in Tamiami Canal south of Area 3. It is primarily a fish of canals and deep-water marshes and may have extended its range southward with the construction of the canal system.

Order CYPRINODONTIFORMES, Family CYPRINIDAE

Notemigonus crysoleucas (Mitchill). The golden shiner is widely distributed throughout southern Florida from Lake Okeechobee (Ager, 1971) to the limits of freshwater in the Everglades. It is especially common in ponds, sloughs and canals where it achieves its largest size. Juveniles have been collected in open dwarf cypress swamp and open marsh prairie in the Big Cypress Swamp and the Everglades. The subspecies is *N. c. bosci* (Valenciennes).

Notropis chalybaeus (Cope). The ironcolor shiner occurs in Lake Okeechobee (Ager, 1971) westward to Fort Myers (W. R. Courtenay, Jr., personal communication).

Notropis emiliae (Hay). The pugnose minnow is found in Lake Okeechobee (Ager, 1971; Gilbert and Bailey, 1972). The subspecies is *N. e. peninsularis* Gilbert and Bailey (1972).

Notropis maculatus (Hay). The taillight shiner has been recorded throughout much of southern Florida. It occurs in Lake Okeechobee (Ager, 1971), in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Raney et al., 1953; Gunter and Hall, 1965), and in several locations in the Big Cypress Swamp. It was collected in Shark River Slough several miles south of Tamiami Canal but has not yet been found further south. It seems to prefer slow-moving canals (W. R. Courtenay, Jr., personal communication).

Notropis petersoni Fowler. The coastal shiner seems to occur throughout much of southern Florida. It occurs in Lake Okeechobee (Ager, 1971) and the Caloosahatchee River (Raney et al., 1953; Gunter and Hall, 1965), but Gunter and Hall (1963a) did not report it from the St. Lucie River. It is the most abundant shiner (*Notropis*) in the southern Everglades although varying in abundance in different years. It has been collected as far south as the freshwater streams of lower Shark River Slough. It also has been collected in the Big Cypress Swamp near Copeland (C. R. Robins, personal communication) and Monroe.

Family Catostomidae

Erimyzon sucetta (Lacepede). The lake chubsucker is abundant and widespread throughout southern Florida from Lake Okeechobee (Ager, 1971) south throughout the Everglades and Big Cypress Swamp. It has been collected in the streams of the lower Everglades and in freshwater in mangrove swamps. It usually occurs in vegetated areas and is common in canals and ponds. Juveniles have been collected widely in sawgrass marsh, marsh prairie, cypress sloughs and ponds. The subspecies is *E. s. sucetta* (Lacepede).

Order Siluriformes, Family Ictaluridae

Ictalurus catus (Linnaeus). The white catfish has been recorded from Lake Okeechobee where it is abundant in open water (Ager, 1971) and from the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965) where it occurs only in low salinity.

Ictalurus natalis (Lesueur). The yellow bullhead ranges from Lake Okeechobee (Ager, 1971), throughout the Everglades and Big Cypress Swamp, and into mangrove swamps during periods of heavy rainfall. It is most abundant in close proximity to submerged vegetation in canals and ponds but has been collected in dwarf cypress swamp, marsh prairie and sawgrass marsh. The population has been referred to as *I. n. erebennus* Jordan (Hubbs and Allen, 1943).

Ictalurus nebulosus (Lesueur). The brown bullhead occurs throughout southern Florida being abundant in Lake Okeechobee (Ager, 1971) and common in the Big Cypress Swamp. It occurs in low salinity in the St. Lucie River (Gunter and Hall, 1963a). It apparently occurs in more open, muddy bottomed situations than does *I. natalis* and so is found in shallow ponds and sloughs as well as in the deeper water of canals and lakes. It seems generally less abundant than *I. natalis.* The subspecies is *I. n. marmoratus* (Holbrook).

Ictalurus punctatus (Rafinesque). The channel catfish occurs in open water in Lake Okeechobee (Ware, 1966; Ager, 1971) and in low salinities in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965). It ranges south through the conservation areas to Tamiami Canal (Hunt, 1953) and into Everglades National Park (Phillips, 1971) inhabiting deep canals almost exclusively.

Noturus gyrinus (Mitchill). The tadpole madtom ranges from Lake Okeechobee (Ager, 1971) throughout southern Florida to Taylor Slough, lower Shark River Slough of the Everglades, and into the mangrove swamps of the southern coast (Tabb and Manning, 1961).

Noturus leptacanthus Jordan. The speckled madtom has been recorded from the Caloosahatchee River (Gunter and Hall, 1965).

Family Clariidae

Clarius batrachus (Linnaeus). The walking catfish was established near West Palm Beach in 1968 (Idyll, 1969). It now ranges from Ft. Lauderdale north to Lake Okeechobee and West Palm Beach with disjunct populations around Miami (Lachner, Robins and Courtenay, 1970).

Family Ariidae

Arius felis (Linnaeus). The sea catfish occurs in freshwater in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965) and in canals further south. It is abundant in freshwater throughout North River (Odum, 1971).

Bagre marinus (Mitchill). The gafftopsail catfish occurs in freshwater in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965).

Family Loricariidae

Hypostomus sp. A mailed catfish identified as *Hypostomus plecostomus* (Linnaeus) has been reported from a borrow pit in west Miami by Rivas (1965). However, due to taxonomic uncertainty, identification of southern Florida specimens is not presently possible (C. R. Robins, personal communication). Mailed catfish have been taken from the Snapper Creek Canal system (Lachner, Robins, and Courtenay, 1970) and canals near Conservation Area 3 (C. R. Robins, personal communication).

Order Percopsiformes, Family Aphredoderidae

Aphredoderus sayanus (Gilliams). The pirate perch has been recorded to range to Lake Okeechobee (Florida Game and Fresh Water Fish Commission, 1956). Although Briggs (1958) and Carr and Goin (1955) stated that it ranges throughout southern Florida, the only specimen known from the area was near Florida City in 1930 (Kilby and Caldwell, 1955). In view of the lack of additional specimens, we assume that location data of the 1930 specimen is probably erroneous.

Order Atheriniformes, Family Belonidae

Strongylura marina (Walbaum). The atlantic needlefish is found in many southern Florida canals even into the Everglades. It is common throughout open areas and bullrush marshes of Lake Okeechobee and has reproduced there (Ager, 1971).

Strongylura notata (Poey). The redfin needlefish has been recorded from freshwater in the St. Lucie River (Gunter and Hall, 1963a, b).

Strongylura timucu (Walbaum). The timucu has been found in canals in southeast Dade County (Belshe, 1961) and in freshwater near the northern Ten Thousand Islands area (T. Schmidt, personal communication).

Family Cyprinodontidae

Adinia xenica (Jordan and Gilbert). The diamond killifish ranges along the Gulf Coast to the southern tip of the peninsula primarily in brackish water (Carr and Goin, 1955; Tabb and Manning, 1961). It has been collected in freshwater in North River (Odum, 1971), and it extends in some years into the freshwater of the southern Florida Everglades nearly as far north as Tamiami Canal.

Cyprinodon variegatus Lacepede. The sheepshead minnow occurs in brackish and freshwater from Lake Okeechobee (Ager, 1971) and the Caloosahatchee River (Raney et al., 1953) south to the mangroves and rivers of southern coast (Tabb and Manning, 1961; Odum, 1971). In some years it becomes very abundant in some localities in the Everglades and Big Cypress Swamp while in other years it is uncommon. This also appears to be the case in North River (Odum, 1971). Scattered individuals can be found in most open habitats. In the southern Everglades and Big Cypress the species is usually encountered near rocky culverts. It becomes more abundant and more regularly present in the southern Everglades near the mangrove coast. The subspecies is *C. v. variegatus* Lacepede.

Floridichthys carpio (Gunter). The goldspotted killifish is a euryhaline species occurring along both coasts (Briggs, 1958) in southern Florida. It has been recorded from freshwater in the North River (Odum, 1971). The subspecies is *F. c. carpio* (Gunter).

Fundulus chrysotus (Gunter). The golden topminnow ranges throughout southern Florida. It occurs in shallow spikerush marshes of Lake Okeechobee (Ager, 1971) and in all habitats southward to the limits of freshwater in lower Shark River Slough. It seems primarily a fish of relatively deeper water being common in ponds and along canal margins.

Fundulus cingulatus Valenciennes. The banded topminnow is apparently not common in southern Florida but extends to at least Ft. Myers on the west coast according to Brown (1957) who also recorded it from the Tamiami Canal.

Fundulus confluentus Goode and Bean. The marsh killifish is a euryhaline species that ranges as far south as Key West (Miller, 1955). It occurs in freshwater in the Caloosahatchee River (Raney et al., 1953), in the Everglades, Big Cypress Swamp (Kushlan, 1973), and rivers and mangroves of the southern coast (Tabb and Manning, 1961; Odum, 1971). The subspecies is *F. c. confluentus* Goode and Bean.

Fundulus grandis Baird and Girard. The gulf killifish is a euryhaline and primarily brackish water species ranging along the Gulf (Miller, 1955) and Atlantic coasts (Briggs, 1958; Harrington and Harrington, 1961) and into the keys (Rivas, 1948). It occurs in freshwater in coastal canals, the Caloosahatchee River (Gunter and Hall, 1965) and mangroves (Tabb and Manning, 1961). The subspecies is *F. g. grandis* Baird and Girard.

Fundulus seminolis Girard. The seminole killifish occurs in Lake Okeechobee (Ager, 1971), the Caloosahatchee River (Raney et al., 1953; Gunter and Hall, 1965) and the Everglades to lower Shark River Slough. In the Big Cypress Swamp its been collected in the Fahkahatchee Strand.

Fundulus similis (Baird and Girard). The longnose killifish is a primarily brackish water species found along both coasts to Key West (Briggs, 1958). It ascends streams and canals into slightly brackish and freshwater (Tabb and Manning, 1961; Phillips, 1971; Carr and Goin, 1955).

Jordanella floridae Goode and Bean. The flagfish occurs throughout southern Florida. It is common in shallow marginal areas in Lake Okeechobee (Ager, 1971) and along canals. It occurs in marsh prairies and sawgrass marshes in the Everglades and especially in dwarf cypress in the Big Cypress Swamp. It becomes abundant in ponds during low water level (Kushlan, 1972a). It is primarily a bottom fish, common in dense, submerged vegetation and is also found in brackish water (Tabb and Manning, 1961).

Lucania goodei Jordan. The bluefin killifish is common throughout southern Florida into pools of the mangrove swamp where it occurs only during pulses of freshwater (Tabb and Manning, 1961; Odum, 1971). It is abundant in highly vegetated areas and especially along canal margins but is widespread in all habitats of the Big Cypress Swamp and Everglades. It occurs in the littoral zone of Lake Okeechobee (Ager, 1971).

Lucania parva (Baird). The rainwater killifish is a primarily brackish water species ranging to the Florida Keys (Hubbs and Miller, 1965). It occurs in freshwater in the Caloosahatchee River (Gunter and Hall, 1965), in mangrove swamps, rivers and canals along the coast (Carr and Goin, 1955; Raney et al., 1953; Belshe, 1961; Odum, 1971).

Rivulus marmoratus Poey—hypothetical. The rivulus is a brackish water species (Harrington and Rivas, 1958) which was found in canals in southeast Dade County by Belshe (1961), but the salinity was not reported.

Family Poeciliidae

Belonesox belizanus Kner. The introduced pike killifish is abundant in canals in southeastern Dade County (Belshe, 1961; Lachner, Robins and Courtenay, 1970).

Gambusia affinis (Baird and Girard). The mosquitofish ranges throughout fresh and brackish water in southern Florida where it is the most ubiquitous species of fish (Kushlan, 1972a). It is found in habitats ranging from salt marshes (Harrington and Harrington, 1961) to Lake Okeechobee (Ager, 1971). It is usually the most abundant fish in canals, cypress sloughs, ponds, and dwarf cypress swamps. The subspecies is called the eastern mosquitofish, *G. a. holbrooki* Girard.

Gambusia rhizophorae Rivas—hypothetical. The mangrove gambusia is characteristically found in estuarine situations in association with mangrove swamps. Rivas (1969) however, stated that the original specimens were obtained near Paradise Key (Everglades National Park) which is surrounded by freshwater. We have no other records of its occurrence in freshwater. It is possible that the location data on the Paradise Key specimens was in error as it is doubtful that the species occurs even rarely in freshwater (C. R. Robins, personal communication).

Heterandria formosa Agassiz. The least killifish is found in freshwater throughout southern Florida. It is abundant in the littoral zone of Lake Okeechobee (Ager, 1971), in canals (Hunt, 1953), in the Big Cypress Swamp and in marsh prairies and sawgrass marshes of the Everglades where it is often one of the most abundant species. It also occurs in freshwater in mangrove swamps (Tabb and Manning, 1961) but rarely if ever moves into brackish water. It is usually associated with thick emergent and submerged vegetation where it remains close to submerged stems.

Poecilia latipinna (Lesueur). The sailfin molly is a euryhaline species occurring in freshwater throughout southern Florida. In freshwater habitats, it is probably most abundant and reaches its greatest size in canals but it occurs in most habitats including Lake Okeechobee (Ager, 1971).

Xiphophorus helleri Heckel. The green swordtail is established in canals in Palm Beach County (W. R. Courtenay, personal communication).

Xiphophorus variatus (Meek). The variable platyfish is established in canals in Palm Beach County (W. R. Courtenay, personal communication).

Family Atherinidae

Labidesthes sicculus (Cope). The brook silverside occurs in freshwater throughout southern Florida from Lake Okeechobee (Ager, 1971) and the Caloosahatchee River (Raney et al., 1953) to the southern Everglades. It is common in open canals, clearwater ponds and deeper cypress sloughs. The subspecies is *L. s. vanhyningi* (Bean and Reid).

Menidia beryllina (Cope). The tidewater silverside is a euryhaline species which occurs in freshwater in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965), and in west coast mangroves (Raney et al., 1953) and canals. It is probably the most abundant fish in the North River (Odum, 1971) and other southern rivers from which it penetrates the southern Everglades. It also occurs in Lake Okeechobee (Ager, 1971).

Order Gasterosteiformes, Family Syngnathidae

Syngnathus scovelli (Evermann and Kendall)—hypothetical. The gulf pipefish enters freshwater in north Florida (Carr and Goin, 1955; Tagatz, 1968) and is a permanent resident in freshwater elsewhere (Whatley, 1969). Although it occurs in estuaries in southern Florida (Gunter and Hall, 1963a, 1965), we find no documented records for freshwater.

Order Perciformes, Family Centropomidae

Centropomus ensiferus Poey. The swordspine snook is known from the freshwater canals of southeastern Dade County (Rivas, 1962).

Centropomus parallelus Poey. The fat snook has been reported from Lake Okeechobee and canals of Dade County (Rivas, 1962).

Centropomus pectinatus Poey. The tarpon snook is known from the Caloosahatchee River and Dade County canals (Rivas, 1962).

Centropomus undecimalis (Bloch). The snook occurs in freshwater as both adult and juveniles. Ranging throughout southern Florida (Marshall, 1958), it occurs in freshwater canals in the Big Cypress Swamp, Conservation Area 3 (Dineen, 1972), Everglades National Park, and Lake Okeechobee (Ager, 1971; Rivas, 1962). Movement of snook between fresh and salt water has been shown by Volpe (1959). It enters the southern Everglades via air boat trails. Young occur in canals and freshwater ponds in mangroves (Tabb and Manning, 1961).

Family Centrarchidae

Elassoma evergladei Jordan. The everglades pigmy sunfish ranges throughout southern Florida including Lake Okeechobee (Ager, 1971), the northern Everglades of Conservation Areas 2 and 3 (Clugston, 1966; Dineen, 1972), the southern Everglades and the Big Cypress Swamp (Kushlan, 1972a and unpubl. data). It is primarily a bottom fish commonly associated with submerged plants and fallen litter, especially in cypress sloughs. However, it is also found abundantly in stands of water hyacinth.

Enneacanthus gloriosus (Holbrook). The blue spotted sunfish occurs throughout the Everglades (Clugston, 1966; Dineen, 1972) and Big Cypress Swamp (Kushlan, 1972a and unpubl. data), in the eelgrass and pondweed communities of Lake Okeechobee (Ager, 1971) and in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965). It also occurs in canals but is apparently becoming rarer in that habitat along the urbanized east coast.

Lepomis gulosus (Cuvier). The warmouth is widespread and abundant throughout all of southern Florida. It is very abundant in canals (Hunt, 1953) and ponds (Kushlan, 1972a) and occurs in the littoral zone of Lake Okeechobee (Ager, 1971). It is the hardiest of the southern Florida centrarchids (Kushlan, 1974) and is one of the first invaders into excavated pits and canals (Ogilvie, 1969).

Lepomis macrochirus Rafinesque. The bluegill is probably the most common sunfish in southern Florida. It is very abundant in Lake Okeechobee (Ager, 1971) and in canals but has been found in all other freshwater habitats as well. The subspecies is *L. m. purpurescens* Cope.

Lepomis marginatus (Holbrook). The dollar sunfish occurs in Lake Okeechobee (Ager, 1971), the St. Lucie River (Gunter and Hall, 1963a), and the northern Everglades of the Conservation Areas (Clugston, 1966; Dineen, 1972) as far south as Tamiami Canal (Martin, 1963). However the southern extent of its range in the Everglades is not clear as it has not been reported from Everglades National Park (Phillips, 1971). It was collected on the east coast in Little River Canal in northeastern Dade County. It is apparently widely distributed in the Big Cypress Swamp, having been collected in Lake Trafford, Corkscrew (Martin, 1963), Deep Lake, Fahkahatchee Slough, and north of Tamiami Canal near Monroe. However it has not been collected in six years of intensive sampling at an alligator pond near Pinecrest (Kushlan, 1972a and unpubl. data). It occurs primarily in ponds, lakes, and canals.

Lepomis microlophus (Gunther). The readear sunfish (also called shellcracker) ranges throughout southern Florida (Briggs, 1958) but seems to occur especially in such deeper-water habitats as ponds, lakes, canals, and cypress sloughs. The subspecies is *L. m. microlophus* (Gunther).

Lepomis punctatus (Valenciennes). The spotted sunfish (also called stumpknocker) ranges throughout southern Florida including Lake Okeechobee, where it occupies the littoral zone (Ager, 1971). It is found abundantly in canals, sloughs and ponds, but it ranges into dwarf cypress swamps. It is generally the most common sunfish in cypress sloughs and sawgrass marshes. The subspecies is *L. p. punctatus* (Valenciennes).

Micropterus salmoides (Lacepede). The largemouth bass ranges throughout southern Florida. It is found throughout Lake Okeechobee (Ager, 1971) and reaches its maximum abundance in canals during low water. It is also found in most other habitats including dwarf cypress and marsh prairie. The subspecies is *M. s. floridanus* (Lesueur) (Briggs, 1958).

Pomoxis nigromaculatus (Lesueur). The black crappie (also called speckled perch) ranges throughout southern Florida to the southern Everglades (Phillips, 1971). It is pelagic in Lake Okeechobee in winter moving into the littoral zone to breed (Ager, 1971). Further south it is primarily a fish of canals and is seldom found far from canal edge marshes. It is possible that this species may have extended its range into extreme southern Florida within historic times.

Family Percidae

Etheostoma fusiforme (Girard). The swamp darter is a common bottom-dwelling fish in Lake Okeechobee (Ager, 1971). It seems to be widespread in southern Florida and has been found in the Big Cypress Swamp, Conservation Area 3 (Dineen, 1972) and canals near Miami International Airport (C. R. Robins, personal communication).

Family Carangidae

Caranx hippos (Linnaeus). The crevalle jack is abundant throughout the Everglades estuary region (Tabb and Manning, 1961) and was commonly collected by Odum (1971) throughout North River.

Caranx latus Agassiz—hypothetical. The horse-eye jack has been found in freshwater (Briggs, 1958), and Belshe (1961) found it in canals in southeast Dade County but the salinity was not reported.

Oligoplites saurus (Bloch and Schneider). The leatherjacket is a marine fish recorded from freshwater in the St. Lucie River by Gunter and Hall (1963a, b). The subspecies is *O. s. saurus* (Bloch and Schneider).

Family Lutjanidae

Lutjanus griseus (Linnaeus). The gray snapper occurs in freshwater in the St. Lucie River (Gunter and Hall, 1963a), coastal streams, and in canals in southeastern Dade County (Belshe, 1961) and near Naples (Gunter, 1942).

Lutjanus apodus (Walbaum)—hypothetical. The schoolmaster is a euryhaline species (Briggs, 1958) recorded from freshwater in Florida by Carr and Goin (1955). Whether it occurs in freshwater in southern Florida is not known.

Family Gerreidae

Diapterus olisthostomus (Goode and Bean). The irish pompano enters freshwater along the canals of southern Florida and has been recorded from the St. Lucie River (Gunter and Hall, 1963a, b).

Diapterus plumieri (Cuvier). The striped mojarra is a species favoring brackish to freshwater (Waldinger, 1968) and is commonly found in freshwater in southern Florida. It occurs in the mangroves of the southern coast (Tabb and Manning, 1961), North River (Odum, 1971) and coastal canals.

Eucinostomus argenteus Baird and Girard. The spotfin mojarra, although favoring high salinities along the southwest coast (Waldinger, 1968), has been collected in freshwater in the St. Lucie (Gunter and Hall, 1963a, b), Caloosahatchee (Gunter and Hall, 1965) and North Rivers (Odum, 1971).

Eucinostomus gula (Quoy and Gaimard). The silver jenny is one of the most abundant species in the Everglades estuaries (Roessler, 1968; Odum, 1971) and has been collected in the southern Everglades in lower Shark River Slough. It also occurs in freshwater in the Caloosahatchee River (Gunter and Hall, 1963b, 1965).

Gerres cinereus (Walbaum)—hypothetical. The yellowfin mojarra was found in canals in southeastern Dade County by Belshe (1961), the salinity of which was not reported.

Family Sparidae

Archosargus probatocephalus (Walbaum). The sheephead was reported to be widely distributed in freshwater in southern Florida by A. F. Carr (Gunter, 1942) and was found in freshwater in the North River by Odum (1971).

Diplodus holbrooki (Bean)—hypothetical. The spottail pinfish is a euryhaline species (Briggs, 1958) stated to enter freshwater streams along both coasts by Carr and Goin (1955). We know of no southern Florida records.

Lagodon rhomboides (Linnaeus). The pinfish is a euryhaline species (Briggs, 1958) which enters freshwater streams along both coasts (Carr and Goin, 1965). Odum (1971) found only stray individuals near the mouth of the North River.

Family Sciaenidae

Cynoscion arenarius Ginsburg. The sand seatrout is recorded from freshwater in the Caloosahatchee River (Gunter and Hall, 1963b, 1965).

Cynoscion nebulosus (Cuvier)—hypothetical. The spotted seatrout occurs in freshwater streams along both coasts (Carr and Goin, 1955; Tagatz, 1968), but we have found no records from freshwater in southern Florida.

Cynoscion regalis (Bloch and Schneider). The weakfish has been collected in the St. Lucie River (Gunter and Hall, 1963a, b).

Leiostomus xanthurus Lacepede. The spot occurs in freshwater in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965). It has also been found in canals in southeastern Dade County by Belshe (1961) but salinity was not reported.

Micropogon undulatus (Linnaeus). The Atlantic croaker ascends freshwater streams along both coasts (Carr and Goin, 1955) and has been found in freshwater in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965).

Pogonias cromis (Linnaeus). The black drum is known to ascend freshwater streams in Florida (Carr and Goin, 1955) and has been found in freshwater near the northern Ten Thousand Islands (T. Schmidt, personal communication).

Sciaenops ocellata (Linnaeus). The red drum (also called redfish) occurs in freshwater in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965).

Family Cichlidae

Astronotus ocellatus (Agassiz). The oscar is well established in canals in Dade (Rivas, 1965) and Broward counties.

Cichla ocellaris Bloch and Schneider—hypothetical. The peacock cichlid was introduced in 1964 (Moe, 1964) but the population was apparently destroyed by a cold winter (Courtenay and Robins, 1973).

Cichlasoma bimaculatum Linnaeus. The black acara is well established in coastal canals in Palm Beach (Ogilvie, 1969) and Broward (Rivas, 1965) to southeastern Dade Counties. It has extended westward into the Everglades (Dineen, 1972) and Big Cypress Swamp (Kushlan, 1972b). (This is the species called *Aequidens portalegrensis* (Hansel) by Bailey et al. (1970) (W. R. Courtenay, personal communication).)

Cichlasoma octofasciatum (Regen). The jack dempsey is established in southern Florida canals (Ogilvie, 1969).

Cichlasoma nigrofasciatum (Gunther). The convict cichlid is established in borrow pits in North Dade County (Rivas, 1965).

Cichlasoma meeki (Brind)—hypothetical. The firemouth was reported in a Northwest Miami rockpit (Rivas, 1965) but present information on reproduction is lacking (Lachner, Robins and Courtenay, 1970).

Hemichromis bimaculatus Gill. The jewelfish is established in several locations in Dade County (Bailey et al., 1970) including canals in Hialeah and near Miami International Airport (Rivas, 1965).

Tilapia mossambica (Peters). The mozambique mouthbrooder is established in a tributary canal of the Miami Canal near Miami (W. R. Courtenay, personal communication).

Family Mugilidae

Mugil cephalus Linnaeus. The striped mullet is a euryhaline fish abundant in Lake Okeechobee (Ager, 1971). It is found in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965). It is often common in freshwater canals of southern Florida and has been found in the Everglades, the Big Cypress Swamp, and in freshwater mangrove swamps (Tabb and Manning, 1961).

Mugil curema Valenciennes. The white mullet occurs in freshwater in the St. Lucie River (Gunter and Hall, 1963a). It was found in canals in Dade County by Belshe (1961) but the salinity was not reported.

Mugil trichodon Poey. The fantail mullet is a euryhaline species which occurs in freshwater canals in southern Florida (Carr and Goin, 1955).

Family Eleotridae

Dormitator maculatus (Bloch). The fat sleeper occurs in freshwater in southern mangrove swamps (Tabb and Manning, 1961) and probably in coastal canals of southeastern Dade County (Belshe, 1961).

Eleotris pisonis (Gmelin). The spinycheek sleeper is a euryhaline species collected in freshwater near Palm Beach (C. R. Robins, personal communication) and was recorded from southeastern Dade County (Belshe, 1961).

Gobiomorus dormitor Lacepede. The bigmouth sleeper is a euryhaline species found in the canals of southeastern Florida (Carr and Goin, 1955; B. P. Hunt, personal communication).

Family GOBIIDAE

Evorthodus lyricus (Girard)—hypothetical. The lyre goby was found in canals in southeastern Dade County (Belshe, 1961) but salinity was not reported.

Gobioides broussonneti Lacepede. The violet goby has been reported from the St. Lucie River (Gunter and Hall, 1963a, b).

Gobionellus boleosoma (Jordan and Gilbert). The darter goby has been found in freshwater in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965).

Gobionellus gracillimus Ginsburg. The slim goby has been reported from the St. Lucie River (Gunter and Hall, 1963a) although its identification may be uncertain (Gunter and Hall, 1963b).

Gobionellus shufeldti (Jordan and Eigenmann)—hypothetical. The freshwater goby has been found in the Fahka Union Canal but in brackish water (T. Schmidt, personal communication).

Gobionellus hastatus Girard. The sharptail goby was found in the St. Lucie River (Gunter and Hall, 1963a) and in canals in southeastern Dade County (Belshe, 1961), but salinity was not reported.

Gobiosoma bosci (Lacepede). The naked goby is a brackish water species which has been found in Lake Okeechobee (Ogilvie, 1969) and the Caloosahatchee River (Gunter and Hall, 1969). It has also been recorded from canals in southeast Dade County (Belshe, 1961), but salinity was not reported.

Gobiosoma robustum Ginsburg. The code goby occurs in freshwater in north Florida (Tagatz, 1968) and in canals of undetermined salinity in southeast Dade County. It is the most abundant goby in the Everglades estuary (Tabb and Manning, 1961) and North River (Odum, 1971) where it occurs in fresh water.

Lophogobius cyprinoides (Pallas). The crested goby is a euryhaline species which was recorded from freshwater in Lee County (Carr and Goin, 1955) and was found in canals in southeastern Dade County (Belshe, 1961), but salinity was not reported. It also occurs abundantly in North River (Odum, 1971).

Microgobius gulosus (Girard). The clown goby is a primarily brackish water species found in such habitats throughout southern Florida (Raney et al., 1953; Tabb and Manning, 1961; Belshe, 1961). It also occurs commonly in freshwater having been found in the Caloosahatchee (Gunter and Hall, 1963b, 1965) and North Rivers (Odum, 1971), in east and west coast canals, and in Lake Okeechobee where it breeds (Ager, 1971).

Order PLEURONECTIFORMES, Family BOTHIDAE

Citharichthys spilopterus Gunter. The bay whiff occurs in freshwater in the St. Lucie River (Gunter and Hall, 1963a).

Family SOLEIDAE

Achirus lineatus (Linnaeus). The lined sole has been recorded from the St. Lucie (Gunter and Hall, 1963a, b) and Caloosahatchee Rivers (Gunter and Hall, 1963b, 1965) and from streams in the southern Everglades.

Trinectes maculatus (Bloch and Schneider). The hogchoker is a euryhaline species recorded in Lake Okeechobee (Ager, 1971) and in the St. Lucie (Gunter and Hall, 1963a) and Caloosahatchee Rivers (Gunter and Hall, 1965). It occurs in canals and in streams of the southern Everglades. The subspecies is *T. m. fasciatus* (Lacepede).

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LITERATURE CITED

AGER, L. A. 1971. The fishes of Lake Okeechobee, Florida. Quart. J. Florida Acad. Sci. 34:53-62.

BAILEY, R. M., J. E. FITCH, E. S. HERALD, E. A. LACHNER, C. C. LINDSEY, C. R. ROBINS, AND W. B. SCOTT. 1970. A list of common and scientific names of fishes from the United States and Canada. 3rd ed. Amer. Fish. Soc. Spec. Publ. 6:149 p.

BELSHE, J. F. 1961. Observations on an introduced tropical fish *Belonesox belizanus* in southern Florida. M. S. thesis. Univ. of Miami. Coral Gables, Florida.

BRIGGS, J. C. 1958. A list of Florida fishes and their distribution. Bull. Florida State Mus. 2:223-318.

BROWN, J. L. 1957. A key to the species and subspecies of the cyprinodont genus *Fundulus* in the United States and Canada east of the continental divide. J. Washington Acad. Sci. 47:69-77.

CARR, A. F. 1937. A key to the freshwater fishes of Florida. Proc. Florida Acad. Sci. 1:72-90.

———, AND C. J. GOIN. 1955. Guide to the reptiles, amphibians and freshwater fishes of Florida. Univ. of Florida Press. Gainesville.

CLUGSTON, J. P. 1966. Centrarchid spawning in the Florida Everglades. Quart. J. Florida Acad. Sci. 29:137-143.

COURTENAY, W. R., JR. AND C. R. ROBINS. 1973. Exotic aquatic organisms in Florida with emphasis on fishes: A review and recommendations. Trans. Amer. Fish. Soc. 102:1-12.

CRAIGHEAD, F. C., SR. 1971. The Trees of South Florida. Vol. 1. The natural environments and their succession. Univ. Miami Press. Coral Gables, Florida.

DAVIS, J. H., JR. 1943. The natural features of southern Florida. Florida Geol. Survey Bull. 25:310 p.

DINEEN, J. W. 1968. Fish population studies in seven Everglades Canals. 16 p. Mimeo Rpt. Florida Game and Freshwater Fish Comm. Tallahassee.

———. 1972. Life in the tenacious Everglades. In Depth Report, Central and Southern Florida Flood Control District 1(5):12 p.

EVERMANN, B. W. AND W. C. KENDALL. 1900. Check-list of the fishes of Florida. Rpt. U. S. Fish and Fisheries for 1899:35-103.

FLORIDA GAME AND FRESH WATER FISH COMMISSION. 1956. Recommended program for northwest shore of Lake Okeechobee. 237 p. Mimeo Rpt. Tallahassee.

GILBERT, C. R. AND R. M. BAILEY. 1972. Systematics and zoogeography of the American cyprinid fish *Notropis (Opsopoeodus) emiliae*. Occ. Pap. Mus. Zool. Univ. Mich. 664.

GUNTER, G. 1942. A list of the fishes of the mainland of north and middle America recorded from both freshwater and seawater. Amer. Midland Natur. 28:305-326.

———, AND G. E. HALL. 1963a. Biological investigations of the St. Lucie Estuary (Florida) in connection with Lake Okeechobee discharges through the St. Lucie Canal. Gulf Res. Rpt. 1:189-307.

———, AND ———. 1963b. Additions to the list of euryhaline fishes of North America. Copeia 1963:596-597.

———, AND ———. 1965. A biological investigation of the Caloosahatchee Estuary of Florida. Gulf Res. Rpt. 2:1-71.

HARRINGTON, R. W., JR. AND E. S. HARRINGTON. 1961. Food selection among fishes invading a high subtropical salt marsh: from onset of flooding through the progress of a mosquito brood. Ecology 42:646-666.

———, AND L. R. RIVAS. 1958. The discovery in Florida of the cyprinodont fish, *Rivulus marmoratus*, with a redescription and ecological notes. Copeia 1958:125-130.

HERALD, E. S., AND R. R. STRICKLAND. 1949. An annotated list of the fishes of Homossassa Springs, Florida. Quart. J. Florida Acad. Sci. 11:99-109.

HUBBS, C. L., AND E. R. ALLEN. 1943. Fishes of Silver Springs, Florida. Proc. Florida Acad. Sci. 6:110-130.

_________, AND R. R. MILLER. 1965. Studies of cyprinodont fishes XII. Variation in *Lucania parva*, its establishment in western United States, and description of a new species from an interior basin in Coahuila Mexico. Misc. Publ. Mus. Zool. Univ. Mich. 127.

HULET, W. H., S. J. MASEL, L. H. JODREY, AND R. G. WEHR. 1967. The role of calcium in the survival of marine teleosts in dilute sea water. Bull. Mar. Sci. 17:677-688.

HUNT, B. P. 1953. Food relationship between Florida spotted gar and other organisms in the Tamiami Canal, Dade County, Florida. Trans. Amer. Fish. Soc. 82:14-32.

_________. 1960. Digestion rate and food consumption of Florida spotted gar, warmouth, and largemouth bass. Trans. Amer. Fish. Soc. 89:206-211.

IDYLL, C. P. 1969. New Florida resident, the walking catfish. Nat. Geogr. Mag. 135:846-851.

KILBY, J. E., AND D. K. CALDWELL. 1955. A list of fishes from the southern tip of the Florida peninsula. Quart. J. Florida Acad. Sci. 17:195-206.

KUSHLAN, J. A. 1972a. An ecological study of an alligator pond in the Big Cypress Swamp of southern Florida. M. S. thesis. Univ. of Miami. Coral Gables, Florida.

_________. 1972b. The exotic fish, *Aequidens portalegrensis*, in the Big Cypress Swamp. Florida Natur. 97:102.

_________. 1973. Differential responses to drought in two species of *Fundulus*. Copeia 1973:808-809.

_________. 1974. Effects of a natural fish kill on the water quality, plankton and fish population of a pond in the Big Cypress Swamp, Florida. Trans. Amer. Fish Soc. 103:348-352.

LACHNER, E. A., C. R. ROBINS AND W. R. COURTENAY. 1970. Exotic fishes and other aquatic organisms introduced into North America. Smith. Contr. Zool. 1970(59):29 p.

MARSHALL, A. R. 1958. A survey of the snook fishery of Florida, with studies of the biology of the principle species, *Centropomus undecimalis* (Bloch). Florida State Bd. Conserv. Tech. Ser. 22:39 p.

MARTIN, R. A. 1963. Centrarchid fishes of the genus *Lepomis* in Florida. M. S. thesis. Univ. of Miami. Coral Gables, Florida.

MARTIN, F. D. 1972. Factors influencing local distribution of *Cyprinodon variegatus* (Pisces: Cyprinodontidae). Trans. Amer. Fish. Soc. 101:89-93.

MILLER, R. R. 1955. An annotated list of the American cyprinodontid fishes of the genus *Fundulus*, with the description of *Fundulus persimilis* from Yucatan. Occ. Pap. Mus. Zool. Univ. Mich. 568:25 p.

_________. 1966. Geographical distribution of Central American freshwater fishes. Copeia 1966:773-802.

MOE, M. A., JR. 1964. Survival potential for Piranhas in Florida. Quart. J. Florida Acad. Sci. 27:197-210.

MEYERS, G. S. 1938. Fresh-water fishes and West Indian zoogeography. Ann. Rept. Smith. Inst. 1937:339-364.

ODUM, H. T. 1953. Factors controlling marine invasion into Florida fresh waters. Bull. Mar. Sci. 3:134-156.

ODUM, W. T. 1971. Pathways of energy flow in a South Florida estuary. Univ. Miami Sea Grant Tech. Bull. 7:162 p.

OGILVIE, V. E. 1969. Illustrated guide to the fresh water fishes of Florida. Vol. 1. The Kissimmee River, Lake Okeechobee and the Everglades. V & M Publ. Co. West Palm Beach, Florida.

PHILLIPS, J. W. 1971. Check list of fishes of Everglades National Park, Ever. Natl. Park. Mimeo. 9 p.

RANEY, E. C., R. H. BACKUS, R. W. CRAWFORD, AND C. R. ROBINS. 1953. Reproductive behavior in *Cyprinodon variegatus* Lacepede, in Florida. Zoologica 38:97-104.

RIVAS, L. R. 1948. Cyprinodont fishes of the genus *Fundulus* in the West Indies, with the description of a new subspecies from Cuba. Proc. U. S. Nat. Mus. 98:215-222.

_________. 1962. The Florida fishes of the genus *Centropomus*, commonly known as snook. Quart. J. Florida Acad. Sci. 25:53-64.

_________. 1965. Florida freshwater fishes and conservation. Quart. J. Florida Acad. Sci. 28:225-258.

_________. 1969. A revision of the poeciliid fishes of the *Gambusia punctata* species group, with descriptions of two new species. Copeia 1969:778-795.

ROESSLER, M. 1968. Observations on the seasonal occurrence and life histories of fishes in Buttonwood Canal, Everglades National Park, Florida. Ph.D. thesis. Univ. of Miami. Coral Gables, Florida.

TABB, D. C., AND R. B. MANNING. 1961. A checklist of the flora and fauna of northern Florida Bay and adjacent brackish waters of the Florida mainland collected during the period July, 1957 through September, 1960. Bull. Mar. Sci. Gulf and Carib. 11:552-649.

TAGATZ, M. E. 1968. Fishes of the St. Johns River system, Florida. Quart. J. Florida Acad. Sci. 30:25-50.

VOLPE, A. V. 1959. Aspects of the biology of the common snook *Centropomus undecimalis* (Bloch) of southwest Florida. Florida State Bd. Conserv. Tech. Ser. 31:37 p.

WADE, R. A. 1962. The biology of the tarpon, *Megalops atlanticus* and the oxeye, *Megalops cyprinoides*, with emphasis on larval development. Bull. Mar. Sci. Gulf Carib. 12:545-622.

WALDINGER, F. J. 1968. Relationship of environmental parameters and catch of three species of the mojarra family (Gerreidae), *Eucinostomus gula*, *Eucinostomus argenteus*, and *Diapterus plumieri* collected in 1963 and 1964 in Buttonwood Canal, Everglades National Park, Florida. M. S. thesis. Univ. Miami. Coral Gables, Florida.

WARE, F. J.,1966. The food habits of channel catfish in South Florida. Proc. S. E. Assoc. Game & Fish Comm. 20:283-287.

WHATLEY, E. C. 1969. A study of *Syngnathus scovelli* in fresh waters of Louisiana and salt waters of Mississippi. Gulf. Res. Rpt. 2:437-474.

Florida Sci. 37(2):110-128. 1974.

REVIEW

DAWES, CLINTON J. *Marine Algae of the West Coast of Florida.* i-xvi; 1-201; 2 maps; 82 figs. 6 × 9 inches. Univ. Miami Press. Coral Gables. Publication date: October 31, 1974. $15.00. ISBN 0-87024-258-X.

From time to time a book is released which is potentially of considerable interest to Academy members. By taking advantage of the location of Tampa Bay at the northern and southern distributional limits of certain algal species, Dr. Dawes has given us such a book in the form of a handy manual based upon coastal habitats from Cedar Key to Cape Romano. However, the discussion of marine habitats and coastal plant communities are applicable beyond these limits. They contribute an extra dimension to the book of value to the "interested layman, as well as . . . high school and college students" to whom the book is addressed.

The user will find the keys well laid out with most dichotomies parallel and well drawn. However, some lapses can be found, for example: *Anacystis dimidiata* in the key has cells 8-50 μm but the text says 10-16 μm and thus it overlaps nearly the whole range of *A. aeruginosa* with which it is contrasted; a similar problem arises between *Calothrix crustacea* and *C. pilosa*; and "Plants partially embedded in soft mud, branching irregular" for *Vaucheria* is contrasted to "Erect branches bearing distichous, radial, or second ramuli" with no reference to habitat for *Bryopsis.*

The Linda Baumhardt illustrations stand out as most pleasing to the eye and they create a good visual image of the plant. The photographs of the bluegreen algae are less uniformly successful, e.g., fig. 17, and some line drawings would enhance the effectiveness of the treatment. Perhaps the 74 species illustrated are the most common of the 296 species treated in the text, but there is no indication of the reason for selection of the species figured.

The bibliography includes a broad coverage of algal literature applicable to Florida as well as publications on marine spermatophytes and ecology. Numerous M. A. and Ph. D. theses (some "in preparation"!) are cited as well as an extensive unpublished manuscript and an oral presentation to the Florida Academy in 1965. Citation of any but completed Ph. D. theses presents severe problems to other investigators. Even Ph. D. theses available through University Microfilms are not considered formally published although copies can be obtained if ordered by the microfilm number which was not given. We encourage the author to issue a supplement in a year or so citing places of publication for these manuscripts and theses as well as to list the microfilm catalog numbers for the Ph. D. dissertations.

All in all, the minor problems noted above do not diminish the immediate usefulness and value of the book. It should see wide usage in Florida and around the Gulf coast. I know of no better introduction to the study of Florida seaweeds.—HARVEY A. MILLER. Department of Biological Sciences, Florida Technological University, Orlando.

INSTRUCTIONS TO AUTHORS

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QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

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Biological Sciences

THE ESTUARINE DECAPOD CRUSTACEANS IN BREVARD COUNTY, FLORIDA

R. E. Grizzle

Brevard County Health Department, 1744 S. Cedar St., Rockledge, Florida 32955

Abstract: *A preliminary survey of the decapod crustaceans of the estuarine waters of Brevard County, on the central east coast of Florida, was made during the summer months of 1971 and the summer and fall of 1972. In all, 44 species and subspecies of decapods were collected from the estuaries and adjacent shorelines, and brief annotations are included for each. A three year summary of salinity and temperature levels occurring in the estuaries is also given.*

In 1969 Richard S. Fox, then employed as a biologist for the State of Florida Department of Air and Water Pollution Control, began a baseline survey of the macro-invertebrates of the estuarine waters of Brevard County, Florida. The present report is a contribution to the baseline survey, which is still incomplete, but is being continued in a modified form. The author, while on a three-month assignment, June-September, 1971, to Brevard County Health Department, compiled much of the data represented by this report. The remainder of the report resulted from collections made by the author during the summer and fall of 1972, while again employed by the Brevard County Health Department. Specimens for this survey were also supplied by Mr. Fox and Mrs. Cherie Down, biologist, Brevard County Health Department. This paper primarily provides an annotated checklist of each decapod crustacean species and subspecies collected, and a distribution map.

Reports concerning the lagoonal-estuarine systems of the east-central Florida coast, especially investigations of the macro-invertebrates, have unfortunately been few and generally not very extensive. Brice, et al. (1898) reported on the fisheries of this area. Chew (1956) reported on projected salinity values for the Indian River that would result from specific environmental alterations. Tabb (1960, 1961, 1966) completed several papers dealing with the biology of the spotted weakfish, *Cynoscion nebulosus* (Cuvier), and considered the estuaries of this area as a habitat. Brown, et al. (1962) reported on the water resources of Brevard County, and included sections dealing with the estuaries. Futch (1967) surveyed the oysters of Brevard County. Some other reports concerned with the estuaries of this area contain only notations on the examination of specimens collected from the Indian River (Rathbun, 1918, 1925, 1930; Thomas, 1962), or else are brief "surveys" of one type or another (Casper, et al., 1966).

In the checklist of this report no detailed synonymies are given. However, at least one reference is provided wherein each species or subspecies is well illustrated and described.

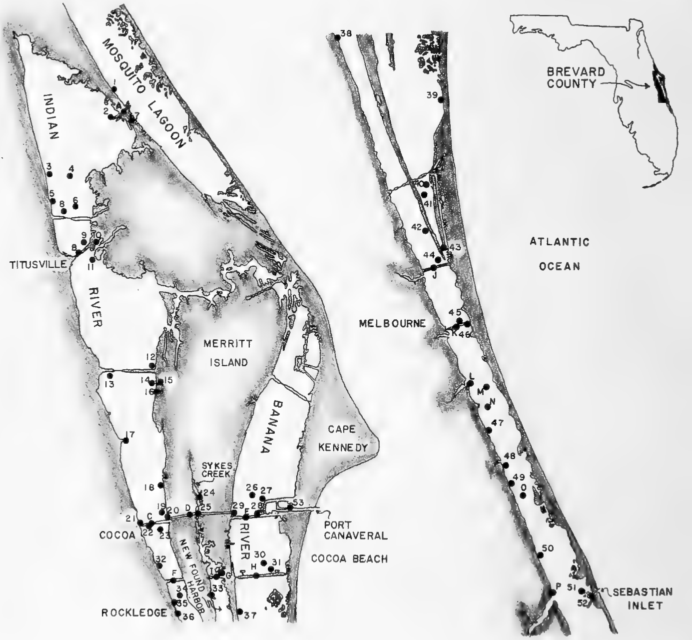

Fig. 1. North (left) and south (right) halves of Brevard County, respectively. Decapod collection stations numbered 1-53; Brevard County Health Department physical data stations A-P.

METHODS—Collections were made at 53 different stations (Fig. 1); samples were taken only once at most stations. A rigid-frame trawl was constructed by the author and utilized in the deeper waters (over 2 m) on soft sand-mud bottoms, where it worked best. The trawl frame consisted of a 1/8 × 1 in flat steel rod formed into a rectangle, approximately 1 × 3 ft. The bag was 7 ft long, of 1/4 in nylon mesh netting, with the last 2 ft underlain by 1/16 in mesh. Three 1/4 in nylon ropes were used as leads from the frame; a length of this rope strung with lead weights, was hung between the two bottom leads about 1 ft from the frame, functioning as a tickler. An 8 × 18 in, 1/16 in nylon mesh, dip net was used extensively at the shallower stations. A shovel was employed in sampling for the burrowing species. Most of the collecting was done in the shallows, and involved much hand collecting with the dip net, examination of submerged objects, and digging. Stations 6, 8, 9, 11, 19, 23, 30, 40, 41 and 44 were sampled by trawl only. The remaining stations were worked with a combination of the above methods.

Measurements were made with a metric rule, with the aid of a dissecting scope in some cases, using the following abbreviations and criteria: c.l. (carapace length)—taken dorsally at the approximate midline of the carapace from the rostrum tip to the posterior margin; c. w. (carapace width)—taken along the dorsal surface of the carapace at the widest point, and considering any teeth or other lateral projections as part of the carapace; t.l. (total length)—taken along the dorsal surface of the animal from the anterior tip of the rostrum to the posterior tip of the telson.

The measurements given were generally taken only from ovigerous specimens which were collected over the entire time span of the survey, unless otherwise noted.

Description of Study Area—*Geography*: An adequate general discussion and description of Brevard County may be found in Brown, et al. (1962). The following paragraphs summarizing the climate and geography of the area, are based on that report unless noted otherwise.

Brevard County is between north latitude 28° 48′ and 27° 49′, and west longitude 80° 27′ and 80° 57′, adjacent to the Atlantic Ocean (Brevard County Health Department geographical data). It covers an area of approximately 1,298 square miles; has a north-south length of 66 miles and is about 20 miles wide. The principal physical features of the county, the St. John's River valley, the Atlantic Coastal Ridge, the barrier islands area, and the coastal terraces, are discussed in Brown, et al. (1962).

Climate: The average yearly air temperature is about 22°C. The lowest and highest air temperatures recorded for the years 1965 to 1972 are –2°C and 36°C (NASA Weather Service). Normal winter air temperatures are near 16°C and normal summer air temperatures are around 32°C. Annual rainfall is usually slightly in excess of 125 cm, the major portion occurring from May to October. Mean wind velocities are between 8 and 12 kn. The winds prevail from the east to southeast during the summer months, and from the northwest to northeast during the winter (NASA, 1972). The climate is termed humid subtropical.

The Estuarine Waters: Hydrography. The estuarine waters of Brevard County consist of a portion of the Indian River; the entire Banana River, Sykes Creek—a slightly less-saline area, and New Found Harbor; and the southern end of Mosquito Lagoon (Fig. 1). Of Brevard's total 1,298 square miles, 257 square miles are covered by the Indian and Banana Rivers (Futch, 1967). It should be noted that the term river in Banana River and Indian River is a misnomer, in that these waters are not rivers in any sense of the word (Morisawa, 1968). They are lagoonal estuaries, bounded on the east by narrow barrier islands, with only one restricted direct connection to the Atlantic in Brevard County—Sebastian Inlet. An indirect connection is via the Canaveral Locks, in central Brevard. Several freshwater streams, e.g. Eau Gallie River, Sebastian River, Crane Creek and Turkey Creek, empty into the Indian River. Some information is available concerning flow measurements in these streams during the mid 1950's (Brown, et al., 1962); however few or no data are available for the past 15 yr. Water depths in the estuaries are shallow, generally ranging from less than 1 m to 4 m; most areas are less than 2 m deep. A detailed description of Brevard's estuaries is found in Brice, et al. (1898). Causeway construction and other dredge-fill activities are primarily responsible for deviations from their description, but generally the report is valid at the present.

Hydrology. The water levels of the estuaries seem little affected by tidal action (personal observations, and Chew, 1956), except very near Sebastian Inlet, although no quantitative data are available. Winds, rainfall, and evaporation appear to be the major factors determining water levels; wind is also thought to be the primary element producing water circulation. However, no reports are available, to the author's knowledge, that deal with these factors. Hydrological studies are thus very much needed in these waters. Information concerning circulation, residence time, exchange at the inlet, and other hydrological aspects, would give much insight into numerous ecological questions.

Salinity and Temperature. Salinity data, obtained from single grab samples taken once per month at each station, have been recorded by the Brevard County Health Department from January, 1968 to May, 1971; random data are available through 1972. Salinity samples have also been taken by the author at many collection stations during this survey. Temperature values recorded once per month, per station, are available from 1968 to the present. A summary of the 1968 to 1971 data is given in Table 1, and the locations of the corresponding sampling stations are given in Fig. 1. The salinity values obtained from mid-1971 to the present are random, but they do not appear markedly different from the data in Table 1. Specifically, the temperatures and salinities obtained during the months

TABLE 1. A summary of salinity and temperature data taken from laboratory records of the Brevard County Health Department from January 1968 to May 1971.

Station No.	SALINITY (‰)			TEMPERATURE (°C)		
	Min.	Max.	Average	Min.	Max.	Average
A	27.0	38.0	32.54	11	30	22.7
B	20.2	37.5	30.20	11	30	22.7
C	18.6	33.7	24.67	13	31	23.3
D	9.0	35.2	24.73	11	31	22.7
E	9.0	--	23.31	13	31	22.2
F	18.8	36.6	25.79	12	30	22.7
G	9.8	31.8	20.78	12	31	23.3
H	9.3	34.5	21.75	--	30	22.2
I	9.3	30.7	20.40	--	--	--
J	10.5	31.2	22.34	13	30	23.3
K	11.9	34.0	22.31	12	30	23.3
L	9.4	37.7	22.29	14	29	22.2
M	9.4	31.8	21.20	18	29	23.9
N	10.0	34.6	22.90	14	29	19.5
O	11.6	37.2	25.11	14	29	22.2
P	12.8	36.4	25.86	14	30	22.2

of this survey ranged from 17°C to 35°C, and 19.7‰ to 40.6‰; most salinity values were in the mid-twenties. These salinity and temperature values and those in Table 1, were taken only in the open estuaries and not at collection stations in the mouths and backwaters of streams and canals that empty into the estuaries. Salinities in these areas were often less than 5‰. Observed salinity ranges (O.S.) are given under the heading for each species, where available.

Flora: Extensive sand-bottom, grass-flat areas were found in many of the shallower (less than 2-m) waters, and sand or mud bottoms with algal vegetation were generally prevalent in the deeper waters. The grass flats consisted primarily of two species of flowering seagrasses, *Diplanthera wrightii* Ascherson and *Syringodium filiforme* Kutzing. Any mention of seagrass beds, or grass flats in this report with regards to the estuaries surveyed, is a general reference to these two species. Algal species were very numerous. A report of the flora of Brevard County's estuaries is in preparation by Mrs. Cherie Down.

ANNOTATED LIST OF SPECIES

Order Decapoda, Suborder Natantia, Section Penaeidea, Family Penaeidae, Subfamily Penaeinae

Penaeus (Melicertus) duorarum duorarum Burkenroad. Pérez Farfante (1969): 499, figs. 20-31. Sta. 1, 26, 27, 28, 29, 30, 44, 46, 49, 50. O.S.: 21.8‰.

This subspecies was found throughout the estuaries.

Data from this study suggests that pink shrimp (*P. d. duorarum*) considerably outnumbered white shrimp (*P. setiferus*) in these waters during the months that collections were made. Most specimens collected were juveniles, under 70mm t. l.

Penaeus (Litopenaeus) setiferus (Linnaeus). Pérez Farfante (1969): 468, figs. 4-13. Sta. 28.

At the single station where this species was found, it was far outnumbered by *P. d. duorarum*.

Section Caridea, Family Palaemonidae, Subfamily Pontoniinae

Periclimenes (Harpilius) americanus (Kingsley). Holthuis (1951):60, figs. a-j; pl. 19, figs. a-e. Sta. 52.

This caridean was collected only at Sebastian Inlet; it was found among rocks, and in a seagrass bed, in a small tidal cove. One ovigerous specimen collected in November: 14.5mm t.l.

Subfamily Palaemoninae

Leander tenuicornis (Say). Holthuis (1952):155, pl. 41, figs. a-g; pl. 42, figs. a-f. Sta. 52.

Specimens were taken among mangrove branches, and in a small seagrass bed; all were collected at Sebastian Inlet. Ovigerous females, all collected in November: 25-31mm t.l.

Palaemon (Palaeander) northropi (Rankin). Holthuis (1952):192, pl. 47, figs. a-l. Sta. 49, 52.

One specimen was taken about 4.5 miles north of Sebastian Inlet. All others were collected at the inlet, where it was common. Two ovigerous specimens, collected in November: 33mm and 34mm t.l.

Palaemonetes (Palaemonetes) intermedius Holthuis. Holthuis (1952):241, pl. 55, figs. a-f. Sta. 1, 2, 4, 5, 9, 10, 12, 13, 14, 17, 18, 23, 24, 26, 27, 29, 31, 33, 35, 36, 37, 38, 39, 40, 43, 45, 46, 48, 50, 51. O.S.: 4.6-27.3‰.

An extremely common caridean. *P. intermedius* was collected from most areas of the estuaries. Ovigerous individuals: 24-36mm t.l. (See discussion of *P. vulgaris* for additional notes.)

Palaemonetes (Palaemonetes) paludosus (Gibbes). Holthuis (1952):207, pl. 51, figs. e-j. Sta. 24. O.S.: 4.8‰.

A freshwater species. This caridean was only taken in streams, ponds, or canals connected to the estuaries.

Palaemonetes (Palaemonetes) pugio Holthuis. Holthuis (1952):244, pl. 55, figs. g-l. Sta. 10, 15, 24. O.S.: 4.6-17.4‰.

This species was collected from several locations, but it is apparently limited to the less-saline areas of the estuaries. It was found to be very common in brackish ponds, canals, or streams, but was rarely found in the open estuaries. These brackish waters were not sampled until the fall, thus ovigerous specimens were only reported from November. Ovigerous individuals: 25-34mm t.l. (See discussion of *P. vulgaris* for additional notes.)

Palaemonetes (Palaemonetes) vulgaris (Say). Holthuis (1952):231, pl. 54, figs. f-l. Sta. 29, 52.

Holthuis (1952), p. 240, states: "The general impression I got is that *Palaemonetes vulgaris* is much more confined to salt water than *Palaemonetes pugio* is." This is exactly the situation that the present study suggests. *P. vulgaris* was represented by only three specimens, one collected near the Canaveral locks and two from Sebastian Inlet, while *P. pugio* was found to be quite common in the less-saline portions of the estuaries. *P. intermedius* was found to be the "intermediate" of the three with respect to salinity preference, as it was common in almost all areas of the estuaries. Two ovigerous specimens of *P. vulgaris* were collected by Richard S. Fox in May, 1970: 30mm and 36mm t.l.

Family Alpheidae

Alpheus armillatus H. Milne Edwards. Williams (1965):67, fig. 55. Sta. 22.

Only two specimens were collected, in shallow water off a shell-rock bottom.

Alpheus heterochaelis Say. Williams (1965):66, fig. 54. Sta. 1, 4, 5, 8, 9, 12, 13, 14, 21, 23, 26, 27, 30, 38, 41, 44, 45, 48. O.S.: 19.7-32.5‰.

A very common snapping shrimp in the estuaries, living on a variety of substrates, under submerged debris in burrows, and in sponges. Ovigerous specimens: 20-47mm t.l.

Alpheus normanni Kingsley. Williams (1965):65, fig. 53. Sta. 23, 26, 30. O.S.: 27.1‰.

Wass (1955) often found this species in ascidian colonies. Williams (1965) gave habitats of shallow rocky bottoms, or on pilings. During this survey most specimens were collected with the trawl from deeper waters (over 2 m), off sand-mud bottoms with algal vegetation. Four specimens were also taken from the stomach of a young *Cynoscion nebulosus* (Cuvier), spotted weakfish, caught in approximately 2 m of water. *A. normanni* was not encountered until the trawling was initiated in October; egg-bearing females were reported only from that month. Ovigerous specimens: 24-29mm t.l.

Synalpheus apioceros Coutière. Coutière (1909):27, fig. 9. Sta. 26.

Chace (1972) reported this species from grass flats, weed-covered objects, and under rocks and pieces of coral. During this survey the only specimens collected came from a sponge attached to power poles, near Canaveral Locks. Two ovigerous specimens, collected in October: 13mm and 19mm t.l. *S. apioceros* had previously been reported by Tabb and Manning (1961) from the east coast to southern Florida.

Family Ogyrididae

Ogyrides alphaerostris (Kingsley). Williams (1965):75, fig. 61. Sta. 52.

Only three specimens were collected, in a small cove at Sebastian Inlet. Williams (1965), p. 76, reported this species as . . . "Often on firm bars of sand . . . " All three specimens from Brevard County were captured by sieving the white fine sand of the cove. Chace (1972) reported this species as extending from Virginia to Georgia, then northwest Florida to Mississippi.

Ogyrides yaquiensis Armstrong. Armstrong (1949):3, fig. 1. O.S.: 24.8‰.

A single specimen of this species was taken by the author from the Indian River at Cocoa during April, 1973. It was sieved from a dredge-grab sample taken off a silty-mud bottom at a depth of approximately 4 m. Chace (1972) recorded the distribution of this species as being southern Florida and the Dominican Republic. Chace (1972) also states that the congeners *O. yaquiensis*, *O. limicola*, and *O. occidentalis* may possibly prove to be synonymous species.

Family HIPPOLYTIDAE

Hippolyte zostericola (Smith). Chace (1972):118, figs. 49-50. Sta. 1, 2, 4, 8, 9, 11, 12, 13, 14, 17, 18, 27, 29, 30, 31, 35, 36, 37, 38, 43, 45, 46, 48, 50, 51, 52. O.S.: 27.3-32.5‰.

This small shrimp was found to be very abundant in the estuaries, usually being collected from the grass beds. The differences between *H. zostericola* and *H. pleuracantha* are somewhat questionable; the reader is referred to Chace (1972), p. 118-121, for a discussion of the two species. Ovigerous specimens: 12.5-21mm t.l.

Tozeuma carolinense Kingsley. Williams (1965):83, fig. 67. Sta. 27, 52.

This species is represented by one specimen taken at Sebastian Inlet, and another collected near the Canaveral locks. Both were netted from a grass bed. Mr. Richard Fox reported an additional specimen from the Mosquito Lagoon. One oviger taken in July: 47mm t.l.

Suborder REPTANTIA, Section ANOMURA, Superfamily GALATHEIDEA, Family PORCELLANIDAE

Pachycheles monilifer (Dana). Haig (1960):160, pl. 33, fig. 4. Sta. 53.

One damaged specimen represents this species. It was collected from Canaveral Harbor by Richard S. Fox in May, 1970. Gore (personal communication) states that this species is common on offshore worm reefs of east-central Florida.

Petrolisthes armatus (Gibbes). Haig (1960):50, pl. 19, fig. 2. Sta. 20, 22, 26, 34, 38, 48, 50, 52. O.S.: 19.9-27.7‰.

This species was found to be quite common in the estuaries, being primarily found in any of the fouling communities, or in sponges. Tabb and Manning (1961) reported this species from similar habitats in the Florida Bay area of south Florida. Few ovigerous specimens: 5.5-9mm c.l.

Superfamily PAGURIDEA, Family DIOGENIDAE

Clibanarius antillensis Stimpson. Provenzano (1959):368, fig. 5B. Sta. 51, 52, 53.

This very small hermit crab was abundant at Sebastian Inlet, and was found only there, and at Canaveral Harbor. Provenzano (1959) reported this species as extending only to "Southern Florida".

Clibanarius vittatus (Bosc). Williams (1965):120, fig. 97. Sta. 1, 26, 27, 29, 31, 48, 50, 51, 52.

C. vittatus was found to be common at many of the stations. It was collected mainly from the grass beds, and along the shoreline. Williams (1965) gave carapace lengths of 32mm for males, and 29mm for females; most of the specimens examined were about half that size.

Petrochirus diogenes (Linnaeus). Williams (1965):122, fig. 98. Sta. 52.

Several specimens were collected just inside Sebastian Inlet, from a grass bed. These were small non-ovigerous individuals, ranging from 3-13mm c.l.

Family PAGURIDAE

Pagurus bonairensis Schmitt. Provenzano (1959):407, fig. 18 [as *Pagurus annulipes* (Stimpson)] Rouse (1970):142. Sta. 1, 2, 8, 9, 11, 12, 13, 14, 17, 23, 26, 27, 30, 31, 36, 37, 41, 44, 45, 46, 50, 52. O.S.: 19.7-32.5‰.

This very small hermit crab was found to be quite common in the estuaries, being easily collected at many stations, especially from shallow grass bed areas. Some confusion surrounds this species and the related *Pagurus annulipes* in the literature. However, the matter is apparently cleared up in Rouse (1970). Ovigerous specimens: 1.5-3mm c.l.

Pagurus longicarpus Say. Provenzano (1959):394, fig. 13. Williams (1965):125, fig. 101. Sta. 52.

Specimens of *P. longicarpus* were collected only along the shoreline at Sebastian Inlet, where it was very common.

Section BRACHYURA, Subsection OXYSTOMATA, Family LEUCOSIIDAE, Subfamily PHILYRINAE

Persephona mediterranea (Herbst). Williams (1965):150, fig. 127 [as *Persephona punctata aquilonaris* Rathbun, 1937]. Sta. 52.

Only one small specimen was collected, by trawl, just inside Sebastian Inlet.

Subsection BRACHYGNATHA, Superfamily BRACHYRHYNCHA, Family PORTUNIDAE, Subfamily PORTUNINAE

Callinectes ornatus Ordway. Williams (1966):84, fig. 1, 4A, 4B. Chace and Hobbs (1969):132, fig. 37e. Sta. 27, 48, 50, 52.

This species was particularly abundant along the south shoreline at Sebastian Inlet. It should be noted that the collecting methods used in this survey were not especially suited for capturing the swimming crabs.

Callinectes sapidus Rathbun. Rathbun (1930):99, pl. 47, text figs. 15a, 16c, 17c, 18a, 19. Williams (1965):168, fig. 151. Sta. 1, 18, 26, 29, 30, 31, 46, 48, 51.

The blue crab was collected from many areas of the estuaries, and is caught locally for its commercial value.

Family XANTHIDAE

Eurypanopeus depressus (Smith). Williams (1965):195, figs. 179, 183L. O.S.: 21.8-27.7‰. Sta. 2, 3, 4, 5, 12, 13, 14, 16, 17, 20, 21, 22, 23, 26, 27, 29, 30, 31, 33, 34, 35, 37, 38, 39, 40, 41, 43, 45, 46, 48, 50, 51.

By far the most common xanthid collected during this survey. *E. depressus* was found to inhabit grass beds, rocky areas, sponges, oyster beds, mud bottoms, but most often, the fouling community, usually represented by barnacle-encrusted pilings. The largest specimens came from a sponge attached to wooden power poles at a depth of approximately 0.5 m; one unusually large male had a carapace width of 24.5mm. Ovigerous specimens: 6-19mm c.w.

Menippe mercenaria (Say). Rathbun (1930):472, pl. 191-193, fig. 78. Williams (1965):183, figs. 164D, E; fig. 166. Sta. 6, 34, 37, 50. O.S.: 29.3‰.

Williams (1965) stated that the young inhabit the deeper channels of the saltier estuaries. In the present study young *M. mercenaria* were found only in waters in excess of 2 m deep, and on channel marker pilings. Adults were collected and observed in the shallows. Adults are also occasionally caught in the traps set by commercial "crabbers" for the blue crab, and are sometimes captured by individuals diving in the deeper, rocky areas of the estuaries. Manning (1960) discussed the morphological changes associated with the maturation of *M. mercenaria.*

Neopanope packardii (Kingsley). Rathbun (1930):380, pl. 168, figs. 5-6. Text fig. 59. Sta. 8, 11, 22, 23, 26, 30, 32, 37, 41, 52. O.S.: 22.7-32.5‰.

This species was found to be quite common in the estuaries, apparently preferring the deeper, mud-bottom areas. Two very large males, 23mm and 24mm c.w., were collected. Ovigerous specimens: 7-12.5mm c.w.

Neopanope sayi (Smith). Abele (1972):263, figs. 2 B, C, D and 3D. Sta. 2, 4, 5, 6, 8, 11, 13, 21, 23, 34, 41, 44. O.S.: 21.8-32.5‰.

This species had long been confused with *N. texana*, but it has recently been redescribed by Abele (1972).

Panopeus herbstii H. Milne Edwards. Rathbun (1930):335, pl. 156, 157, text fig. 52. Sta. 14, 38, 43, 51, 52, 53.

P. herbstii was collected from a variety of habitats including rocky areas, barnacle-encrusted pilings, oyster beds, and mud banks—all commonly reported habitats for this species (Williams, 1965). Several specimens were found that keyed to *Panopeus americanus* Saussure, when following the key in Rathbun (1930), which utilizes the basal widths of the third and fourth lateral teeth of the carapace. These basal teeth widths were found to be quite variable in the *P. herbstii* examined. In comparing these specimens of *P. herbstii* with specimens of *Panopeus americanus* from Jamaica, (USNM No. 7783) which were in the possession of Dr. Robert Gore at the time of examination; it was found that other differences are quite consistently evident. These are: 1) gape of figures of the major chela more pronounced in *P. americanus*; 2) the basal tooth on the movable finger of the major chela longer and curved in *P. americanus*; and 3) the body areas of the carapace much more delineated in *P. americanus*. Ovigerous specimens of *P. herbstii* collected: 26-40mm c.w.

Panopeus occidentalis Saussure. Williams (1965):198, figs. 181, 183N. Sta. 51.

P. occidentalis is represented by a single specimen taken from an oyster bed, just north of Sebastian Inlet.

Rhithropanopeus harrisii (Gould). Williams (1965):187, figs. 169, 183C. Sta. 15, 24, 40, 41, 44. O.S.: 4.6-22.7‰.

This xanthid is abundant in streams and ponds connected to the estuaries. It is also common in Sykes Creek, which is generally 1 to 5‰ less saline than the surrounding estuarine waters. Mud bottoms or a fouling community seem to be preferable habitats; similar habitat types are reported by Williams (1965). Ovigerous specimens, taken only during the fall (see note for *Palaemonetes pugio*): 7-10mm c.w.

Family Pinnotheridae, Subfamily Pinnotherinae

Pinnotheres ostreum Say. Williams (1965):203, figs. 187, 188, 189. Sta. 53.

Two specimens of this commensal species were taken from Canaveral Harbor by Richard S. Fox in 1970. Other commensals may have been overlooked in this study due to the collecting techniques employed.

Family Grapsidae, Subfamily Grapsinae

Pachygrapsus transversus (Gibbes). Williams (1965):217, fig. 202. Sta. 50, 51, 52, 53.

This species was taken only at or near Sebastian Inlet and in Canaveral Harbor. It was abundant among the rocks on the shoreline at both locations.

Subfamily Sesarminae

Sesarma (Holometopus) cinereum (Bosc). Williams (1965):222, fig. 206. Sta. 16, 25, 51.

This shore crab was collected twice from burrows in peat-like soil, and once from under a log in sand.

Sesarma (Sesarma) curacaoense de Man. Rathbun (1918):293, pl. 78, figs. 1-2; pl. 160, fig. 3; text fig. 147. Sta. 16.

Rathbun (1918) listed this crab's habitat as being "under fallen leaves and other rubbish among mangrove roots"; the only specimen collected in this survey came from a burrow in peat-like soil just above the water line. This tropical species has been reported from southern Florida by Tabb and Manning (1961).

Family Ocypodidae

Uca pugilator (Bosc). Williams (1965):232, figs. 209C, 210C, D, 211. Sta. 2, 5, 14, 15, 29, 33, 51, 53.

This well-known fiddler crab was found to be abundant along many of the sandy shorelines of the estuaries.

Uca rapax (Smith). Rathbun (1918):397, pl. 140 [as *Uca pugnax rapax* (Smith)]. Chace and Hobbs (1969):214, figs. 73a, b. Sta. 16.

Uca rapax is represented by two large males collected from burrows in peat-like soil. This species was taken at only one station; however few stations were adequately sampled for the burrowing species. Chace and Hobbs (1969) reported this crab from habitats of mangrove swamps and mud flats near coasts and river mouths.

Uca speciosa (Ives). Rathbun (1918):408, pl. 145. Sta. 7, 15.

Several specimens were collected from their burrows in mud. Chace and Hobbs (1969) reported a habitat of "very wet mud". Tabb and Manning (1961) reported this species from south Florida.

Superfamily Oxyrhyncha, Family Majidae, Subfamily Pisinae

Libinia dubia H. Milne Edwards. Williams (1965):252, figs. 232, 233G. Sta. 11, 12, 13, 23, 27, 35, 45, 48. O.S.: 21-29.7‰.

Williams (1965) reported this crab from "almost all types of bottom". During this survey this spider crab was commonly taken from stations representing nearly all depths and substrate types present in the estuaries.

Subfamily Mithracinae

Microphrys bicornutus (Latreille). Williams (1965):259, figs. 239, 245F. Sta. 52.

M. bicornutus, heavily "decorated" with algae, hydroids, and other foreign material, was found to be abundant on the rocks in shallow water along the north shoreline of Sebastian Inlet. This was the only place it was collected.

?*Mithrax (Mithraculus) forceps* A. Milne Edwards. Williams (1965):258, figs. 238, 245E. Sta. 50.

This species is represented by only one damaged specimen; it is missing both chelipeds, thus making identification somewhat uncertain. The single specimen was taken in shallow water, about three miles north of Sebastian Inlet.

Discussion—No attempt has been made to thoroughly compare relationships between the decapod fauna of Brevard County's estuarine waters and decapod faunas from other areas. However, the interested reader is referred to the following reports ranging from North Carolina to Texas, and containing especially pertinent information and references on estuarine decapod crustaceans: Parker (1959); Tabb and Manning (1961); Wells (1961); Tabb, et al. (1962); Dragovich and Kelly (1964); and Lyons, et al. (1971).

Table 2 illustrates the fact that there were at least two areas in the estuaries where additional decapod species were collected. These areas were, primarily, near or in Sebastian Inlet, and secondarily in the waters adjacent to the Canaveral Locks. This should be expected since oceanic influences on such parameters as salinity, temperature, tidal forces, and other factors are probably more pronounced in these waters; and there is generally an increase in the number of species present in the waters of an estuarine system that are more influenced by the adjacent marine waters (Remane and Schlieper, 1971; Wells, 1961).

Table 2. List of species and subspecies of decapod crustaceans from the estuarine waters of Brevard County, Florida.

I. Species apparently restricted to oceanic inlets and adjacent waters.		
Clibanarius antillensis	*Pachygrapsus transversus*	*Periclimenes americanus*
Leander tenuicornis	*Pagurus longicarpus*	*Persephona mediterranea*
Microphrys bicornutus	*Palaemonetes vulgaris*	*Petrochirus diogenes*
Mithrax forceps	*Panopeus occidentalis*	*Pinnotheres ostreum*
Ogyrides alphaerostris	*Penaeus setiferus*	*Synalpheus apioceros*
Pachycheles monilifer		
II. Species found elsewhere in the estuaries.		
Alpheus armillatus	*Neopanope packardii*	*Penaeus duorarum duorarum*
Alpheus heterochaelis	*Neopanope sayi*	*Petrolisthes armatus*
Alpheus normanni	*Ogyrides yaquiensis*	*Rhithropanopeus harrisii*
Callinectes ornatus	*Pagurus bonairensis*	*Sesarma cinereum*
Callinectes sapidus	*Palaemon northropi*	*Sesarma curacaoense*
Clibanarius vittatus	*Palaemonetes intermedius*	*Tozeuma carolinense*
Eurypanopeus depressus	*Palaemonetes paludosus*	*Uca pugilator*
Hippolyte zostericola	*Palaemonetes pugio*	*Uca rapax*
Libinia dubia	*Panopeus herbstii*	*Uca speciosa*
Menippe mercenaria		

Temporary changes in the species composition of the invertebrate populations of many estuarine areas, caused by seasonal migrations and sporadic movements of various species into and out of the estuaries, are well-documented occurrences (Copeland, 1965; Hoese, et al., 1968; Tabb, et al., 1962; Odum, 1971; and Gunter, 1950). Thus, periodic movements of many marine species into the estuaries at the inlet is probably a common occurrence, and may also contribute to the findings presented in Table 2.

The present survey indicates the following to be the most common species present in the open estuaries during the summer months: *Penaeus duorarum duorarum, Palaemonetes intermedius, Alpheus heterochaelis, Hippolyte zostericola, Petrolisthes armatus, Clibanarius vittatus, Pagurus bonairensis, Callinectes sapidus, Neopanope sayi, Neopanope packardii, Eurypanopeus depressus,* and *Libinia dubia.*

SUMMARY—1. During the summer of 1971 and the summer and fall of 1972, biological collections were made, as a part of a macro-invertebrate baseline survey, in the estuarine waters of Brevard County, Florida to determine the decapod crustaceans present.

2. Forty-four decapod species and subspecies, representing 29 genera, and 14 families were collected. Ten species and subspecies were considered to be the most commonly encountered decapods in the open estuaries.

3. Annotations containing pertinent information obtained during the survey are given for each species and subspecies listed.

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LITERATURE CITED

ABELE, L. G. 1972. A re-evaluation of the *Neopanope texana sayi* complex with notes on *N. packardii* (Crustacea: Decapoda: Xanthidae) in the northwestern Atlantic. Chesapeake Sci., 13:263-271.

ARMSTRONG, J. C. 1949. New Caridea from the Dominican Republic. Amer. Mus. Novit. 1410:27 p. (Not seen)

BRICE, J. J., B. W. EVERMANN, B. A. BEAN, AND W. A. WILCOX. 1898. Report on the fisheries of Indian River, Florida. U. S. Comm. of Fish and Fisheries. Rpt. 22:223-262.

BROWN, D. W., W. E. KENNER, J. W. CROOKS, AND J. B. FOSTER. 1962. Water resources of Brevard County, Florida. Rpt. of Investig. (28). Florida Geol. Survey. Tallahassee.

CASPER, V. L., R. J. HAMMERSTROM, J. C. BUGG, J. D. CLEM. 1966. Sanitary survey of body "F", Brevard County, Florida. 36 pp. Gulf Coast Sanitation Research Center, Shellfish Sanitation Branch. Dauphin Island, Alabama.

CHACE, F. A., JR. 1972. The shrimps of the Smithsonian-Bredin Caribbean expedition with a summary of the West Indian shallow-water species (Crustacea: Decapoda: Natantia). Smith. Contrib. Zool. 98:1-179.

———, AND H. H. HOBBS. 1969. The freshwater and terrestrial decapod crustaceans of the West Indies with special reference to Dominica. U. S. Nat. Mus. Bull. 292:i-v, 1-258.

CHEW, F. 1956. The probable lowest average salinity in the Indian River. Quart. J. Florida Acad. Sci. 19:241-250.

COPELAND, B. J. 1965. Fauna of the Aransas Pass Inlet, Texas. I. Emigrations as shown by tide trap collectionss. Publ. Inst. Mar. Sci. Texas. 10:9-21.

COUTIÈRE, H. 1909. The American species of snapping shrimps of the genus *Synalpheus*. Proc. U. S. Nat. Mus. 36(1659):1-93. (Not seen)

DRAGOVICH, A., AND J. A. KELLY, JR. 1964. Ecological observations of macro-invertebrates in Tampa Bay, Florida. Bull. Mar. Sci. Gulf and Carib. 14:74-102.

FUTCH, C. R. 1967. A survey of the oysters of Brevard County, Florida. Florida Dept. Nat. Resources Spec. Sci. Rpt. 18:1-6.

GUNTER, G. 1950. Seasonal population changes and distributions as related to salinity, of certain invertebrates of the Texas coast, including the commercial shrimps. Publ. Inst. Mar. Sci. Texas. 1:7-51.

HAIG, J. 1956. The Galatheidea (Crustacea Anomura) of the Allan Hancock Expedition with a review of the Porcellanidae of the western North Atlantic. Allan Hancock Atlantic Exped. Rpt. 8:1-44.

———. 1960. The Porcellanidae (Crustacea Anomura) of the eastern Pacific. Allan Hancock Pacific Exped. 24:1-440. (Not seen)

HOESE, H. D., B. J. COPELAND, F. N. MOSELEY, E. D. LANE. 1968. Fauna of the Aransas Pass Inlet, Texas. III. Diel and seasonal variations in trawlable organisms of the adjacent area. Texas. J. Sci. 20:33-60.

HOLTHUIS, L. B. 1951. A general revision of the Palaemonidae (Crustacea Decapoda Natantia) of the Americas. I. the subfamilies Euryhynchinae and Pontoniinae. Allan Hancock Found. Publ. Occ. Pap. 11:1-332.

———. 1952. A general revision of the Palaemonidae (Crustacea Decapoda Natantia) of the Americas. II. the subfamily Palaemoninae. Allan Hancock Found. Publ. Occ. Pap. 12:1-396.

LYONS, W. G., S. P. COBB, D. K. CAMP, J. A. MOUNTAIN, T. SAVAGE, L. LYONS, AND E. A. JOYCE, JR. 1971. Preliminary investigation of marine invertebrates collected near the electrical generating plant, Crystal River, Florida, in 1969. Florida Dept. Nat. Resources. Prof. Pap. Ser. 14:1-45.

MANNING, R. B. 1960. Some growth changes in the stone crab, *Menippe mercenaria* (Say). Quart. J. Florida Acad. Sci. 23:273-277.

MORISAWA, M. 1968. Rivers. *In*: FAIRBRIDGE, R. W. (ed.), The Encyclopedia of Geomorphology, Encyclopedia of Earth Sciences Series, Vol. III. Reinhold Book Corp. New York.

NASA. 1972. Shuttle Project Office. Amendment No. 1 to the Institutional Environmental Impact Statement. 120pp. NASA Space Center. Cape Kennedy, Florida.

ODUM, W. E. 1971. Pathways of energy flow in a south Florida estuary. Univ. Miami Sea Grant Tech. Bull. 7:1-162.

PARKER, H. 1959. Macro-invertebrate assemblages of central Texas coastal bays and Laguna Madre. Bull. Amer. Assoc. Petrol. Geol. 43:2100-2166.

PÉREZ-FARFANTE, I. 1969. Western Atlantic shrimps of the genus *Penaeus*. Fish. Bull. 67:461-591.

PROVENZANO, A. J., JR. 1959. The shallow water hermit crabs of Florida. Bull. Mar. Sci. Gulf and Carib. 9:349-420.

RATHBUN, M. J. 1918. The grapsoid crabs of America. Bull. U. S. Nat. Mus. 97:1-561.

———. 1925. The spider crabs of America. Bull. U. S. Nat. Mus. 129:1-613.

———. 1930. The cancroid crabs of America of the Families Euryalidae, Portunidae, Atelecyclidae, Cancridae, and Xanthidae. Bull. U. S. Nat. Mus. 152:1-609.

———. 1937. The oxystomatous and allied crabs of America. Bull. U. S. Nat. Mus. 166:1-278.

REMANE, A., AND C. SCHLIEPER. 1971. Biology of Brackish Water. John Wiley and Sons, Inc. New York.

ROUSE, W. L. 1970. Littoral Crustacea from southwest Florida. Quart. J. Florida Acad. Sci. 32:127-152.

TABB, D. C. 1960. The spotted seatrout fishery of the Indian River area. Florida Bd. Cons. Tech. Ser. 33:18 pp.

———. 1961. A contribution to the biology of the spotted seatrout, *Cynoscion nebulosus* (Cuvier) of east-central Florida. Florida Bd. Cons. Tech. Ser. 35:24 pp.

———. 1966. The estuary as a habitat for spotted seatrout, *Cynoscion nebulosus*. Amer. Fisheries Soc. Spec. Publ. 3:59-67.

———, AND R. B. MANNING. 1961. A checklist of the flora and fauna of northern Florida Bay and adjacent brackish waters of the Florida mainland collected during the period July, 1957 through September, 1960. Bull. Mar. Sci. Gulf and Carib. 11:552-649.

———, D. L. Dubrow, and R. B. Manning. 1962. The ecology of northern Florida Bay and adjacent estuaries. Florida Bd. Cons. Tech. Ser. 39:1-81.

Thomas, L. P. 1962. The shallow water amphiurid brittle stars (Echinodermata, Ophiuroidea) of Florida. Bull. Mar. Sci. Gulf and Carib. 12:623-694.

Wass, M. L. 1955. The decapod crustaceans of Alligator Harbor and adjacent inshore areas of northwestern Florida. Quart. J. Florida Acad. Sci. 18:129-176.

Wells, H. W. 1961. The fauna of oyster beds, with special reference to the salinity factor. Ecol. Monogr. 31:239-266.

Williams, A. B. 1965. Marine decapod crustaceans of the Carolinas. Fish. Bull. 65:1-298.

———. 1966. The western Atlantic swimming crabs *Callinectes ornatus*, *C. danae*, and a new related species (Decapoda, Portunidae). Tulane Stud. Zool. 13:83-93.

Florida Sci. 37(3):129-141. 1974.

Biological Sciences

FISH SCALES AS SEEN BY SCANNING ELECTRON MICROSCOPY

Edward D. DeLamater and Walter R. Courtenay, Jr.

Experimental Cytology Laboratory and Department of Biological Sciences, Florida Atlantic University, Boca Raton, Florida 33432

Abstract: *Scale structure is characterized by means of the Scanning Electron Microscope. Characters, including circuli, dentition on the crests of the circuli, the cteni and the subjacent anterior areas of the scale plate are described and their potential usefulness in taxonomy indicated. The range of diversity of the lateral line scales has been emphasized separately.*

The structure of the scales of fishes, including their sculptural design and shape, have been inconsistently used as limited characters in fish taxonomy. Their numbers and distribution at selected sites on the body have been given much greater taxonomic value (Goodrich, 1908; Norman, 1951; Van Oosten, 1957; Lagler et al., 1962). Visualization of their detailed characteristics, as has been done by Cockerell (1912), Chu (1935), Kobayashi (1951, 1952, 1953, 1954a, 1954b, 1955) and McCully (1961), has been restricted by the resolving power and the very limited depth of focal field of the photonic microscope. Use of the scanning electron microscope (SEM) circumvents these problems and affords a new basis for taxonomic applications by establishing the presence of previously unsuspected features of scale morphology as well as scale growth and development (DeLamater et al., 1972; DeLamater and Courtenay, 1973a, 1973b, 1974). The photonic microscope is best used to observe the features of fish scale morphology as seen in material stained for calcium (McCully, 1961); the SEM for finer details on the same or unstained material. The two methodologies are mutually supportive. The SEM directly extends in depth of focus and resolving power to allow visualization of what cannot be seen through the optical microscope. This latter instrument, however, allows definition of other features such as centers of calcification which appear to be uniquely different in different forms (DeLamater and Courtenay, 1974).

It is the purpose of this paper to note morphological patterns of circuli (ridges), to describe what can be termed "dentition" along their margins (crests), and further to indicate the types and diversity of characters of the cteni and the adjacent anterior area of the scale.

Materials and Methods—Observations were made with both the ISI Mini-Sem scanning electron microscope (SEM) and the AMR 1000 SEM supplemented by a Reichert photonic microscope, with or without an "epilum" (surface viewing) attachment, and a 35mm camera, or a B&L reverse stand research microscope set on a B&L-L camera using 5×7 photographic film. The B&L-L camera was set at 20 in above the microscope to achieve 2× multiplication of the microscopic magnification. For larger scales, a Wild dissecting microscope was used. A range of 3.5× to 40× objectives were used and paired with a range of 1× to 28× occulars to obtain desired magnifications. Light source for the Reichert system was a mercury vapor arc lamp or an alternative tungsten source. For the B&L and Wild systems, a 100W Zirconium arc lamp was used at a distance to achieve Koehler illumination. A ground glass filter eliminated diffractions and increased certain details, particularly of bony structures. However, it likewise obliterated phase differences wiping out certain delicate details, particularly of soft tissues, which were sometimes desired.

Kodak Ectopan and DuPont Cronar graphic 5×7 cut film were used in the B&L system; Kodak Plus-X 35mm film in the Reichert system. Polaroid PN55 film, used exclusively in the scanning instrument, provided negatives for the production of prints for study, comparison and publication.

Each system, scanning and photonic microscopy, required a separate method for preparation of material. SEM preparations were first cleaned by physically removing as much adhering tissue and debris as possible without touching or damaging the scale surface. They were then soaked in a 10% H_2O_2 solution for several hours to bleach chromatophores and to soften adhering tissues, followed by 12-24 hr in saturated borax solution with trypsin (1 teaspoonful per 0.5 pint) to clear them. Gentle sonication in a Desontegrator, Model #T4C1, sonicator finalized the cleaning procedure. It was also found that a few minutes exposure of specimens to 10% KOH effectively loosened adhering tissues and speeded the cleaning and clearing procedure. Dehydration was done rapidly through a series of alcohol to 100%, blotted free of solvent and pressed flat on the metal specimen pegs to which a small piece of double stick tape had been applied. Electrical contact with the peg was insured by touching a small drop of aluminum paint between the specimen and peg at one point. Sections of skin carrying scales were handled and mounted in the same way. Mounted preparations were coated with carbon and gold or gold-rhodium in a Kinney vacuum evaporator.

Specimens for white light microscopy were cleaned in the same manner and cleared by exposure to the borate-trypsin solution. Staining proceeded in 5cc of 0.05% KOH to which 5cc of Alizarin Red S solution was added. After staining for 8-10 min, or longer as needed, the specimens were passed through a 25%, 50%, 75% and 100% glycerin series and mounted in 100% glycerin on glass slides. The specimens were held flat with 1-2 oz lead weights and sealed with nail polish. Both individual scales and skin mounts were handled in the same manner.

List of Fishes Studied

1. *Tilapia melanotheron* (Ruppell)
2. *Tilapia aurea* (Steindachner)
3. *Kyphosus sectatrix* (Linnaeus)
4. *Synodus foetens* (Linnaeus)
5. *Haemulon plumieri* (Lapécède)
6. *Pomacentrus leucostictus* (Miller & Troschel)
7. *Equetus acuminatus* (Bloch & Schneider)
8. *Diplectrum formosum* (Linnaeus)
9. *Myripristis jacobus* (Cuvier)

Observations—Figure 1 illustrates a teleostean lateral-line scale for purposes of orientation and identification of parts and features of the scale. Anteroposterior (A-P) and Dorsoventral (D-V) axial lines are drawn dividing the scale into four quadrants or fields for purposes of easier description. As shown, the lateral-line canal, in this instance, lies on the A-P axis of the scale with the posterior canal opening at the posterior margin dividing the cteni and anterior subjacent sculptured (subctenoid) area. The focus or area where scale formation was initiated lies approximately under the sulcus on the lateral-line canal cover (# 12 in diagram) near the center of the combined posterior field. This central or focal area of the scale in this case is unsculptured, having no circuli. The circuli or bony ridges of the scale are initiated posteriorly, just anterior to the sculptured subctenoid area dorsal and ventral to the focus and proceed anteriorly, increasing in number progressively by bifurcations and insertions. New circuli also originate along the dorsal and ventral margins. In many species there is a band of bifurcations and insertions of new circuli just dorsal to, just ventral to, and parallel to the most dorsal and most ventral radius. The bifurcations and insertions multiply the number of circuli anteriorly with a corollary marked reduction of the spacing between them. The numbers of circuli are usually quite constant in the anterior fields between the radii, there being few insertions and bifurcations in this area as a rule.

The shape of the scale may vary widely and, even characteristically, in certain groups of fishes from one area of the body to another (e.g., as in squirrelfishes), so that the specific area from which scales are taken for comparative observations must be consistent from one specimen to another. This also means that extensive analysis of scale form without reference to body position is not significant diagnostically. In fact, it may produce such confusion as to obscure identification. Interestingly, the lateral-line scales in general tend to be more consistent in form and shape than body scales from head to tail (with notable exceptions) and possess, because of the presence of the canal, additional features of potential diagnostic significance (DeLamater and Courtenay, 1973a)—contrary to the opinion of McCully (1961).

The Circuli—The circuli are ridges formed in the outer calcified layer of the scale. In many ways these compare remarkably with the ridges in fingerprints, having "minutiae" in the form of insertions, bifurcations and endings that equate to those formed on palmer epithelium.

Figure 2A demonstrates this pattern as seen in the dorsoanterior field of a body scale of *Tilapia melanotheron*. The concentrated band of insertions and bifurcations just dorsal to the most dorsal radius is obvious, as are those occurring less frequently more dorsally in the field. Insertions and bifurcations rarely occur on the circuli occurring between the radii in this species.

Figure 1B demonstrates in *T. melanotheron* a portion of the combined posterior fields of the scale including the lateral-line canal and most of the posterior exposed area of the scale covered with epithelial tissues. The circuli in this area are widely spaced and appear through the covering tissue as rows of bumps we have called "pseudotubercles" to distinguish them from tuberculate structures which occur on the bony plate of certain scales (see below and Fig. 1C). Where this epithelium has broken away, the widely spaced ridges are seen to have roughened crests.

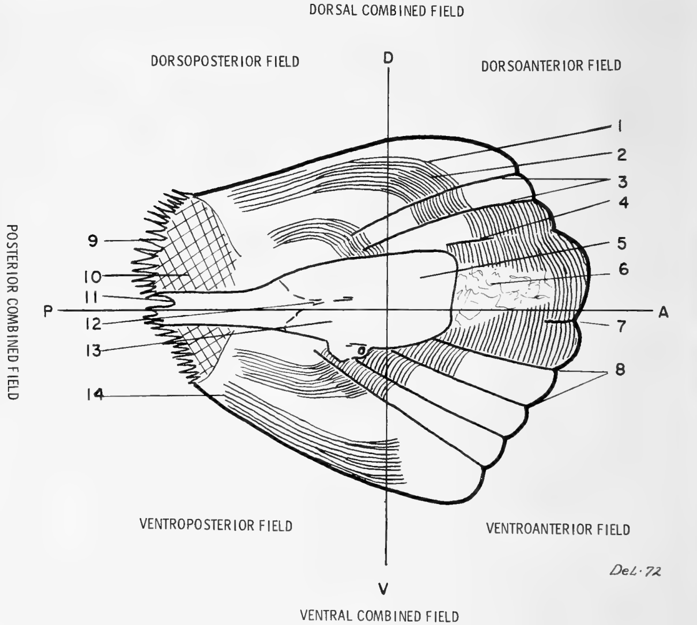

Fig. 1. (1) Circuli bifurcations; (2) Circuli insertions; (3) Primary radii; (4) Secondary radius of central origin; (5) Cantilevered eave over anterior lateral-line canal opening; (6) Denuded area anterior to anterior canal opening; (7) Secondary radius of peripheral origin; (8) Scallops at anterior margin at radii; (9) Cteni; (10) Subctenoid area; (11) Posterior lateral-line canal opening at margin; (12) Sulcus in lateral-line canal cover; (13) Lateral-line canal; (14) Primary circuli.

The lateral-line canal in the Tilapias characteristically lies along the A-P axis with the posterior opening at the posterior margin and the anterior opening anterior to the focus of the scale as seen in Fig. 2B. The anterior opening is likewise characteristically uncovered by a cantilevered extension, as in other forms (DeLamater and Courtenay, 1973a).

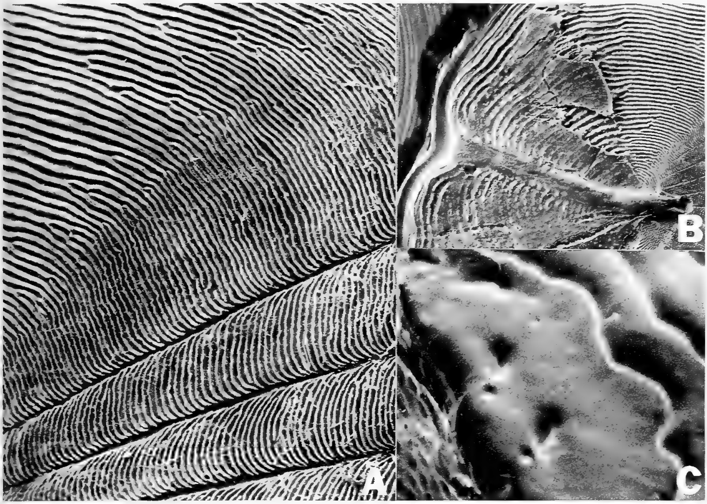

Fig. 2. (A) *Tilapia melanotheron.* Circuli and radii in anterior dorsal field showing insertions and bifurcations (39×). (B) *T. melanotheron.* Lateral-line canal in combined posterior fields showing circuli as rows of pseudotubercles in tissue covering and widely spaced primary circuli with roughened crests where tissue has broken away (105×). (C) *T. aurea.* Central area (focus) of scale with circuli without dentition and two true tuberculi present (627×).

Figure 1C, at much higher magnification, shows circuli adjacent to the focus of the scale in *T. aurea* in this area of the scale. The crests of the circuli are smooth and not denticulate. To the left of the circuli are two tuberculate knobs or bumps (tuberculae) on the calcified scale plate apparently representing early or juvenile circuli.

Figure 3A-D demonstrates four examples of dentition along the crests of the circuli in three genera of widely unrelated fishes and two species of one genus; Fig. 3A shows rather pointed teeth, seemingly held in sockets along the crests of the circuli in *Tilapia melanotheron*; Fig. 3B demonstrates the more conical and somewhat recurved teeth in *Tilapia aurea*—no suggestion that teeth are set in sockets is seen here; Fig. 3C demonstrates the irregularly conical and blunted teeth on the circuli crests in *Kyphosus sectatrix*; and Fig. 3D shows the more widely spaced blunted and irregular teeth on the crests of circuli in *Synodus foetens.* In neither of the latter is there a suggestion that the teeth occur in sockets. It would appear that these tooth features could serve to characterize genera and may have specific significance.

The diverse characters of the cteni are demonstrated in Figs. 4A-D and 5A-D. Figure 4A and B shows the similarity of the cteni and the mosaic pattern of the subctenoid area in lateral-line and body scales respectively of *Haemulon plumieri.* Growth apparently proceeds along the posterior margin of the scale by the formation of new rows of cteni. The older cteni appear to be cut off or resorbed in a characteristic fashion to a consistent point on the ctenus to produce the characteristic mosaic pattern observed. The resorption process appears to continue progressively reducing the older remnants of cteni.

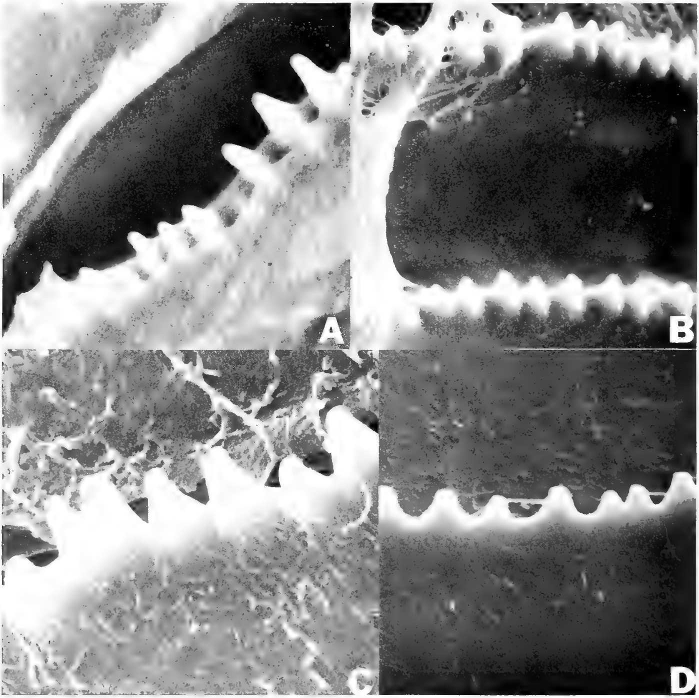

Fig. 3. (A) *Tilapia melanotheron.* Teeth occurring along the crests of the circuli in the anteroventral field of a lateral-line scale (2700×). (B) *T. aurea.* Teeth occurring along the crests of the circuli in the anteroventral field of a lateral-line scale (2130×). (C) *Kyphosus sectatrix.* Irregularly shaped, blunted and more or less conical teeth along the crest of the circuli (7648×). (D) *Synodus foetens.* Highly irregular blunted teeth along the crests of circuli (5700×).

A similar process appears to operate in the formation of the cteni and subctenoid area in *Pomacentrus leucostictus*, but the shape of the cteni and their remnants produce again a distinctive pattern characteristic of the species (Fig. 4C-D).

The equally distinctive cteni and mosaics produced on the scales of four other species are shown in Fig. 5A-D. Figure 5A depicts the characteristic cteni on the scales of *Kyphosus sectatrix.* Here the cteni and their remnants lie tangential to the scale plate and also appear to be resorbed in a characteristic manner to produce a mosaic quite unlike that seen in *Equetus acuminatus* (Fig. 5B) in which the cteni lie parallel to the scale plate and, upon modification with growth and resorption, produce a pattern suggestive of bricks in a wall.

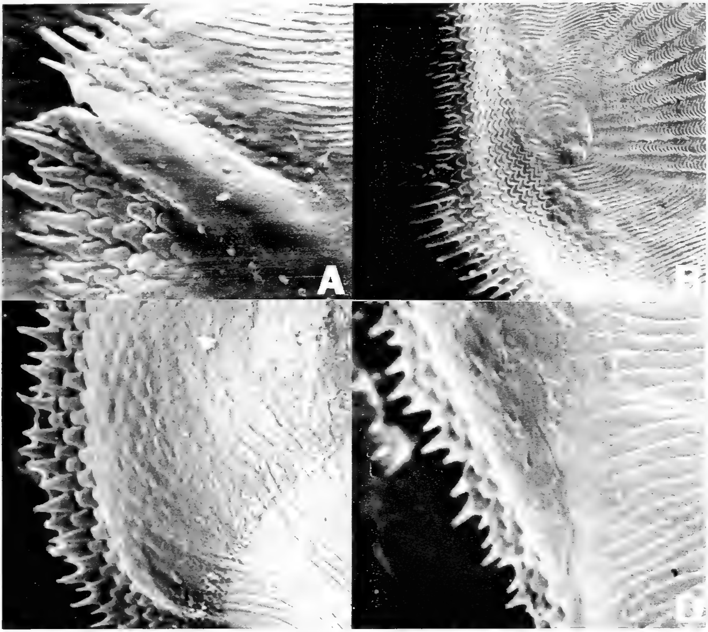

Fig. 4. (A) *Haemulon plumieri.* Lateral-line scale (90×). Posterior border and posterodorsally deviated segment of lateral-line canal. (B) *H. plumieri.* Body scale (56×). Cteni along posterior margin and bases of former cteni are of same form and arrangement as those on the lateral-line scale. (C) *Pomacentrus leucostictus.* Body scale (46×). (D) *P. leucostictus.* Lateral-line scale (120×).

In *Diplectrum formosum* (Fig. 5D) the newest cteni develop in two rows, each abutting the remnant of the previous ctenus in its row and also articulating laterally with the bases of adjacent cteni. As growth and resorption of earlier cteni proceeds, this produces a very different and distinctive mosaic for this form.

Myripristis jacobus (Fig. 5C) presents a quite different form of cteni and apparently also a different growth pattern. The cteni occur as a single row along the posterior border of the scale. Growth appears to occur by the progressive addition of new layers of calcified material to existing cteni and by the addition of new cteni at the dorsal and ventral ends of the row of cteni. Resorption does not appear to be involved. As a consequence any sculptured pattern produced shows a direct continuity and dependence on this distinctive growth pattern.

Discussion—This limited demonstration of the characteristic patterns of the circuli and of the cteni and the associated subctenoid area by means of the SEM clearly shows the types of details and differences in scale structure available for study and analysis. The differences between unrelated genera and between closely related species give credence to the possibility that thorough characterization of fish scales by means of the SEM, extending observations made with the optical microscope, may produce a supplemental system for fish identification of great usefulness, especially in certain special situations.

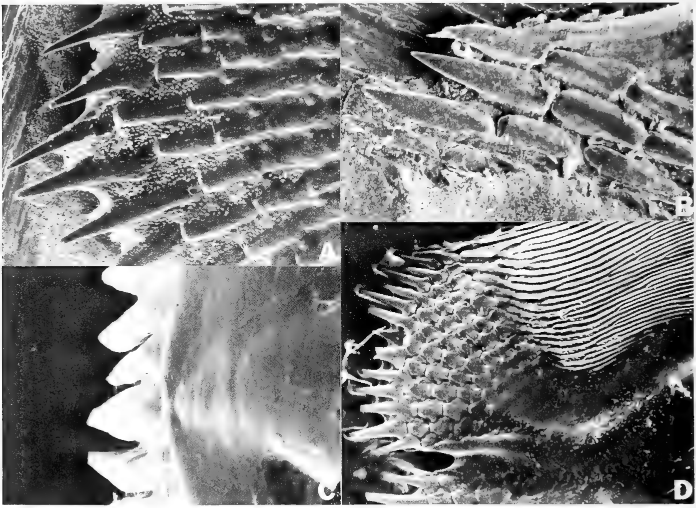

Fig. 5. Ctenoid border of lateral line scales. (A) *Kyphosus sectatrix* (23×). (B) *Equetus acuminatus* (238×). (C) *Myripristis jacobus* (152×). (D) *Diplectrum formosum* (84×).

The genus *Tilapia*, for example, is considered by ichthyologists to pose one of the most difficult taxonomic problems in the field. Some 200+ species have been described separated mainly on the basis of overlapping meristic values and frequently by geographic distribution. *T. aurea* for example occurs in Israel and surrounding countries; its meristic equivalent or counterpart, *T. nilotica*, occurs in Africa. If the geographic origin of a particular specimen is not known, it cannot be identified. Preliminary studies of several "species" of *Tilapia* in which the patterns of the circuli of these non-ctenoid scales are being analyzed suggest that "species" may be arranged into groups on the basis of scale patterns. It seems likely that scale analysis will afford the development of a useful tool in the study of this relatively recent, difficult and complex group in which speciation may still be in process.

Other studies in progress on *Haemulon* suggest the possibility that relatively non-migratory geographic populations of the same described species occurring in widely separated areas may also be identified by this means.

On the other hand, in other groups such as squirrelfishes (Holocentridae) separation of genera appears to be relatively easy on the basis of scale morphology, but separation of species is extremely difficult or impossible at this stage of these studies. Fortunately species are clearly defined by other means in this group (Woods and Sonoda, 1973).

In extensive continuing studies of the flatfishes (DeLamater and Courtenay, 1973), the dimorphism of these fishes is frequently reflected not only in scale distribution but likewise in differences in scale morphology on the eyed and blind sides. In this fascinating group, it is beginning to appear that relationships between groups can be defined on the basis of scale morphology.

The potential usefulness of scale morphology as a tool is apparent, and it is odd that relatively few studies in depth have been done with it.

ACKNOWLEDGMENTS—This paper was supported by the Sea Grant Program Grant #RB-1.

LITERATURE CITED

CHU, Y. T. 1935. Comparative studies on the scales and on the pharyngeals and their teeth in Chinese cyprinids, with particular reference to taxonomy and evolution. Biol. Bull. St. John's Univ. 2:226 pp.

COCKERELL, T. D. A. 1912 [1913]. Observations on fish scales. Bull. Bureau Fisheries 32:doc. 779.

DELAMATER, E. D., AND W. R. COURTENAY, JR. 1973a. Variations in structure of the lateral-line canal on scales of *Teleostean* fishes. Zeit. Morph. Tiere 75:259-266.

_________, AND _________. 1973b. Multiple patterns in differentiation of lateral-line scales of fishes. Proc. Cell Biol. 13th Ann. Meeting. Miami Beach. 14-17 Nov. 1973.

_________, AND _________. 1974. Studies on the scale structure of flatfishes. I. The genus *Trinectes* with notes on related forms. Proc. S.E. Game and Fish Comm. (In Press).

_________, _________, AND C. WHITAKER. 1972. Scanning electron microscopy of fish scales as an adjunctive aid in speciation (species recognition). *In* Arcenaux, C. J. (ed.) Proc. E.M.S.A. 1972:394-395. Los Angeles.

GOODRICH, E. S. 1908. On the scales of fishes living and extinct, and their importance in classification. Proc. Zool. Soc. London 1908:751-774.

KOBAYASI, H. 1951. On the value of scale character considered as materials for study of fishes. Jap. J. Ichthyol. 1:226-237. [Japanese with English summary]

_________. 1952. Comparative studies of the scales in Japanese freshwater fishes, with special reference to phylogeny and evolution. I. Introduction, and II. Table of Fishes used in this study. Jap. J. Ichthyol. 2:183-191.

_________. 1953. Comparative studies on the scales in Japanese freshwater fishes, with special reference to phylogeny and evolution. III. General lepidology of freshwater fishes. Jap. J. Ichthyol. 2:246-260.

_________. 1954a. Comparative studies on the scales in Japanese freshwater fishes, with special reference to phylogeny and evolution. IV. Particular lepidology of freshwater fishes. (I.) Suborder Isospondyli. Jap. J. Ichthyol. 3:83-86.

_________. 1954b. Comparative studies on the scales in Japanese freshwater fishes, with special reference to phylogeny and evolution. IV. Particular lepidology of freshwater fishes. (I.) Suborder Isospondyli (cont.). Jap. J. Ichthyol. 3:203-208.

_________. 1955. Comparative studies on the scales in Japanese freshwater fishes, with special reference to phylogeny and evolution. IV. Particular lepidology of freshwater fishes. (I.) Suborder Isospondyli (cont.). Jap. J. Ichthyol. 4:64-75.

LAGLER, K. F., J. E. BARDACH AND R. R. MILLER. 1962. Ichthyology. John Wiley & Sons, Inc. New York.

MCCULLY, H. H. 1961. The comparative anatomy of the scales of serranid fishes. Dissertation Abstracts. 22(5):Order #61-4145.

NORMAN, J. R. 1951. A history of fishes. Chapt. 5 *In* Skin, scales and spines. A. A. Wyn, Inc. New York.

VAN OOSTEN, J. 1957. The skin and scales. pp. 207-244. *In* (Ed.) The Physiology of Fishes, Vol. I. Academic Press, New York.

WOODS, L. P., AND P. M. SONODA. 1973. Order Berycomorphi (Beryciformes). Mem. Sears Found. Mar. Res. 1:263-396.

Florida Sci. 37(3):141-149. 1974.

GROWTH OF MICROORGANISMS IN PHOSPHATE SLIME

Patricia R. Aston[1], R. J. Wodzinski[2] and J. H. Ware[3]

Growth Sciences Center, International Minerals and Chemicals Corporation, Libertyville, Illinois 60048

Abstract: *Several autotrophic organisms were grown in phosphate slime wastes.* Thiobacillus thiooxidans *oxidized exogeneous sulfur to sulfuric acid and effected the liberation of bound phosphate from the slime solids. The particle bound phosphate was converted to a soluble recoverable form by microbial action.* Ferrobacillus sulfoxidans *and* Thiobacillus ferrooxidans *oxidized exogeneous iron in the presence of slime but had no effect on the iron in the solids. Iron released by acidification of slime could not serve as an energy source for these iron oxidizing organisms. Microscopic observations indicated that the diatoms* Navicula incerta *and* Amphora exiqua *were able to grow and divide in unsupplemented slime. None of the autotrophs tested changed the colloidal state of the slime appreciably.*

Phosphate mining has resulted in acres of waste slime ponds which present storage and processing difficulties. These ponds are the result of beneficiation of the phosphate solids. Colloidal properties of this material prevent dewatering without treatment beyond 30% solids and the small particle size (<150 mesh) prohibits economic recovery of the contained phosphate by present methods (Gary et al., 1963). In 1960, slime ponds in Florida constituted a potential resource of 175 billion gal of water and 45 million tons of phosphorus (Gary et al., 1963). These resources have increased appreciably since then. Attempts over a 30 yr period to sediment and dewater the slime and to recover the mineral values have not produced a satisfactory solution. Many chemical and physical methods have been technically successful but not economically feasible (Gary et al., 1963).

The chemical and mineralogical analysis of a typical phosphatic slime is in Table 1. The solids are predominately apatite, clay and quartz. The clay is predominately montmorillonite. The chemical composition limits any microbial approach to beneficiate slime, and the relatively low economic value of phosphate and water in slime restricts the choice and degree of supplementation. Growth of heterotrophs without supplementation would be limited by the low content of organic material. Autotrophic bacteria which derive energy from oxidation of inorganic compounds and carbon from CO_2 fixation are known to serve as "miners" (Bryner et al., 1963; Canadian Chemical Processing, 1964; Carpenter and Herndon, 1933; Duncan et al., 1964; Duncan et al., 1967; Leathen et al., 1953a; Leathen et al., 1953b; Perkins and Novielli, 1962; Silverman et al., 1961; Sutton and Corrick, 1961). They were judged likely candidates for growth in

[1]Deceased.

[2]Present Address: Gordon J. Barnett Professor of Environmental Sciences, Department of Biological Sciences, Florida Technological University, Orlando, Florida 32816.

[3]Present Address: 2921 Glenwood Lane, Billings, Montana 59102.

slime. High silicon concentration suggested the possibility of dewatering slime by growth of diatoms.

Data reported here summarize attempts to utilize microorganisms to dewater slime, aid settling of the material, and reclaim water and phosphate.

TABLE 1. Typical analysis of phosphate slime solids.

CHEMICAL[a]	PERCENT	MINERAL	PERCENT
SiO_2	47.8	Apatite (Ca-fluophosphate)	25
Al_2O_3	8.3	Quartz (SiO_2)	30
Fe_2O_3	3.4	Montmorillonite (hydrous Mg-Al-silicate)	25
CaO	13.4	Attapulgite (hydrous Mg-silicate)	5
MgO	1.8	Wavellite (hydrous Al-phosphate)	7
P_2O_5	11.2	Dolomite (Ca-Mg carbonate)	1
CO_2	1.5	Feldspar (Fe-oxides, other)	7
LOI[b]	8.9		
F	1.0		
Misc.	2.7		
	100.0		100

[a]Based upon known compositions of component minerals.
[b]Ignition loss at 1000°C primarily H_2O; some organic.

MATERIALS AND METHODS—*Organisms. Thiobacillus thiooxidans* was obtained from F. Adair, Rutgers University. *Thiobacillus ferrooxidans* strain 13728 and *Ferrobacillus sulfoxidans* strain 14119 were obtained from the American Type Culture Collection. (BERGEY'S MANUAL OF DETERMINATIVE BACTERIOLOGY, 8th Ed. 1974, lists *Thiobacillus ferrooxidans* and *Ferrobacillus sulfoxidans* as identical species.) *Navicula incerta* strain 1262 and *Amphora exiqua* strain 685 were obtained from the Indiana University culture collection (Starr, 1964).

Media. Thiobacillus thiooxidans was cultured in a medium described by Cook (1964). Sulfur was added separately and sterilization was by intermittent steaming for 2 hr on two consecutive days. Iron oxidizing medium was used for cultivation of *T. ferrooxidans* and *F. sulfoxidans* (Silverman and Lundgren, 1959). *Navicula incerta* and *A. exiqua* were cultured in seawater medium (Starr, 1964).

Analytical Procedures. Phosphate (Fiske and Subbarow, 1925) and ferrous iron (Kolthoff and Belcher, 1957) were determined by standard procedures. Potassium ferricyanide and potassium thiocyanate were used for qualitative estimation of ferrous and ferric ions, respectively. Aluminum was determined by mass spectroscopy (Perkin-Elmer Corporation, 1966).

Manometric Procedure. Oxygen uptake was measured manometrically with the Gilson Respirometer. Each flask contained water, 0.05 ml of 0.01 M HCl, and 0.5 ml washed cell suspension in the main compartment, 200 μmoles $FeSO_4 \cdot 7 H_2O$ in the side arm and 0.2 ml of 20% (w/v) KOH plus a small folded square of Whatman 42 filter paper in the center well. Slime (0.2 ml) was added to the main compartment when indicated. Total volume was 2.0 ml. Oxygen uptake was recorded after 5 min temperature equilibration. Neither autooxidation of iron nor endogenous metabolism of "resting cells" was detected.

RESULTS—*Effect of microbial oxidation on slime.* *Thiobacillus thiooxidans* was cultivated in dispersed slime on a rotary shaker at 23°C. Reduction in pH due to production of H_2SO_4 and H_3PO_4 indicated growth (Fig. 1). Optimum sulfur concentration was 0.5g/100 ml slime. Nitrate improved the growth rate but was not essential for growth. The pH was lowered to 5.5 when sulfur was added to non-sterile slime, indicating the presence of naturally-occurring, sulfur oxidizing organisms. There was no acid produced chemically when sulfur was added to sterilized slime.

Microbial sulfur oxidation resulted in solubilization and liberation of inorganic phosphate from the slime solids. The concentration of phosphate liberated depended on the concentration of sulfur provided as substrate (Fig. 2). Maintenance of pH 2.5, optimum for growth of *T. thiooxidans*, encouraged phosphate liberation (Fig. 3). However, the ratio of phosphate liberated to sulfur oxidized did not increase appreciably.

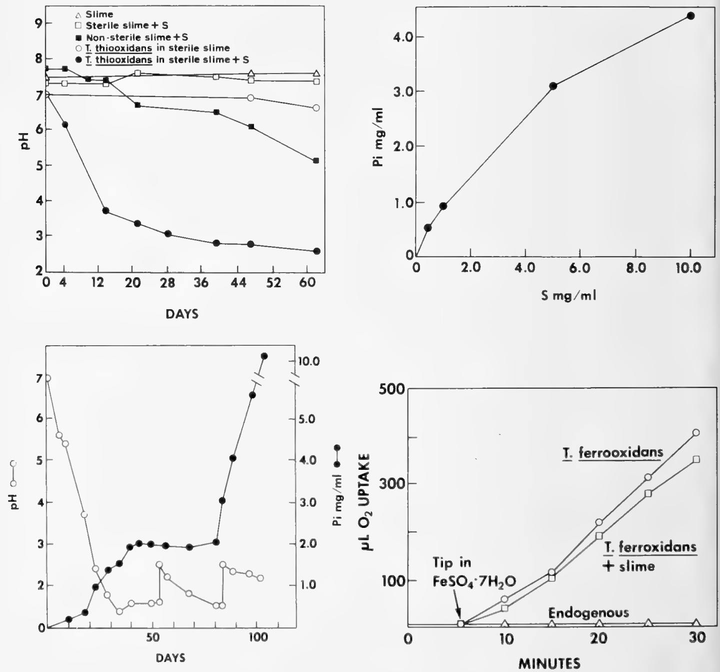

Fig. 1-4. Fig. 1. (upper left) Acid production by *T. thiooxidans* in Florida phosphate slime. Fig. 2. (upper right) Effect of sulfur concentration in the presence of *T. thiooxidans* on release of inorganic phosphate from Florida phosphate slime. Fig. 3. (lower left) Release of inorganic phosphate from Florida slime by *T. thiooxidans* in the presence of excess sulfur at 28°C. Fig. 4. (lower right) Effect of slime on oxidation of Fe^{++} by *T. ferroxidans* and *F. sulfoxidans* at 23°C.

Effect of microbial oxidation of iron on slime. *Thiobacillus ferrooxidans* and *F. sulfoxidans,* two iron oxidizing organisms, were examined for their ability to utilize iron present in slime as an energy source. Although the true valence state of iron in slime is unknown, it is thought to be complexed with silicates in the clay fraction, rendering it essentially inert. Slime is unreactive in the presence of thiocyanate and ferricyanide, indicating the absence of free ferric and ferrous irons, respectively. Resting cells of *T. ferrooxidans* and *F. sulfoxidans* were unable to oxidize slime (Fig. 4). When $FeSO_4 \cdot 7H_2O$ was tipped into the manometric flask, rapid uptake of oxygen ensued. Slime did not inhibit this oxidation. Neither organism was able to effect a change in the bound iron, with or without added mineral supplements, when incubated in dispersed slime at 23°C. Supplemental ferrous iron, however, was completely oxidized within 4-5 days (Table 2).

TABLE 2. Oxidation of Ferrous Iron[a] by *F. sulfoxidans* and *T. ferrooxidans.*

	Ferrous Iron Concentration			
	Day 1	Day 2	Day 4	Day 5
Uninoculated Control	+ + + +	+ + + +	+ + + +	+ + +
F. sulfoxidans	+ + + +	+ +	+	–
T. ferrooxidans	+ + + +	+ +	–	–

[a]The organisms were incubated in dispersed slime at 23°C on a rotary shaker. The flask contained 20 ml slime and 0.4 mg/ml $FeSO_4 \cdot 7H_2O$. Concentration of reduced iron was estimated by the intensity of reaction with ferricyanide.

Acidification of slime to pH 2.0 released iron from the slime solids. The possibility of an acid-leached energy source for iron-oxidizing organisms was tested. Both *T. ferrooxidans* and *F. sulfoxidans* appeared to survive in acidic slime (short motile rods present) but had no effect on the settling or percent solids of the slime. Attempts at quantitative estimation of ferrous iron concentration in slime were inconclusive. The slime itself apparently interfered with the color reaction, and the data were extremely variable.

Effect of diatoms on phosphate slime. *Navicula incerta* and *Amphora exiqua* were cultivated in dispersed slime at 23°C with illumination. Growth occurred without supplementation. The addition of seawater or montmorillonite, the clay fraction of slime, stimulated growth. Cell counts increased 100-500 fold in 20 days. The morphology of *N. incerta* propagated in slime differed from that of cells propagated in seawater medium (Fig. 5). The cells elongated, the internal deposits became accentuated, and the cell walls thickened and were more dense when grown in slime (Fig. 5b) than when grown in seawater medium (Fig. 5a).

Attempts at quantitating the effects of diatoms were unsuccessful. Separation of diatoms from the slime matrix, into which they were embedded, was not accomplished. Aluminum and silicon were not detected in supernatant fractions.

DISCUSSION—Phosphate slime supports growth of autotrophic bacteria only when properly supplemented with a suitable energy source. Acidification of slime by microbial sulfur oxidation is a possible method for recovery of bound mineral constituents. The release of phosphate was demonstrated. Other metals were

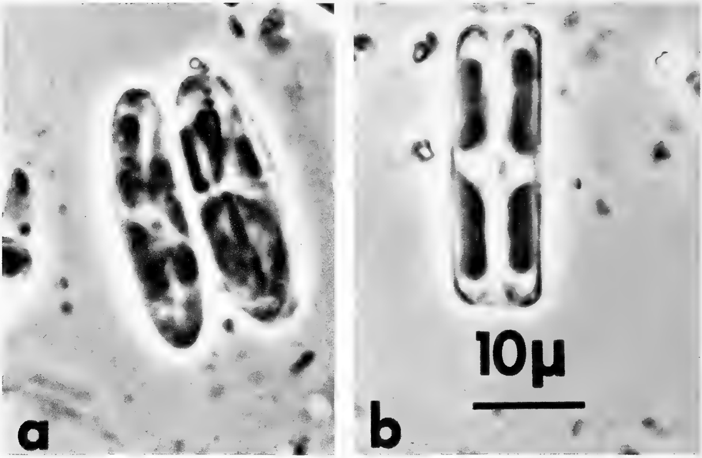

Fig. 5. Accumulation of internal metaphosphate and silica by *Navicula incerta*: (a) seawater medium; (b) Florida phosphate slime.

undoubtedly leached in the process, thereby hindering purification of any single metal. The process is uneconomical at present because a high ratio of phosphate liberated to sulfur oxidized was not achieved. Microbial oxidation of solids-bound iron offered a possible means of changing the character of slime. The two iron oxidizing organisms tested had no effect on the slime solids and did not beneficiate slime.

Since diatoms require silicon for cell division (Lewin, 1962) and are known to dehydrate silica gels with the release of Al_2O_3 and the precipitation of SiO_2 (Vinogradov, 1953), it was hoped that they might beneficiate phosphate slimes. The slimes contain *ca* 20% (w/v) silicon held in colloidal suspension in the clay fraction. These complex silicates are believed to be hydrated alumina silicates with the formula: $Al_2O_3{\cdot}2SiO_2{\cdot}2H_2O$. *Navicula incerta* and *A. exiqua* grew in unsupplemented phosphate slimes. They appeared to accumulate internal metaphosphate. Apparently silica was accumulated in their cell walls. The quantity of mineral removed from the slime by the diatoms was not sufficient to effect a change in the physical characteristics of the slime.

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LITERATURE CITED

Bryner, L. C., J. V. Beck, D. B. Davis and D. G. Wilson. 1954. Microorganisms in leaching sulfide minerals. Ind. Eng. Chem. 45:2587-2592.

Buchanan, R. E. and N. E. Gibbons. 1974. Bergey's Manual of Determinative Bacteriology. Williams & Wilkins. Baltimore.

CANADIAN CHEMICAL PROCESSING. 1964. The new miners: acid-loving bacteria. Canad. Chem. Processing 48(7):55-57.

CARPENTER, L. V. AND L. K. HERNDON. 1933. Acid drainage from bituminous coal mines. West Virginia Univ. Eng. Exp. Sta. Res. Bull. 10:37pp.

COOK, T. M. 1964. Growth of *Thiobacillus thiooxidans* in shaken culture. J. Bacteriol. 88:620-623.

DEER, W. A., R. A. HOWIE AND J. ZUSSMAN. 1962. Rock Forming Minerals, Vol. III, Sheet Silicates. Longmans, Green Co. Ltd. London.

DUNCAN, D. W., P. C. TRUSSELL AND C. C. WALDEN. 1964. Leaching of chalcopyrite with *Thiobacillus ferrooxidans*: Effect of surfactants and shaking. Appl. Microbiol. 12:122-126.

DUNCAN, D. W., J. LANDESMAN AND C. C. WALDEN. 1967. Role of *Thiobacillus ferrooxidans* in the oxidation of sulfide minerals. Canad. J. Microbiol. 13:397-403.

FISKE, C. H. AND Y. SUBBAROW. 1925. The colorimetric determination of phosphorous. J. Biol. Chem. 66:375-400.

GARY, J. H., I. L. FELD AND E. G. DAVIS. 1963. Chemical and physical benefication of Florida phosphate slimes. U. S. Bur. Mines Rep. Invest. 6163. 35pp.

KOLTHOFF, I. M. AND R. BELCHER. 1957. Volumetric Analysis III. Interscience Publ., Inc. New York.

LEATHEN, W. W., S. A. BRALEY AND L. D. MCINTYRE. 1953a. The role of bacteria in the formation of acid from certain sulfuritic constituents associated with bituminous coal. I. *Thiobacillus thiooxidans.* Appl. Microbiol. 1:61-64.

———, ———, AND ———. 1953b. The role of bacteria in the formation of acid from certain sulfuritic constituents associated with bituminous coal. II. Ferrous iron oxidizing bacteria. Appl. Microbiol. 1:65-68.

LEWIN, J. C. 1962. Silicification p. 445-453. *In* LEWIN, R. A. Physiology and Biochemistry of Algae. Academic Press. New York.

PERKIN-ELMER CORPORATION. 1966. Analytical methods for atomic absorption spectrophotometry. Perkin-Elmer Corp. p. A1-1.

PERKINS, E. C. AND F. NOVIELLI. 1962. Bacterial leaching of manganese ores. U. S. Bur. Mines Rep. Invest. 6102. 11pp.

SILVERMAN, M. P. AND D. G. LUNDGREN. 1959. Studies on the chemoautotrophic iron bacterium *Ferrobacillus ferrooxidans.* J. Bacteriol. 77:642-647.

———, M. H. ROGOFF AND I. WENDER. 1961. Bacterial oxidation of pyritic materials in coal. Appl. Microbiol. 9:491-496.

STARR, R. C. 1964. The culture collection of algae at Indiana University. Amer. J. Bot. 51:1013-1044.

SUTTON, J. A. AND J. D. CORRICK. 1961. Bacteria in mining and metallurgy: leaching selected ores and minerals; experiments with *Thiobacillus thiooxidans.* U. S. Bur. Mines Rep. Invest. 5839. 16pp.

VINOGRADOV, A. P. 1953. The Elementary Chemical Composition of Marine Organisms. Sears Foundation for Marine Research. New Haven.

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Biological Sciences

DISTRIBUTIONAL NOTES ON THE BIRDS OF CAYMAN BRAC

SEBASTIAN T. PATTI, DANIEL I. RUBENSTEIN AND NANCY RUBENSTEIN

Department of Zoology, Duke University, Durham, North Carolina 27706

ABSTRACT: *Sight and photographic records are reported for 11 species which were rare or previously unknown for the island.*

IN conjunction with a research project on Yellow-faced Grassquits, the authors spent a week (17-24 November 1973) on the Caribbean island of Cayman Brac, 150 miles NW of Jamaica. Observations of other species were also made during that time and noteworthy observations are presented here to supplement published data on the avifauna of the Cayman Islands (Johnston, Blake and Buden, 1971).

While most of these observations are significant only because of the paucity of field work on the island, some do seem to indicate changes in status among resident species (e.g., Common Gallinule and Greater Antillean Grackle).

Dendrocygna arborea. West Indian Tree Duck. A single individual was observed on 24 November near the lagoons on the west end of the island. This is apparently only the second sight record of this species, the first having been made by Blake in October 1956.

Anas americana. American Wigeon. One male was seen on 21 November on the west end. This is the first report from Cayman Brac.

Falco columbarius. Merlin. A male was seen on 19 November on the west end of the island. This is the first sight record from Cayman Brac.

Gallinula chloropus. Common Gallinule. Johnston et al., 1971, list records of this species from May, June and August. At least six or seven individuals (including immatures) were regularly seen during the study period, suggesting that the species is resident on the island.

Capella gallinago. Common Snipe. One bird was flushed from a damp marsh on 19 November. This is evidently the first report from Cayman Brac.

Helmitheros vermiverus. Worm-eating Warbler. An individual was mist netted and photographed on 22 November. This is apparently the first record since Cory, 1889.

Parula americana. Northern Parula. At least 10-12 birds were seen in widely scattered areas of the island throughout the study period. However, these seem to be the first sight records since Cory, 1889.

Dendroica virens. Black-throated Green Warbler. A single bird was seen on 19 November. This is the first sight record from Cayman Brac.

Dendroica palmarum. Palm Warbler. This species was very common on Cayman Brac in mid November, being found in almost every possible habitat; apparently not reported since Cory, 1889.

Quiscalus niger bangsi. Greater Antillean Grackle. Listed by Johnston et al., 1971, as an "uncommon resident" on Cayman Brac. However, they also note that the species was "curiously absent from Cayman Brac in summers of 1970 and 1971." No individuals of this species were found during our week stay on Cayman Brac.

Passerculus sandwichensis. Savannah Sparrow. Two sightings (one individual?) were made on 20 November. This is the first sight record from Cayman Brac.

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LITERATURE CITED

Bond, J. 1971. Field guide to birds of the West Indies. Houghton Mifflin. Boston.

———. 1956. Checklist of the birds of the West Indies. Ed. 4. Acad. Nat. Sci. Philadelphia. 12 Supplements, 1956-1967.

Cory, C. B. 1889. A list of the birds collected by Mr. C. J. Maynard in the islands of Little Cayman and Cayman Brack, West Indies. Auk 6:30-32.

Johnston, D. W., C. H. Blake and D. W. Buden. 1971. Avifauna of the Cayman Islands. Quart. J. Florida Acad. Sci. 34:141-156.

Florida Sci. 37(3):155-156.

POPULATIONS OF BEAR, PANTHER, ALLIGATOR AND DEER IN THE FLORIDA EVERGLADES

SANFORD D. SCHEMNITZ

School of Forest Resources, University of Maine, Orono, Maine 04473

ABSTRACT: *This study attempted to determine the population status of the Florida black bear, white-tailed deer and two endangered wildlife species, the American alligator and Florida panther in the Everglades Region. Questionnaires distributed to field personnel of the Florida Game and Fresh-water Fish Commission and the Florida Department of Natural Resources and interviews resulted in population estimates of 145 black bears and 92 panthers, mostly in Collier County. Nocturnal and diurnal counts show that alligator population trends have been upward in recent years despite the loss of more than 1.5 million acres of habitat. Aerial deer counts both pre- and post-hunting season yield a deer population estimate for the 4.5 million acre Everglades Region of 20,000 with a 1971-72 legal deer harvest of 900 from the 800,000 acre Everglades Wildlife Management Area.*

THE natural environment of southern Florida is undergoing vast changes associated with land development resulting from a burgeoning human population. Corresponding changes can be expected in wildlife populations in response to widespread habitat alteration and destruction. Specific information on the population status of panther (*Felis concolor*), alligator (*Alligator mississippiensis*), black bear (*Ursus americanus*) and white-tailed deer (*Odocoileus virginianus*) is needed to provide baseline information. Both the bear and panther are characteristically wilderness species and do not thrive where densities of people are high. Two of these species, the alligator and Florida panther, currently are included on the "Endangered Species List" of the Department of the Interior, (Committee on Rare and Endangered Fish and Wildlife of the U.S., 1966).

The objectives of this study were to determine from existing records and supplemental studies the present distribution and abundance of the Florida black bear, the American alligator, the Florida panther and the Florida white-tailed deer in the Everglades (defined as the area south of the Caloosahatchee River, Lake Okeechobee and the St. Lucie Canal in Florida).

BLACK BEAR AND PANTHER

METHODS—A questionnaire patterned after one used by L. C. Chappell in 1971 (unpublished) to obtain population information on the black bear was distributed to field personnel in the Game and Fresh Water Fish Commission's Everglades Region to gather information on the status of the panther in south Florida. Individuals reporting panther sightings were interviewed for details and to gain insight into the reliability and validity of their reports. Records of bear and panther observations on file at Everglades National Park headquarters were reviewed and recent sightings were tallied.

RESULTS AND DISCUSSION—*Bear.* A questionnaire distributed by Game Biologist L. C. Chappell to commission personnel in the Everglades Region in

February 1971 indicated a population of about 145 bears in Collier (100); Hendry (20); Monroe (20); and Palm Beach (5) Counties. The U. S. Department of the Interior (1969) estimated 80-100 bears in the Big Cypress Swamp. The trend in population appears to be downward apparently due to habitat destruction. This trend conforms to the statewide population decline from an estimated 1,000 bears in 1961 to 500 to 600 bears in 1971 (Smith, 1971). However, this 1971 population estimate is about equal to the 1959 population level of 530 to 860 reported by Harlow (1961) and 1940 population of 500 by Frye, et al. (1950). Only one black bear observation was reported in Conservation Area 3 (Fig. 1) during 1971 by Wildlife Officer McTyre on November 20, 1971, south of Alligator Alley. The number of black bears recorded in the Everglades National Park files may be representative of the status in extreme south Florida. The most recent observation at the Park was made at Bear Lake on March 18, 1970. Only six other bears have been seen at Everglades Park since 1965.

Acquisition of land for the Big Cypress as a National Fresh Water Reserve would curtail additional development and perpetuate bear habitat in public ownership. Continued protection from hunting is advised until populations respond with significant increases.

Panther. The panther has been fully protected from hunting in Florida since 1958. In 1966 the U. S. Fish and Wildlife Service estimated the Florida population at 100 to 300 according to Smith (1970). Jenkins (1971) cited a lower statewide population estimate of between 50 and 100 made by James A. Powell, Chief, Game Division, Florida Game and Fresh Water Fish Commission. In 1969, the U. S. Department of the Interior (1969) estimated 125 panthers in the Big Cypress Swamp. This is 1 panther per 10 sq miles. Based on my questionnaire and personal interviews, there are about 92 panthers in south Florida (Table 1).

TABLE 1. Estimated Florida panther population in south Florida, south of the Caloosahatchee River and the St. Lucie Canal, February 1972.

Area	Number of Panthers
Broward County	4
Collier County	50
Dade County	4
Everglades National Park	8
Hendry County	10
Jonathan Dickinson State Park	2
Lee County	4
Loxahatchee National Wildlife Refuge	2
Martin County	2
Monroe County	4
Palm Beach County	2
Total	92

Although frequent reports of black panthers were received, the true status of "black panthers" remains much in doubt. One supposed melanistic specimen was collected by Alexander Sprunt, Jr. from Upper Matecumbe Key, Monroe County in the spring of 1937. This skin which is now in the Charleston (South Carolina)

Museum was later identified by Dr. David H. Johnson, Curator, Division of Mammals, U. S. National Museum to be a stretched skin of a large housecat (Tinsley, 1970). Layne (in litt. April 27, 1972) mentions a supposed black panther shot by Carl King in the period 1932-1934 about 10 miles west of Homestead. Paradiso (1973) has reliable records of the only known melanistic bobcat from south Florida. Many of the black panther sightings may have been large otters.

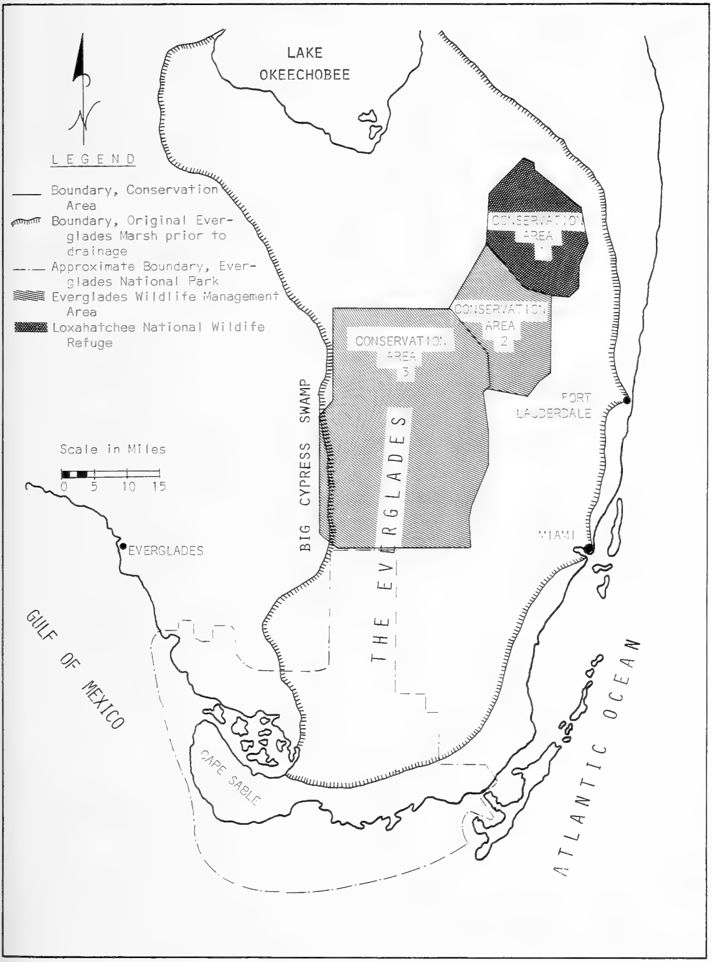

Fig. 1. Lower Florida showing Conservation Areas and Everglades National Park.

In 1971 and 1972 several telephone calls were received at the Fort Lauderdale office regarding panthers from nearby Pompano Beach, Oakland Park, and Flamingo Road. Upon investigation these supposed sightings were determined to be large dogs.

Alligator

The decline of the alligator in south Florida in recent years has been documented by Craighead (1968). King (1972) reports the recent reversal of the downward population trend. He cites a figure of 300,000 alligators in Florida in 1970 based on estimates compiled by wildlife officers. This Florida count exceeded an estimate of 200,000 alligators in Louisiana for the same period. A more specific similar estimate of 251,569 alligators was arrived at in 1972 (Anon., 1972b). This represented an increase of 53.3% during the past 4 yr.

Methods—No feasible technique was developed during this study for a realistic population estimate of alligators. Chabreck (1966) discussed methods for determining alligator population size and composition. He thought nest counts to be one of the best means of censusing alligators. The American Alligator Council has decided upon a survey procedure to determine population trends. Survey lines 10 miles long are run at night 1 hr after sunset when the temperature is 70°F or more. The number of alligators seen are tabulated by 1-ft size classes. The observed distance from the nose to the eye in inches provides a reliable estimate of the total length in feet.

Results and Discussion—Biologist Schortemeyer counted 18.56 alligators per mile on the Miami Canal in Conservation Area 3 in Broward County, July 7, 1971. This figure is much higher than the 1971 average of 5.1 alligators per mile along 56 survey lines in eight southern states (Chabreck, 1971). A repeat count of this census route by Schortemeyer on June 9, 1972 showed 8.6 alligators per mile. These counts represent an increase from 1.6 alligators sighted per mile on the Miami Canal in 1968 reported by Hines et al. (1968). Similar high numbers of alligators were seen on the C-40 canal, Palm Beach County on the periphery of Conservation Area 1 (Loxahatchee National Wildlife Refuge). Refuge personnel counted 13.5 alligators per mile on July 22, 1971. A daytime count by R. Martz and S. Schemnitz in the C-67 canal south of the Tamiami Trail on March 21, 1972 totaled 102 alligators (11.2 per mile).

The accuracy of nocturnal counts needs additional study. A test of airboat vs. outboard motorboat as a means of nocturnal counting was made with the aid of J. L. Schortemeyer on August 18, 1971 on the Miami Canal census route. The counts for both methods were nearly the same (73 vs. 76). A comparison of slow vs. high airboat speed over the same route yielded nearly identical counts (117 vs. 112 alligators).

Unfortunately only a few active alligator nests were found during the summer of 1971 in Conservation Area 3 due to low water levels created by drought conditions. Because of this, the nest count survey suggested by Chabreck (1966) could not be used. John Ogden (personal communication) believes that the 1971 alligator nesting at Everglades National Park was normal. In 1972 alligator nesting activity in Conservation Area 3 was improved with 25 active nest sites coincident with higher water levels than 1971 (Fogarty and Schortemeyer, 1972).

A possible indirect measurement of alligator population status would be the amount of available habitat and the degree of habitat destruction. Schortemeyer (1972) classified alligator habitat in six south Florida counties (Dade, Broward, Collier, Palm Beach, Monroe, and Hendry) as good, average or poor. Good alligator habitat amounted to 3,875,700 acres or 64.4% of the total acreage (Table 2), and has suffered 23.4% destruction. In the Everglades Region approximately 1,300 miles of canals have been constructed by the Central and Southern Florida Flood Control Districts. Drainage of vast areas of alligator habitat has occurred. This loss is partially compensated for by creating artificial habitat which is especially valuable during drought periods.

Alligator populations are not restricted to the wild wetlands as indicated by the number of "nuisance" alligator complaints received at the Fort Lauderdale office of the Game and Fresh Water Fish Commission. Since 1969 a "complaint" form has been mailed to people who called requesting that alligators be removed. The following complaint figures show a generally increasing trend:

1969— 17 (September 12-December 31) 1971— 65 (January 1-December 31)
1970— 75 (January 1-December 31) 1972—174 (January 1-December 31)

Biologists and wildlife officers of the Florida Game and Fresh Water Fish Commission agree that poaching has been curtailed and alligators have greatly increased in south Florida in recent years.

TABLE 2. Summary of habitat loss by quality in south Florida[1].

Type of Alligator Habitat	Original[2] Habitat (Acres)	Agricultural Development (Acres)	Urban Development (Acres)	Total Loss (Acres)	Percent of Habitat Destroyed
Good[3]	3,875,700	715,800	206,800	922,600	23.4
Average[4]	1,925,100	424,800	223,400	648.200	33.6
Poor[5]	208,700	—	46,300	46,300	22.2
Total	6,009,500	1,140,600	476,500	1,617,100	26.9

[1]Obtained from Schortemeyer (1972).
[2]Includes Dade, Broward, Palm Beach, Monroe, Collier, and Hendry Counties.
[3]Includes sloughs, ponds, lakes, wet prairies, sawgrass, cypress swamp, fresh water marsh, inland swamp, and marsh prairie.
[4]Includes pinelands, mangroves, and dry prairie.
[5]Includes coastal vegetation, salt marsh, hammock forest, and scrub forest.

DEER

METHODS—Precise census methods are unavailable in south Florida as elsewhere due to the deer's secretive habits, cryptic coloration, variable behavior plus dense vegetation. Aerial census appears to be the most practical and accurate means of estimating population in the Everglades. Aerial counts were made from about 7 a.m. until 9 a.m. at which time deer activity greatly declined. The wing struts of the single engine, high wing monoplane were marked with black tape to standardize the census procedure so that counts could be made on a constant transect width. Transects were flown at 1, 2, or 4 mile intervals and 200 ft alt. This procedure was described by Loveless (1959).

A 10% sample of airboat operator licensees and halftrack-swamp buggy registration names and addresses were selected at random and sent a questionnaire. Questionnaires were numbered to determine the rate of return. A second mailing of the questionnaire was made to initial non-respondents.

A modified "Lincoln Index" technique was developed to assess deer harvest on the Everglades Area. The procedure involved field deer harvest checks by biologists and wildlife officers and deer check stations. An example of the procedure is:

$$\frac{\text{(50) Licenses signed (successful hunters) by field personnel through check station}}{\text{Licenses of successful deer hunters signed by field personnel (100)}} = \frac{\text{(400) Total number of deer checked through station}}{\text{X (total harvest)}}$$

$$50\,X = 40{,}000$$
$$X = 800$$

Results and Discussion—*Deer Surveys.* In 1971, a coordinated pre-hunting season aerial deer survey was conducted by two federal and one state agency (Table 3).

Table 3. Deer census counts, pre-hunting season, October 1971.

Area	Number of Deer	Approximate Acreage	Source
Big Cypress Swamp	7,000	600,000	U.S. Dept. of the Interior 1969
Conservation Area 1 (Loxahatchee National Wildlife Refuge)	200[1]	160,000	T. Martin
Conservation Areas 2 & 3, Rotenberger's Holy Land, Brown's Farm	3,400[1]	800,000	J. Schortemeyer
Everglades National Park	1,500[1]	1,300,000	J. Ogden
Totals	12,100	2,860,000	

[1]Aerial deer counts.

When considering aerial surveys, sources of error and inconsistency must be recognized. In south Florida, water level influences vegetation height and density, and deer behavior, and therefore is the major cause of count variability. Also the chronology of fires from year to year influences vegetation density and observability of deer.

Supplemental deer population information on areas (totaling 1,640,000 acres) that were not included in the intensive surveys was estimated from projections of deer populations for similar types of habitat derived from the deer surveys (Table 3). The total deer population for the south Florida study area is estimated to be 20,000.

Comparable past aerial deer census information for Conservation Area 2 (Fig. 1) is available from Loveless (1959) who estimated 1,000 to 1,200 deer in 1956 on 136,000 acres. Schortemeyer covered the same area by air and made the following estimates: 200 (September 30, 1970); 540 (May 20, 1971); 350 (November 1, 1971); and 400 (June 8, 1972). The apparent decline in deer numbers may be explained by the deeper water levels and submersion of tree islands which has been very pronounced (Loveless et al., 1970). Another historical source of information on deer population is reported by the Florida Development Commission (1960), listing 8,000 deer present in the Conservation Areas.

In order to more accurately assess the deer population status, accurate information is needed on the amount of deer habitat available. James Nicholas of Florida Atlantic University provided county acreage and land use acreage figures (Table 4) based on aerial photography. Agricultural, residential, commercial, industrial, transportation, institutional and central business district acreages were considered as non-deer habitat and subtracted from the total county acreage. These acreage figures agree closely with 1971 information separately compiled by Birnhak, U. S. Fish and Wildlife Service, Vero Beach.

Population Derived from Formulae. Another population estimate for the Everglades Area was computed using a formula by Petrides (1949) that utilizes pre- and post-hunting season sex ratios. Aerial flights were conducted to determine pre-hunting season sex ratios in Conservation Areas 2A, 2B, 3 and the Sawgrass Management Area on November 2, 3, and 12, 1971. One antlered deer per 4.2 antlerless deer was observed (N = 83). Flights over the same area were made on November 29 and December 9, and one antlered deer per 18.75 antlerless deer (N = 79) was seen. Calculations using information derived are as follows:

$$P = \frac{(\text{Post season prop. of females} \times \text{total kill}) - (\text{kill of females})}{(\text{Post season prop. of females}) - (\text{Pre-season prop. of females})}$$

$$= \frac{(.95 \times 900) - 50}{.95 - .75}$$

$$= \frac{855 - 50}{.20} = \frac{805}{.2}$$

$$= 4025.$$

Lauckhart (1950) has developed a method for estimating deer populations from herd composition and kill records. He presents curves from which can be read the approximate number of deer left on the area, after hunting season, for every buck killed if herd composition and fawn survival are known. The calculation by the Lauckhart Method is as follows:

Deer left per buck killed (from curves) = 6

900 kill × 6 = 5400 total population.

TABLE 4. Estimated county acreage and potential deer habitat for south Florida.

County	Total County Land Acreage	Total Potential Deer Habitat
Broward	769,520	574,100
Collier	1,308,160	1,121,920
Dade	1,315,000	1,086,500
Hendry	755,200	298,720
Lee (S. of Caloosahatchee River)	299,080	171,670
Martin (S. of St. Lucie Canal)	163,840	67,440
Monroe	696,160	594,060
Palm Beach	1,280,640	593,920
Total Acreage	6,587,600	4,508,330

Deer Harvest—Everglades. One of the main keys to deer population level is the deer harvest. Attempts were made in cooperation with Biologist Schortemeyer to measure deer harvest by a number of methods for the Everglades Area.

Deer hunter check stations were operated at Andytown and Terrytown during the 1971-1972 hunting season. The calculated deer kill was 900 for the Everglades Area (Table 5). Some adjustments were made for check stations that were closed and areas that were incompletely checked.

Wildlife Officers were interviewed to get information on illegal deer mortality they observed or had reported to them. Information was recorded to avoid duplication. A total of 26 deer, amounting to 2.9% of the legal deer harvest, was tallied and included 15 does, 7 bucks with antlers less than 5 in, 2 bucks with antlers more than 5 in and 2 sex unknown.

Deer harvest of past years in the Everglades Management Area (Table 6) show a wide variation from year to year.

An estimate of deer harvest was attempted through a mail questionnaire sent to a 10% random sample of Florida airboat operator licensees. In all, 284 questionnaires were mailed and a 51.4% initial response was received (Table 7). An additional second mailing yielded a response of 22.2%. Respondents indicated a deer kill of 72 deer or 720 deer harvested for the Everglades Area.

TABLE 5. Legal adult male deer kill by area, November 13, 1971—January 9, 1972.

Area	Deer through Check Station	Deer Checked by Field Personnel	Deer Checked in Field and through Check Station	Est. Total Kill
Brown's Farm	3	14	1	40
Conservation Area 2A	1	53	0	100
Conservation Area 2B	2	4	0	20
Conservation Area 3—North	132	58	20	350
Conservation Area 3—South	19	29	6	180
Holy Land	1	3	0	10
Rotenberger's	67	26	1	200
Total	225	187	28	900

TABLE 6. Past records of deer harvest, Everglades Management Area.

Year	Number of Legal Bucks Harvested
1964-65	312
1965-66	335
1966-67	Season Closed
1967-68	319
1968-69	123
1969-70	480 (10 day season)
1970-71	Season Closed
1971-72	660

On the basis of a random mail survey the calculated deer harvest for the Everglades Region in 1970-71 was 11,000 (Anon., 1972a) in which year the Everglades Management Area was closed. Similar kill figures for 1971-72 for the Everglades Region are 10,950 deer (M. J. Fogarty, personal communication, June 29, 1972).

TABLE 7. Summary of deer harvest airboat questionnaire, 1971-72.

Number of questionnaires sent	284
Number of questionnaires received, first mailing	145
Percent response, first mailing	51.4
Number of questionnaires received, second mailing	63
Percent response, second mailing	22.2
Number of questionnaires not deliverable due to wrong address, moved, etc.	15
Percent non-deliverable	5.5
Total return of those sent	209
Percent return	73.6
Number of hunters who did not hunt—1971-72	44
Percent hunters who did not hunt	22.6
Number of non-hunters	14
Percent non-hunters	6.7
Total duck hunt only	6
Total successful deer hunters	63
Percent successful airboat-deer hunters	41.7
Total deer killed from airboat	72

SUMMARY—Black bear and panther population estimates for the Everglades, based mainly on questionnaires, were 145 and 92 respectively with highest numbers for both species in Collier County.

Alligator populations have increased in recent years. Nocturnal canal counts in Broward and Palm Beach Counties exceeded the average of other southern states in 1971. "Nuisance" alligator complaints showed an increase at Fort Lauderdale. Alligator habitat loss totaled 1,617,100 acres or 26.9% of the total acreage of six southern counties.

The estimated 1972 deer population for the Everglades Region is 20,000. The calculated 1971-72 deer harvest for the Everglades Wildlife Management Area plus the Sawgrass Hunt Area was 900.

ACKNOWLEDGMENTS—Numerous personnel of the Florida Game and Fresh Water Fish Commission assisted on this project. Wildlife Biologist Schortemeyer made available his deer and alligator census information. L. C. Chappell in particular was helpful in distributing the panther questionnaire. Wildlife Officers deserve praise for their prompt response to questionnaires on species status. M. J. Fogarty kindly provided secretarial help to distribute the deer harvest questionnaire. Fish Biologist Martz helped investigate local suspected panther sightings and assisted with alligator counts. Wildlife Biologist L. E. Williams, Jr. aided with editorial advice. J. D. Carroll, Jr., C. A. Laffin, and J. P. Crowder, Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Vero Beach provided information on panther observations. T. W. Martin, Refuge Manager, and his co-workers helped with the deer survey and furnished alligator and panther information for Loxahatchee National Wildlife Refuge. J. Ogden, biologist, National Park Service coordinated an aerial deer census at Everglades National Park and provided access to Park Service files on bear and panther sightings. K. C. Alvarez and R. Philips, Park Naturalists, Florida Department of Natural Resources provided data on panther sightings in south Florida State Parks. J. N. Layne, Archbold Biological Station, Lake Placid contributed some very useful advice and information on south Florida mammals. J. Nicholas, Department of Economics, Florida Atlantic University, Boca Raton kindly provided helpful data on county and land use acreage.

LITERATURE CITED

Anonymous. 1972a. Game management notes. Florida Wildl. 25(11):23.

————. 1972b. Alligator information. Florida Dept. Nat. Res. Conserv. News 8(2):8.

Chabreck, R. H. 1966. Methods of determining the size and composition of alligator populations in Louisiana. Proc. Ann. Conf. Southeast Game & Fish Comm. 20:105-112.

————. 1971. Population status surveys of the American alligator in the southeastern United States in 1971. Amer. Alligator Council Proc. Augusta, Georgia. (mimeo.)

Committee on Rare and Endangered Fish and Wildlife of the United States. 1966. Rare and Endangered Fish and Wildlife of the United States. Bur. Sport Fish. & Wildl. Washington, D. C.

Craighead, F. C., Sr. 1968. The role of the alligator in shaping plant communities and maintaining wildlife in the southern Everglades. Florida Nat. 41:3-7; 69-74; 94.

Florida Development Commission. 1960. Recreation plan—the area south of Lake Okeechobee. Central and Southern Florida Flood Control District, Community Services Section. Tallahassee. 96pp.

Fogarty, M. J. and J. L. Schortemeyer. 1972. Alligator ecology in the Everglades. Florida Game and Fresh Water Fish Comm. P-R Proj. Rep. W-41-19. (mimeo.)

Frye, O. E., Jr., B. and L. Piper. 1950. The black bear, saint or sinner. Florida Wildl. 5(6):6-7; 28.

Harlow, R. F. 1961. Characteristics and status of Florida black bear. Trans. N. Amer. Wildl. Conf. 26:481-495.

Hines, T. C., M. J. Fogarty and L. C. Chappell. 1968. Alligator research in Florida: a progress report. Proc. Ann. Conf. Southeast Assoc. Game & Fish Comm. 22:166-180.

Jenkins, J. H. 1971. The status and management of the bobcat and cougar in the southeastern states. pp. 87-91. *In* (Jorgenson, S. E. and L. D. Mech, eds.) Symposium on the Native Cats of North America. Bur. Sport Fish. & Wildl. Minneapolis.

King, F. W. 1972. The American alligator. Nat. Parks & Conserv. Mag. 46(5):15-18.

Lauckhart, J. B. 1950. Determining the big-game population from the kill. Trans. N. Amer. Wildl. Conf. 15:644-650.

Loveless, C. M. 1959. The Everglades deer herd life history and management. Florida Game and Fresh Water Fish Comm. Tech. Bull. 6:104 pp.

————, G. W. Cornwell, R. L. Downing, A. R. Marshall and J. N. Layne. 1970. Everglades water and its ecological implications. Report of the Special Study Team on the Florida Everglades. Florida Chapt. Wildlife Society. 41 pp.

PARADISO, J. L. 1973. Melanism in Florida bobcats. Florida Sci. 36:215-216.

PETRIDES, G. 1949. Viewpoints on the analysis of open season sex and age ratios. Trans. N. Amer. Wildl. Conf. 14:391-410.

SCHORTEMEYER, J. L. 1972. Destruction of alligator habitat in Florida. Amer. Alligator Coun. Proc. Lake Charles, Louisiana. (mimeo.)

SMITH, G. 1970. Mystery cat. Florida Wildl. 24(3):4-6.

________. 1971. Florida black bear. Florida Wildl. 25(5):4-6.

TINSLEY, J. B. 1970. The Florida Panther. Great Outdoors Publ. Co. St. Petersburg, Florida. 60pp.

U. S. DEPT. OF THE INTERIOR. 1969. Environmental impact of the Big Cypress Swamp Jetport. 155pp.

Florida Sci. 37(3):157-167. 1974.

Biological Sciences

PRESENCE OF AZOTOBACTER IN MARINE SAND BEACHES

SUZANNE R. WICKS

Department of Biology, McKendree College, Lebanon, Illinois 62254

ABSTRACT: *Sand samples from the intertidal zone of five marine sand beaches of the Florida Gulf coast and two beaches in the Bahamas were positive without exception for species of* Azotobacter. *If nitrogen fixation by* Azotobacter *occurs in marine sand beaches, as these observations suggest, this process may contribute significantly to the basic productivity of the interstitial unicellular flora and to that of the benthic algae and seagrasses adjacent to sea beaches.*

ALTHOUGH the free-living, aerobic, nitrogen-fixing bacterium, *Azotobacter,* has been reported in the marine environment on a number of occasions, its distribution in the sea is still poorly known and evidence that it contributes significantly to the nitrogen budget of marine plants has not been forthcoming. Of all marine habitats, the intertidal zone of marine sand beaches would seem to be one to which *Azotobacter* is well adapted and in which it might be significantly active. With this idea in mind, the writer undertook an investigation of the presence of *Azotobacter* in intertidal sand beaches of Florida and the Bahamas when an opportunity presented itself during the summer of 1971 while in residence in the Department of Marine Science, University of South Florida, St. Petersburg Campus.

PROCEDURES—Two to four sand samples were taken along transects established in seven sand beaches during an 8-day period beginning July 17, 1971. Five of the beaches were located along the lower Gulf coast of Florida and two on the island of New Providence in the Bahamas, as follows:

1. St. Petersburg Beach at 103rd Avenue and Gulf Boulevard on the open Gulf of Mexico.
2. Spa Beach beside The Pier, downtown St. Petersburg, a beach of the western shore of Tampa Bay.
3. Beach beside the Sunshine Skyway just south of the north toll gate on Boca Ciega Bay, a part of lower Tampa Bay.
4. Crescent Beach on Siesta Key near Sarasota, Florida.

5. The beach on the Atlantic Ocean side of Bahia Honda Key, Florida Keys, about 40 miles northeast of Key West.
6. The public beach off Bay Street, Nassau, New Providence, Bahamas.
7. The beach at Go Slow Point, West Bay, Nassau.

One g of sand from each sample was added to a 250-ml Erlenmeyer flask containing 112 ml of Burke's modified liquid nitrogen-free medium (Wilson and Knight, 1952) made up in aged sea water, cotton-stoppered, and incubated in the dark at 25°C for 8 days. Calcium chloride was substituted for calcium sulfate for better solubility. All procedures were carried out in triplicate.

Transfers by sterile pipette at the end of the incubation period into sterile medium in 250-ml flasks with incubation under the same conditions resulted in cloudy broth by the fourth day. Subculture was repeated after 6 days.

Four days later, 0.1 ml of each culture was added to sterile 2.6% saline to provide 1×10^{-3} dilution. With sterile pipette, 0.1 ml of this dilution was placed on the surface of nitrogen-free agar medium. The inoculum was evenly distributed over the surface by means of a sterile glass rod. Incubation was for 4 days at 25°C.

Gram stains of the broth inoculum and from developing colonies were made.

Results—The original media became cloudy after about 8 days incubation, and subcultures required only about 4 days to develop about the same degree of cloudiness. Well-developed colonies were present on the agar plates after 4 days, and these were typical of *Azotobacter.* They were whitish, translucent, mucoid, circular and raised. Washed colonies showed fluorescence under ultra-violet light in the neighborhood of 3000 Å. The cells were Gram negative and exhibited morphological characteristics of *Azotobacter.* The rods varied from 4μ to 5μ long, appearing almost spherical, confirming their identification on the basis of criteria used by Breed, Murray, and Smith in Bergey's Manual, seventh edition (1957). Colonies obtained from all samples apparently were *Azotobacter agilis* Beijerinck.

Discussion and Summary—Bacteria capable of fixing nitrogen have been found in the sea, both in the water column and in marine sediments (Waksman et al., 1933; Maruyama et al., 1970). Patriquin and Knowles (1972) found *Azotobacter*-like cells from excised rhizomes of the seagrass, *Thalassia,* but they concluded from studies of crude cultures that members of the genera *Clostridium* and *Desulfovibrio* were the predominent N-fixers rather than *Azotobacter.*

Intertidal sand beaches would seem to be ideal habitats for *Azotobacter.* They are well-aerated and, during the two periods each day when the tide recedes, they function as sediment and organic matter traps by the process of filtration. As a wave washes up on the exposed beach, some of the water penetrates the sand and its particulate matter, including the plankton, is caught in the upper, aerated layer of the sand. Such material would, in part, serve as a carbon source for *Azotobacter.* It is not surprising, then, that the intertidal zone of sand beaches along the Florida Gulf coast supports a population of these bacteria. It seems logical to believe that *Azotobacter* is actively fixing nitrogen in intertidal sand beaches in temperate and tropical areas of the world. The resulting nitrogen fixation is of direct benefit to the interstitial sand beach microflora and to the seagrass beds and benthic marine algae that grow along these beaches.

ACKNOWLEDGEMENTS—My special thanks to Dr. H. J. Humm for making available laboratory facilities in the Department of Natural Science, University of South Florida, and for critical review of the manuscript.

LITERATURE CITED

BREED, R. S., E. G. D. MURRAY AND N. R. SMITH. 1957. Bergey's Manual of Determinative Bacteriology. 7th ed. Williams and Wilkins Co. Baltimore.

MARUYAMA, Y., N. TAGA AND O. MATSUDA. 1970. Distribution of nitrogen-fixing bacteria in the central Pacific Ocean. J. Oceanogr. Soc. Japan 26:30-36.

PATRIQUIN, D. G. AND R. KNOWLES. 1972. Nitrogen fixation in the rhizosphere of marine angiosperms. Mar. Biol. 16:49-58.

WAKSMAN, S. A., M. HOTCHKISS AND C. L. CAREY. 1933. Marine bacteria and their role in the cycle of life in the sea. II. Bacteria concerned in the nitrogen cycle in the sea. Biol. Bull. Mar. Biol. Lab. Woods Hole 65:137-166.

WILSON, P. W. AND S. G. KNIGHT. 1952. Experiments in Bacterial Physiology. Burgess Publ. Co. Minneapolis.

Florida Sci. 37(3):167-169. 1974.

Biological Sciences

EGGS AND HATCHLINGS OF THE FLORIDA SCRUB LIZARD

JOHN B. IVERSON

Florida State Museum and Department of Zoology,
University of Florida, Gainesville, Florida 32611

ABSTRACT: *Observations of the 82 day incubation and hatching of* Sceloporus woodi *eggs deposited by a captive female revealed that the hatchlings had a snout-vent length of 19.5-21.4mm and tail 23.5-24.5mm long. Pigmentation was like the adult female even in the ventral markings.*

SINCE its description by Stejneger (1918), very little information has been published concerning the natural history of the Florida scrub lizard, *Sceloporus woodi*. It is one of two oviparous Sceloporine lizard species in the United States for which eggs and/or hatchlings have not been described (Smith, 1946; Fitch, 1970); the other being *S. orcutti* (Mayhew, 1963; Fitch, 1970). Funderburg and Lee (1968) only briefly mention finding the eggs of *S. woodi* associated with the mounds of the pocket gopher (*Geomys*). A study is in preparation by James F. Jackson and S. R. Telford concerning the reproductive ecology of this lizard. Data presented here represent the successful incubation of eggs laid in captivity by the scrub lizard.

On July 11, 1973, several adult *Sceloporus woodi* were collected at Deer Lake Girl Scout Camp in Ocala Forest, Marion County, Florida. In the laboratory these lizards were placed in the cage of a single female *Lampropeltis triangulum gentilis*. On the night of July 22, 1973, the snake tipped the water container while feeding on one of these lizards. The paper toweling lining the cage bottom was thus saturated in the area of the water container. The following morning at 8:00 am, seven eggs had been laid in the area of the water container by the only remaining female *S. woodi*. It appears that the lack of moisture for a nest site previously, and the ultimate appearance of it, stimulated egg deposition. The freshness of the eggs was indicated by the translucency of the egg shell and the visible embryonic development within. During the first day following deposition, the shell lost its translucency in the manner described for *Sceloporus u. undulatus* eggs by Crenshaw (1955).

The eggs were carefully removed and placed in an inverted plastic vial lid. In order to avoid the risk of destroying the eggs, I did not take measurements at this time. The top of the lid was then covered with a thin layer of moist cotton and the "nest" placed in a plastic container lined with moist paper toweling.

The incubator was then placed in a room in which the temperature was regulated at 75°F. During each day, additional heating was supplied by a nearby light bulb, such that the daytime temperature in the incubator was maintained at 82°F.

Due to insufficient moisture, the eggs were found to be partially collapsed on August 20. The cotton and toweling in the incubator was moistened and six of the seven eggs regained their turgidity by the following morning. The remaining egg continued to shrivel and was discarded. The turgid, viable eggs were then measured. They ranged from 12.3 to 14.5 (avg 12.7) mm long and 7.6 to 9.0 (avg 8.3) mm wide.

The eggs were again found collapsed on August 24 (32 days after oviposition). One of the eggs was opened and found to contain a small, unpigmented viable embryo. It measured 16.6 mm from the top of the head to the end of the tail, 10.15 mm from top of head to vent, and 4.4 mm from end of snout to back of head. The remaining five eggs were moistened and they quickly filled out.

On September 13 (52 days after oviposition) a single egg was opened and found to contain a viable embryo. The cephalic region of the unpigmented embryo was still quite large relative to the embryo. The head comprised 6.95 mm of the 14.0 mm snout-vent length. Tail length was only 13.5 mm.

Seventy days after oviposition (October 1) an additional egg was opened to determine if the eggs were still developing. It contained a nearly full term, pigmented viable embryo. It measured 19.75 mm snout-vent length and 20.05 mm tail length.

The remaining three eggs of the clutch hatched on October 13, after 82 days of incubation. At 8:30 am that day, one of the eggs was found to be slit and the lizard's head was protruding with eyes closed (Fig. 1). The slit had not been present at 11:00 pm the previous night. Just after noon (12:45), the second lizard had slit its egg and protruded its head. At this time, the third egg measured 13.1 mm long by 10.25 mm wide. While the length still falls in the range of measurements taken early in incubation, the width does not. The measurements support my observations that most of the egg's size increase during development was in the diameter, with relatively little increase in length.

Between 2:30 and 3:30 pm, the third egg was slit and the head of its occupant protruded (Fig. 2). The other hatchlings appeared to have remained motionless, as their positions were unchanged. When probed, none of the three responded with any movement. With eyes closed, the young lizards appeared lifeless.

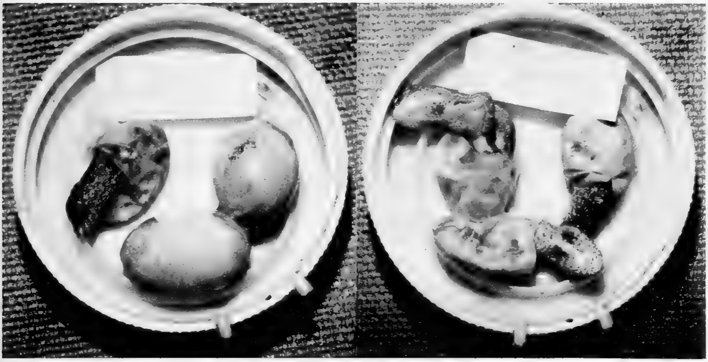

Fig. 1 (left) and 2 (right). Hatching of eggs of *Sceloporus woodi.* Paper scale is 2 cm long.

When checked at 5:20 pm, the first hatchling was out of the egg as far as its hind limbs and the second only as far as its forelimb. The third hatchling remained unchanged with only its head thrust from the egg. At 8:00 pm, the first two hatchlings were found to have emerged from their eggs. Although they were completely free of the eggs, they rested quietly on the collapsed shells. No amount of probing stimulated movement in them, although their eyes were open at this point. No umbilical cords attached the young lizards to the remaining embryonic membranes. The third hatchling still protruded from the shell only by his head.

The following morning at 8:30 am, all three lizards were free of their eggs and resting quietly in the incubator. At 9:30 am, they were moved to a container which offered water and a heat source. They continued to be quite inactive and would run only 5 to 6 cm even when extremely provoked by probing. By 9:45 am, two of the hatchlings had moved spontaneously to the end of the container toward the light from a nearby window. They seemed to favor the natural light source over the bulb placed over another region of the container. At 10:00 am, all three lizards had finally become relatively active. Besides their own movements, they scurried quickly when disturbed in any way.

The 82 day incubation time was much longer than would be expected from data available on the closely-related *S. undulatus* (Crenshaw, 1955) and is most certainly due to incubation temperatures lower than those in nature.

In attempts to measure the hatchling lizards, a portion of the tail of one was lost. His body length was 19.5 mm. The other lizards measured 21.2 (Fig. 3) and 21.4 snout-vent length, and 24.55 and 23.50 mm tail length, respectively. For these two, the body length comprised 46.3% and 47.7% of the total length, respectively.

Fig. 3. Hatchling *Sceloporus woodi.*

In coloration, the hatchlings are like the adult female, as described by Stejneger (1918) and Smith (1946). However, contrary to Smith's observation (p. 247) that "the young lack all markings ventrally . . .", these hatchlings have not only the blue posterior gular regions and lateral abdominal patches, but also the black pigment flecks on the throat and gular region (even onto the pectoral region) that he described for the adult female.

Two days after hatching (October 15) ants and termites were offered as food and readily taken. The lizards were by then extremely active, disturbed by any nearby movement. At dusk, this same evening, the hatchlings first exhibited the "shimmie" behavior characteristic of adult *S. woodi* (personal observations). All three lizards completely buried themselves in the sand by this action. The scrub lizard is quite often uncovered from such retreats when raking through sand in the scrub and sandhills of Florida (personal observations; Funderburg and Lee, 1968).

The hatching lizards and embryos were preserved November 2, 1973, and have been deposited in the Florida State Museum (UF 32812-32817).

LITERATURE CITED

Crenshaw, J. W. 1955. The life history of the southern spiny lizard, *Sceloporus undulatus undulatus* Latreille. Amer. Midland Nat. 54:257-297.

Fitch, H. W. 1970. Reproductive cycles in lizards and snakes. Univ. Kansas Mus. Nat. Hist. Misc. Publ. 52:1-247.

Funderburg, J. B. and D. S. Lee. 1968. The amphibian and reptile fauna of pocket gopher (*Geomys*) mounds in central Florida. J. Herp. 1:99-100.

Mayhew, W. W. 1963. Biology of the granite spiny lizard, *Sceloporus orcutti.* Amer. Midland Nat. 69:310-327.

Smith, H. M. 1946.Handbook of Lizards of the United States and Canada. Cornell Univ. Press. Ithaca.

Stejneger, L. 1918. Description of a new snapping turtle and a new lizard from Florida. Biol. Soc. Washington 31:89-92.

Florida Sci. 37(3):169-172. 1974.

Florida Scientist 36(2-4) was mailed on 3 February 1975.
Florida Scientist 37(1) and (2) were mailed on 7 February 1975.

FLORIDA JUNIOR ACADEMY OF SCIENCES
PROCEEDINGS, 1974 ANNUAL MEETING

A SIGNIFICANT ACTIVITY at each year's Annual Meeting is the presentation of the results of study and experimentation by outstanding junior and senior high school students selected in state-wide competition. The presentations are judged by experts and the best papers identified and ranked. Mrs. Irma Jarvis, Director of the Junior Academy for the 1974 Annual Meeting, provided the abstracts of the winning entries for publication in the FLORIDA SCIENTIST. This is a new kind of recognition for the Junior Academy but so many of our previous winners have distinguished themselves that their participation deserves to be recorded. The members of the Senior Academy can take pride in their sponsorship of the Junior Academy and of the State Science Talent Search coordinated by Dr. Clarence C. Clark. Both programs find and encourage talented youth to enter science.—*Editor.*

SENIOR HIGH EXPERIMENTAL PAPERS

1. *The Refined Period of Eclipsing Binary Star, ER Scuti.* CLARE YU, Gainesville High School. Sponsor, JAY T. COOPER.—Stellar variation is defined as a detectable periodic or non-periodic change in the brightness or spectrum of a star. Variable stars are a result of either internal or external causes. The most common extrinsic variables are the eclipsing binaries. When our line of sight lies close to or on the orbital plane of a binary, each star will successively eclipse the other. The result is an apparent fluctuation in brightness. A primary eclipse occurs when the dimmer star of the binary system passes in front of the brighter star. The eclipse of the dimmer star by the brighter star is a secondary eclipse. The purpose of the project is to refine, as accurately as possible, the previous period determination of the eclipsing binary, ER Scuti. A period is the amount of time needed to complete one revolution of the stars.

After reducing the data of a night, we calculated the amount of light absorbed by the atmosphere. By the use of this calculation, the difference was found between the comparison and variable stars' magnitudes as seen outside the earth's atmosphere. These differences, changing as ER Scuti's magnitude changed, were plotted against time to produce a dip-like curve. From the curve a time of minimum light was found. When several minima were known, a period of 1.361014 days, $\pm$.000018, was computed; this is slightly shorter than the previous period determination of 1.361041 days, $\pm$.000005.

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2. *Detection and Dissociation of Immune Complexes Using I-125 Goat Anti(Human IgG) FAB' Fragments.* BONNIE L. GATES, Gainesville High School. Sponsor, NANCY SMITH.—The purpose of this study was to develop a method to identify immune complexes in serum, based on sucrose gradient centrifugation of samples labeled with I-125 anti(Human IgG); and to develop a dissociation process under which conditions the components of the immune complex, i.e., the antigen and antibody, would retain their activity. Model complexes incorporating Human IgG (gamma globulin) appeared as a reproducible radiopeak which sedimented at 10S rather than at the normal 7S position, and could be detected with a high degree of sensitivity. A similar radiopeak appeared in samples of serum from two patients, one with a solitary metastatic adenocarcinoma in the

liver, and the other with Weber-Christian disease. This peak has not been seen in samples of serum from 10 healthy controls. Serial serum samples from the former patient showed high immune complex levels prior to tumor removal; levels were depressed one week after surgery, and rose again one month later. This pattern suggests correlations of immune complex levels and tumor mass which may prove valuable in management of cancer patients.

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3. *The n-Alkane Distribution in the Cuticle Wax of Various Ferns Native to Florida and North Carolina.* JOHN DENNINGHOFF, Merritt Island High School. Sponsor, PATRICIA DENNINGHOFF.—The major cuticle wax component of hydrocarbons is long chained odd-numbered n-alkanes. Alkanes of carbon number less than C_{25} and more than C_{35} are rarely present, and content of odd-numbered alkanes is usually greater than that of even-numbered alkanes by a factor of more than ten. The major constituent is usually an n-alkane with carbon number 27, 29, 31, or 33.

Samples of Christmas and Boston ferns from Florida were collected, identified, and examined. Results were compared with previous data on the North Carolina ferns. The samples were air dried for two weeks at room temperature. The dried fronds were mascerated in a Waring blender. Waxes were removed by soaking mascerated fronds in enough purified n-hexane to cover the sample. Each sample was extracted six times, total extraction time was 36 to 62 hr. The combined extract from each sample was filtered and allowed to evaporate. The residue was combined with a weighed portion of alumina, and the weight increase was recorded as the total wax extracted. The wax-alumina mixtures were placed on prepared alumina columns, and the columns were eluded with n-hexane. The n-hexane collected was then allowed to evaporate, and the weight increase was recorded as the weight of the alkane fraction. The resulting residue was diluted to a volume of 0.5 ml using n-hexane, and this solution was used for gas chromatographic analysis. For the chromatographic studies a copper column (10 ft by 0.25 in) packed with Chromasorb W coated with 1% SE-30 was used. The coating was applied by the pan coating method. Helium was the carrier gas, and the flow rate for the column was set at 30 ml min^{-1}. Identification of peaks was accomplished by addition of a known n-alkane standard, C_{22}, C_{24}, C_{28}, C_{32}, which resulted in an intensification of those peaks corresponding to the alkanes in the standard. The log retention time for a particular known peak was plotted against the carbon number. This plot resulted in a straight line relationship. The log retention times of the unknown samples were plotted, and the carbon number was read from the graph. The percentage of an individual n-alkane was reported relative to the area under its peak as compared to the total area under all measured peaks. Areas were computed by the height times width-at-half-height method rather than by integration.

The carbon numbers for three samples were determined from the plots of the log of retention times vs. carbon numbers (Table 1). Percentages of the individual n-alkanes were calculated from the actual gas chromatographs using methods already described.

TABLE 1. Data from three samples of Florida ferns analyzed for n-alkanes.

Identification		Boston(1)	Boston(2)	Christmas
Total Mass in g		100.0	100.0	100.0
Total wax extracted in g		.7302	.4731	.7366
Weight of alkane fraction in g		.0539	.0325	.0308
% n-alkanes of carbon number–	24			0.1
"	25	0.1	6.0	0.1
"	26	1.0	0.3	0.5
"	27	6.9	5.5	8.0
"	28	2.5	4.1	3.6
"	29	14.7	37.5	40.0
"	30			
"	31			4.5
"	32	74.0	46.8	44.5

The peaks illustrated the principle of chemotaxonomy in that the Christmas fern has a peak at C_{31} and neither sample of Boston fern shows this same peak. Except for the peak at C_{32} the major peak of all three of these ferns is C_{29}, and the odd-numbered alkanes exceed the even-numbered ones. This is as expected, but the large peak at C_{32} is unexplained. Many more samples are being analyzed, and infra-red spectroscopy will be used to try to further identify the peak at C_{32}. Hopefully this will add to information concerning the chemotaxonomical relationship between the Christmas fern of North Carolina and the "same" species found in Florida as well as comparing both Christmas ferns with the Boston fern found in Florida.

Other State Finalists Were: SHONNIE GRAMLY, Cocoa High; CARMEN MARIA LAUDA, Hialeah High; JOHN D. MALLOY, Chipley High; MIKELL SEELY, Northeast High, Clearwater; SANDRA SIMMONS, Forest Hill High, West Palm Beach; MARGARET ANN WEST, Rockledge High; TERRY WILKINSON, Forest Hill High, West Palm Beach.

JUNIOR HIGH EXPERIMENTAL PAPERS

1. *An Analysis of Detergent Pollution in South Brevard's Waterways.* ELAINE WENSINGER, Stone Middle School, Melbourne. Sponsor, CARL WILKINSON, JR.—In recent years the problem of water pollution has greatly increased. Detergent pollution is one of the eight major types of water pollution because of its non-biodegradability. This project deals with testing nine waterways in the South Brevard area for their detergent content. The results of the tests will be recorded and compared. The densely populated or residential areas should be higher in detergent content than the sparsely populated areas.

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2. *Determining the Degree of Phosphate Pollution in South Brevard Waterways.* L. MAURICE HOLLOMAN, Stone Middle School, Melbourne. Sponsor, CARL WILKINSON, JR.—Phosphates are one of the major causes of water pollution throughout the world. This in turn causes proliferation of living algae. When these die, they decrease the oxygen content in the water. This can greatly accelerate eutrophication. The object of this project is to determine the degree of phosphate pollution in South Brevard waterways and to make a comparison of the densely populated areas, the agricultural and grove areas, and areas that are scarcely populated.

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3. *Lightning and a Lightning Sensing Device.* DANNY WEGERIF, Edgewood Junior High School, Merritt Island. Sponsor, PHILIP ROSE.—1. The purpose of my research is to study lightning and determine the cause of lightning. 2. The field mill has been designed and built by the researcher to determine the potential gradient (ion build-up) of the surrounding air. This instrument is used as lightning sensing device. 3. Cloud descriptions and standard weather forecast readings are being recorded and evaluated in conjunction with the field mill readings.

A phonograph base and motor were used and redesigned to produce approximately 1450 rpm. This instrument consists of four insulated pickup plates attached to a base and a suspended two-bladed rotating shield located above the pickup plates. As the atmospheric electrical potential is picked up on the four lower plates, the rotating upper plate "cuts" the field potential, producing an oscillating current which is then fed to an oscilloscope for analysis and interpretation.

The field mill can be used to detect the possibility of a lightning stroke. By calibrating the field mill and oscilloscope to 200 V at the 1 m height, the field mill can be used to determine the actual potential gradient in a region of atmosphere. On a clear day, the field mill voltage reading per m is between 60-150 V. During a thunder storm the voltage reading has exceeded 600-700 V.

Other State Finalists Were: STEVEN BOSCOVICH, Stone Middle School, Melbourne; DAVID DAMBRO, Stone Middle School, Melbourne; LEONARD MCMILLAN, JR., Stone Middle School, Melbourne; JEANETTE NORTON, Rockledge High; TARA F. PESEK, Kennedy Middle School, Rockledge; DOUGLAS ROWLES, Kennedy Middle School, Rockledge; ANNE SENNE, Stone Middle School, Melbourne.

SENIOR HIGH LITERARY PAPERS

1. *The Infection Process of the* Rhizobium-*Legume Relationship: A Basis for Increased Symbiotic Activity.* LORRAINE PILLUS, Cocoa High School. Sponsor, E. H. STEEL, III.—For six thousand years, the economic value of leguminous plants has been recognized by man. It has only been through extensive experimentation that knowledge has been gained of the factors responsible for the beneficial effects of the leguminous plants. It has been found that legumes enter symbiotic relationships with specific soil bacteria which are members of the genus *Rhizobium*. Roots of leguminous plants become nodulated as one effect of the relationship. As

a direct result of the nodulation, the symbiotic fixation of atmospheric nitrogen, which is beneficial to both organisms, occurs.

The fixation of atmospheric nitrogen is apparently unique to this relationship and is the factor which makes this symbiosis so economically desirable. As a gradual understanding of the rhizobial infection processes has been gained, industry has been able to capitalize on this symbiotic activity through the development of commercial inoculums. Through specific studies designed to improve culturing methods, this researcher in the future hopes to gain information which will aid further in the improvement of media used commercially and for experimentation.

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2. *Acoustical Holography.* MICHAEL T. DYER, Cocoa High School. Sponsor, GENE ARMSTRONG.—A hologram is a recording of the interference pattern formed by the interaction of a set of plane waves and a complex wave. The complex wave is formed by reflection of a set of plane waves off of an object. When the hologram is illuminated again by a set of plane waves, an image is formed of the original object. A hologram is commonly formed using a laser as a source of the coherent waves. This is called an optical hologram. When an optical hologram is illuminated with a reference beam an image can be seen of the original object.

This paper deals with holograms made using sound as the source of coherent waves. The problems in this system lie in recording the wave pattern and reproducing it visually. Many systems have been devised to do this with various degrees of success. Acoustic holography can be used in medicine and technology because the sound waves will penetrate opaque objects. This enables acoustic holography to obtain images the same as X-rays without the harmful effects that come from radiation.

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3. *New Techniques in Burn Treatment.* KATHY MITCHELL, Naples High School. Sponsor, RONALD J. KILLION.—There have been major advances in three aspects of burn therapy: skin debridement; infection control; and skin grafting. The newest technique for necrotic skin removal is an enzymatic agent called Travase. This method of using Travase is much faster and more effective than the natural debriding process. The most important and complex stage of burn therapy is controlling infection of the burn-wound sepsis. The two topical agents used at this time are Sulfamylon and silver nitrate. The last phase in burn treatment is grafting the burned areas for the optimal appearance and function. The use of Xenografts and skin banks are currently becoming a reality. There have been new techniques in various aspects of burn trauma, but none for the injury as a whole. In the years to come, advancements in this field are very desirable.

Other State Finalists Were: JERRY BRIDGHAM, Cocoa High; JAN LYNNE DROMISKY, Gainesville High; FRED MOULTON, Naples High; MARY PELZER, Merritt Island High; TIMOTHY R. SINE, Naples High; NANCY SERIGART, Merritt Island High; LYNN VEGA, Naples High.

JUNIOR HIGH LITERARY PAPERS

1. *The Electron Communication System.* MICHAEL HALEM, Cocoa High School. Sponsor, E. H. STEEL, III.—A communication system originated by the author is described that utilizes amplitude modulated "free space" electrons as carriers. A study is presented on the design of a system, its applications, advantages, limitations, supporting equipment and testing. The system utilizes a standard television electron gun as its source and modulator. A previously unused idea of accelerating low energy electrons in the linear drift tube, accelerator fashion, for greater efficiency, if proposed for the final "boost" out of the accelerator. The electrons are then focused for a trip across a drift space to a receiver where the modulated signal is detected and amplified. Applications include communications, distance measurement and signal delay.

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2. *Transmission of Navigational Information Utilizing Infrared Frequencies.* RICHARD H. MASON, JR., Cocoa High School. Sponsor, GENE ARMSTRONG.—The application of infrared technology to aircraft navigation may offer advantages over radio frequency systems now in use. One of the primary advantages is the possible increase in accuracy because of shorter wavelengths in the infrared portion of the spectrum. This system should simplify airborn equipment, resulting in greater reliability and ease of operation over present systems. This method of navigation will have particular advantage during aircraft landing maneuvers because it can indicate aircraft attitude.

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3. *Location of the Retinal Generator Potential Origin and Rhodopsin in the* Limulus *Lateral Eye.* ROSALIND RAFANELLI, Rockledge High School. Sponsor, ROBERT COLLIER.—The retinal generator potential is a graded and sustained depolarization which initiates the discharge of nerve impulses. Since light first strikes the rhabdomeres in the *Limulus* ommatidia, it is hypothesized that the generator potential originates in this area. The potential will sweep through the junctions of the microvilli which connect the rhabdom and eccentric cells, to be amplified at the eccentric cell and give rise to nerve impulses. This will be tested by intracellular recording in the microvilli upon stimulation by an incandescent illuminator. The *Limulus* ommatidia are sensitive to light because they contain rhodopsin, a combination of 11-cis retinene and opsin. The visual pigments in decapod crustaceans have been located in the microvilli. It is hypothesized that the *Limulus* rhodopsin is found in the microvilli, too. This idea is in accord with the proposed location of the generator potential because the retinene isomerization would depolarize the surrounding membrane; the potential would be propagated to the eccentric cell, and there it would result in spike firing.

Other State Finalists Were: CATHY COLFAX, Edgewood Junior High, Merritt Island; LAURA DAWSON, Rockledge High; CHRISTOPHER M. LOHSE, Cocoa High; BRUCE J. MERAVIGLIA, Edgewood Junior High, Merritt Island; GREGORY MILLER, Rockledge High; DOUGLAS ROSINSKI, Edgewood Junior High, Merritt Island; JON STILLEY, Edgewood Junior High, Merritt Island.

CHARTER AND BYLAWS
Florida Academy of Sciences, Inc.

UNDER the leadership of Dr. Luella Danbaugh, the Charter and Bylaws Committee prepared a thoroughly revised document during the year 1973-1974. The most recent general revision had been done in 1963 and since that time many changes and amendments were made. This version of Charter and Bylaws was presented to the 1974 Annual Business Meeting of the Florida Academy of Sciences and was adopted unanimously.—IRVING G. FOSTER, Secretary

CHARTER
FLORIDA ACADEMY OF SCIENCES, INC.

(adopted at the 38th Annual Meeting, March 22, 1974)

ARTICLE I—NAME. The name of this Corporation shall be FLORIDA ACADEMY OF SCIENCES, INC.

ARTICLE II—PURPOSES. The purposes of the Corporation shall be to promote scientific research, to stimulate interest in the sciences, to encourage the diffusion of scientific knowledge, to sponsor good science teaching, to foster public and governmental understanding and appreciation of the sciences and the industries that apply them, to assist in the formulation of long-range plans together with a time sequence of priorities for the disposition of both natural and technical resources, to promote ethical application of the sciences to the service of humanity, to bring suitable recognition for scientific achievement, to arrange meetings for the presentation and exchange of scientific findings and to publish a journal together with such other scientific works as may further the purposes of the Corporation.

ARTICLE III—MEMBERSHIP. Any person or organization interested in the purposes of the Corporation shall be eligible for membership and shall be admitted to membership upon written application to the Membership Committee and election by the Council or Executive Committee.

ARTICLE IV—TERM. This Corporation shall have perpetual existence unless dissolved pursuant to the provisions of *F. S. 617.05*.

ARTICLE V—SUBSCRIBERS. The names and residences of the subscribers to the Corporation's certificate of reincorporation under *F. S. 617.013* are as follows: President: Alfred P. Mills, University of Miami, Coral Gables and Secretary James B. Lackey, University of Florida, Gainesville.

ARTICLE VI—OFFICERS. The affairs of the Corporation are to be managed by a President, a President-Elect, a Secretary, and a Treasurer. At the Annual Business Meeting of the Corporation the President-Elect shall be elected annually, and the Secretary and the Treasurer for three (3) years. The terms of the Secretary and of the Treasurer shall be arranged not to expire at the same time. No Junior Member of the Corporation shall be eligible for such offices.

ARTICLE VII—NAMES OF OFFICERS. The officers who will serve until the next annual meeting of the Corporation are as follows: President Alfred P. Mills; President-Elect Alex G. Smith; Secretary James B. Lackey; Treasurer John S. Ross.

ARTICLE VIII—COUNCIL. The Council shall exercise general supervision over all the affairs of the Corporation and shall consist of the elected officers, the two immediate Past Presidents, the Chairmen of the Standing Committees, the Editors of Publications, the

Section Chairmen, the Chairmen-Elect of the Sections, the Representative of the Academy to the AAAS, the State Director of the JUNIOR ACADEMY, the State Director-Elect of the JUNIOR ACADEMY, the State Coordinator of the JUNIOR ACADEMY, the Director of the Visiting Scientists Program, the State Science Talent Search Coordinator, and four (4) Councilors-at-Large, two (2) elected by the membership and two (2) appointed by the Council.

ARTICLE IX—AMENDMENTS. Amendments to the Charter may be proposed by the Council and shall be adopted by a three-fourths (3/4) vote of the members present and voting at any Annual Business Meeting of the Corporation, provided notice of the proposed amendments shall have been given to all members of the Corporation at least thirty (30) days prior to such meeting.

ARTICLE X—CLASSES OF MEMBERSHIP. Membership in the Corporation shall be divided into classes of members, which shall be Patron Members, Life Members, Sustaining Members, Regular Members, Junior Members, Student Members, Institutional Members, Industrial Members, Honorary Members, and Emeritus Members. Each member, regardless of class, shall be entitled to one (1) vote and in case of Institutional and Industrial members, such vote shall be cast by the representative designated by such Institutional or Industrial Member; provided, however, that voting rights of Junior Members shall be restricted as provided in the BYLAWS.

ARTICLE XI—EXECUTIVE COMMITTEE. An Executive Committee, consisting of the President, President-Elect, Secretary, Treasurer and two (2) other Council members designated by the Council shall handle the business of the Corporation in the intervals between Council meetings.

ARTICLE XII—MEETINGS. There shall be at least one meeting of the Academy and one business meeting of the Corporation annually. The time and place of the meeting shall be determined by the Council, and notice in writing thereof shall be given to each member by the Secretary or other person designated by the Council, not less than thirty (30) days prior to the time of each meeting.

ARTICLE XIII—EMOLUMENT. No part of the net earnings of the Corporation shall enure to the benefit of any officer, member of the Council, private member or individual within the meaning of the *United States Internal Revenue Code Section 501*; provided, however, any member officer or member of the Council may be paid compensation in a reasonable amount for services rendered the Corporation upon such terms and conditions as may be approved by the Council. In the event of dissolution or final liquidation of the Corporation, the net assets belonging to the Corporation shall be assigned to and become the property of the University of Florida. At the time of dissolution or liquidation, no part of the assets of the Corporation shall enure to the benefit of any officer, member of the Council, private member or individual within the meaning of the *United States Internal Revenue Code Section 501*; provided that if the Corporation reincorporates, all assets and liabilities are to be transferred to the new Corporation.

BYLAWS

FLORIDA ACADEMY OF SCIENCES, INC.

(adopted at the 38th Annual Meeting, March 22, 1974)

ARTICLE I—MEMBERSHIP.

Section 1—Eligibility, Admission and Classes. Eligibility and admission to membership and classes thereof shall be as provided in the Charter.

Section 2—Definition of Classes.

a. Members who contribute, as individuals, $1,000.00 or more to the Corporation shall be designated Patron Members.

b. Members who are individuals and have contributed to the Corporation $200.00 during any calendar year shall be designated Life Members.

c. Members which are industrial or commercial organizations and which pay annual dues of $100.00 or more, as specified by the Council, shall be designated Industrial Members.

d. Members which are institutions and which make annual contributions of $25.00 or more, as specified by the Council, shall be designated Institutional Members.

e. Members who pay annual dues of $15.00 or more shall be designated Sustaining Members.

f. Members who pay annual dues of $10.00 or more shall be designated Regular Members.

g. Members who are regularly enrolled students in accredited colleges and universities and who pay annual dues of $3.00 shall be designated Student Members.

h. Members who are secondary school students of grades seven to twelve inclusive shall be designated Junior Members. These members shall pay annual dues of $1.50, all of which sum shall be credited to the JUNIOR ACADEMY.

i. Regular Members who have been in good standing for ten (10) years and who are active at time of retirement shall be designated Emeritus Members. They shall pay one-half the current annual dues.

j. Honorary Members may be elected by the Council. They shall receive the QUARTERLY JOURNAL, but pay no dues.

Section 3—Limitation Upon Certain Members. Junior Members may attend the sessions of the members of the Corporation and may vote and hold office in the JUNIOR ACADEMY, but shall not vote or hold office in the Corporation.

Section 4—Dues. Dues shall be in the amounts as set forth in *Section 2* hereof and shall be payable for each calendar year; provided, however, Patron Members shall continue as such after contributing $1,000.00 without regard to calendar years, and Life Members shall continue as such after contributing $200.00.

Section 5—Termination of Membership. Any member may be dropped for cause by action of the Council. Members whose dues become one year in arrears shall be dropped from membership and a notice thereof shall be sent each such member by the Treasurer.

ARTICLE II—ACADEMIES AND SECTIONS.

Section 1—The Corporation shall be divided into Sections and Academies.

Section 2—The Sections of the Corporation shall be open to all members and shall consist of the following Sections: Biological Sciences, Physical Sciences, Social Sciences, Medical Sciences, Science Teaching, Conservation, Earth and Planetary Sciences, and such other Sections as the Council may authorize, subject to the approval of the members.

Section 3—The Academies of the Corporation shall be the SENIOR ACADEMY, the JUNIOR ACADEMY, and such other Academies as the Council may authorize, subject to the approval of the members. The officers of the SENIOR ACADEMY shall be the officers of the Corporation.

Section 4—Each Academy and each Section of the Corporation may adopt a Constitution and Bylaws; provided, however, such Constitutions and Bylaws shall not be effective until approved by the Council.

ARTICLE III—AFFILIATIONS.

Section 1—The Corporation may enter into affiliation with other organizations as may be arranged by the Council, subject to the approval of the members.

Section 2—Local Chapters of the Corporation may be organized at centers approved by the Council and each such Local Chapter shall elect such local officers as it may deem necessary. Each Local Chapter may include in its membership and among its officers individuals holding any of the classes of membership of the Corporation and may adopt its own Constitution and Bylaws; provided, however, that the relationship between the Corporation and the Local Chapters shall be determined by the Charter and Bylaws of the Corporation without reference to the Constitution or Bylaws of the Local Chapter.

ARTICLE IV—COMMITTEES

Section 1—The Standing Committees of the Academy are the Executive, Awards and Grants-in-Aid, Charter and Bylaws, Finance, Future Annual Meetings, History and Archives, Honors, Local Arrangements, Membership, Necrology, Nominating, Program, Science Talent Search, Visiting Scientists, and other committees designated by the President as necessary.

Section 2—The Executive Committee is defined in ARTICLE XI of the Charter. The Nominating Committee shall be elected by the Council. The Program and Membership Committees are defined herein. All other committees are appointed by the President, the Chairmen of which must be approved either by the Council or the Executive Committee.

Section 3—The Finance Committee shall engage the services of a Certified Public Accountant, or a recognized Public Accountant, to examine the books of the Corporation for each calendar year.

Section 4—The Program Committee is responsible for the preparation of programs for the annual meetings. The Chairman of this Committee shall be appointed by the Council for a term of three (3) years with the possibility of succession. The Committee shall include, but not be restricted to, the President-Elect, the Secretary, the Chairmen and Chairmen-Elect of the Academy Sections, and the Chairman of the Committee on Local Arrangements.

Section 5—The Membership Committee shall consist of, but not be limited to, the President-Elect, who serves as Chairman, the Treasurer, and the Chairmen of the Sections of the Academy.

Section 6—The President of the Academy, after consultation with the Administration of the Host Institution, shall appoint the Chairman of the Committee on Local Arrangements.

Section 7—All committees shall report in writing to the Corporation at the Annual Business Meeting.

ARTICLE V—COUNCIL.

Section 1—The Council shall exercise general supervision over all of the affairs of the Corporation as constituted and provided in the Charter.

Section 2—One Councilor-at-Large shall be elected by the members at the Annual Business Meeting, and a second Councilor-at-Large shall be appointed by the Council at the first meeting of the new Council, each for a two-year term.

Section 3—The Council shall have the following specific duties: (*a*) handling all publications of the Corporation; (*b*) filling vacancies occurring in any of the offices of the Corporation; (*c*) investing the funds of the Corporation; (*d*) making recommendations to the members regarding general policy; (*e*) electing a Nominating Committee of at least three (3) members; (*f*) advising and approving appointments by the President, no appointment by the President being effective until approved by the Council, or the Executive Committee in the case of appointments made between Council meetings; (*g*) appointing Editors of Publications and approving the Editorial Board; (*h*) appointing the Chairman of the Program Committee for a period of three (3) years: a prospective Chairman shall be asked to serve on the Program Committee for one (1) year prior to taking office as Chairman; (*i*) arranging affiliations with other organizations; (*j*) designating the time and place of meetings of the members; (*k*) approving the agenda for the annual meeting of the members; (*l*) authorizing the formation of Sections and Academies, subject to the approval of the members; (*m*) approving assistance to the officers of the Corporation; (*n*) electing new members; (*o*) appointing the State Coordinator of the JUNIOR ACADEMY who shall serve for a period of three (3) years and shall be eligible for reappointment; (*p*) confirming the appointment of the State Director of the JUNIOR ACADEMY; (*q*) appointing the Director of the Visiting Scientists Program and the State Science Talent Search Director.

Section 4—The Council shall require all reports to it, including Committee Reports, to be in writing.

ARTICLE VI—MEETINGS OF MEMBERS—NOTICE. The members of the Corporation shall meet not less often than annually. The time and place of meetings shall be determined by the Council and notice thereof shall be given to each member by the Secretary, or other person designated by the Council, not less than thirty (30) days prior to the time of each meeting. Such notice shall be in writing and shall be sent by regular United States mail, postage prepaid, to the last address of each member as shown upon the record of memberships kept by the Corporation. The Council shall call a special meeting of the members, upon written request by 10 percent of the members, within ninety (90) days from the date of such request.

ARTICLE VII—OFFICERS.

Section 1—Duties.

a. The President shall discharge the usual duties of a presiding officer at all meetings of the members of the Corporation, of the Council, and of the Executive Committee. He shall be an Ex-Officio member of all Standing Committees, except the Nominating Committee. He shall seek to obtain Industrial, Institutional, and Patron members. He shall seek affiliations with other organizations, subject to the direction of the Council. He may explore new activities which he deems advantageous to the Academy.

b. The President-Elect shall assume the duties of the President in the latter's absence and at the end of one year shall automatically become President. He shall serve as Chairman of the Membership Committee and as a member of the Program Committee. He shall be an Ex-Officio member, without vote, on all Standing Committees. He shall serve in such capacities as assigned by the President.

c. The Secretary shall keep a record of all meetings of the Corporation, the Council and the Executive Committee. He shall report to the members at the Annual Business Meeting and at such other times as the Council may direct. He shall send out official notices of meetings and perform other necessary duties of his office. He, or some other person designated by the Council, shall have charge of the sale and exchange of publications of the Corporation. He shall send to each new member of the SENIOR ACADEMY a copy of the CHARTER AND BYLAWS.

d. The Treasurer shall receive all monies of the Corporation and deposit them in a bank designated by the Council. He shall pay out budgeted monies and all bills approved by the Council or Executive Committee. All checks shall bear his signature or that of the President. He shall keep an accurate account of all receipts and disbursements for each calendar year and shall post a bond for the faithful performance of his duties upon such terms and in such amount as the Council may direct, paying the cost thereof from the funds of the Corporation. The fiscal year for his report shall be the calendar year.

e. Each Section Chairman shall solicit papers in his Section, arrange sessions of papers for his Section at the Annual Meeting in consultation with the Program Chairman, preside or appoint others to preside at paper sessions, appoint a Nominating Committee to nominate a new Section Chairman-Elect, and designate the time and place for an Annual Business Meeting of the Section, at which meeting the Chairman-Elect will be elected. The Chairman and the Chairman-Elect of each Section of the Academy, as members of the Program Committee, shall aid and abet the work of that committee.

f. Each Section Chairman-Elect shall assist the Section Chairman and act in his absence and shall serve on the Program Committee, and after serving one (1) year shall succeed to the office of Chairman of the Section.

Section 2—Election of Officers.

a. The President-Elect shall be elected annually; the Secretary and the Treasurer shall be elected for three (3) years, term to overlap by at least one year, with the possibility of succession.

b. One or more candidates for each office other than President, Section Chairman-Elect and Section Chairman shall be nominated by the Nominating Committee elected by the Council. Additional nominations may be made from the floor during the Annual Business Meeting.

c. Officers shall be elected by a majority of the votes cast by secret ballot of the members present at each Annual Business Meeting and shall enter upon their duties immediately following the adjournment of the Annual Meeting at which they were elected.

d. Vacancies in any office other than President shall be filled by the Council, or between meetings of the Council by the Executive Committee. The Council or the Executive Committee shall promptly appoint a temporary Secretary or a temporary Treasurer in the event that either of said officers becomes unavailable for service for any reason.

ARTICLE VIII—PUBLICATIONS

Section 1—There shall be published an annual volume, in four numbers, to be called the QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES.

Section 2—The QUARTERLY shall be under the direct control of the Council through an Editor appointed by the Council.

Section 3—One copy of the QUARTERLY shall be supplied free to each paid up member in good standing except Junior Members.

Section 4—An issue of the QUARTERLY, published soon after the Annual Meeting of the Corporation, shall include a roster of the Officers, the Council, the Committee Chairmen, and the members of the Corporation. Each issue of the Quarterly shall include such other material as the Council shall direct.

Section 5—There shall be distributed to the membership of the Corporation, at intervals, a NEWSLETTER. It shall contain information about and of interest to scientists in Florida.

ARTICLE IX—BUSINESS OFFICE. The business office of the Corporation shall be the business office of the Treasurer and the said office shall be the repository for the files of the Corporation.

ARTICLE X—AMENDMENTS. These BYLAWS may be adopted, altered, amended or rescinded at any Annual Business Meeting of the Corporation by a two-thirds (2/3) majority of the members present, provided that notice of such change shall have been given to all members of the Corporation at least thirty (30) days prior to the meeting.

Florida Sci. 37(3):179-184. 1974.

INSTRUCTIONS TO AUTHORS

Rapid, efficient, and economical transmission of knowledge by means of the printed word requires full cooperation between author and editor. Revise copy before submission to insure logical order, conciseness, and clarity.

MANUSCRIPTS should be typed double-space throughout, on one side of numbered sheets 8½ by 11 inch, smooth, bond paper.

A CARBON COPY will facilitate review by referees.

MARGINS should be 1½ inches all around.

FOOTNOTES should be avoided. Give ACKNOWLEDGMENTS in the text.

ADDRESS should be given following the author's name.

ABSTRACTS should be typed double-spaced immediately following the address.

LITERATURE CITED follows the text. Double-space every line and follow the form in the current volume.

TABLES are charged to authors at $25.00 per page or fraction. Titles must be short, but explanatory matter may be given. Type each table on a separate sheet, double-space, unruled, to fit normal width of page, and place after Literature Cited.

LEGENDS for illustrations should be grouped on a sheet, double-spaced, in the form used in the current volume, and placed after Tables. Titles must be short but may be followed by explanatory matter.

ILLUSTRATIONS are charged to authors ($20.00 per page or fraction). Drawings should be in India ink, on good board or drafting paper, and lettered by lettering guide or equivalent. Plan linework and lettering for reduction, so that final width is 4 5/8 inches, and final length does not exceed 7 inches. Do not submit illustrations needing reduction by more than one-half. Photographs should be of good contrast, on glossy paper. Do not write heavily on the backs of photographs.

PROOF must be returned promptly. Leave a forwarding address in case of extended absence.

REPRINTS may be ordered when the author returns corrected proof.

FLORIDA ACADEMY OF SCIENCES

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Florida Scientist

Volume 37 Fall, 1974 No. 4

ACADEMY SYMPOSIUM*

Florida's Estuaries—Management or Mismanagement?

*Copies of this issue may be obtained for $5.00 postpaid from the Academy offices, 810 East Rollins Street, Orlando, Florida 32803.

QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

FLORIDA SCIENTIST

QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

Editor: Harvey A. Miller
Department of Biological Sciences
Florida Technological University
Orlando, Florida 32816

The FLORIDA SCIENTIST is published quarterly by the Florida Academy of Sciences, Inc., a non-profit scientific and educational association. Membership is open to individuals or institutions interested in supporting science in its broadest sense. Applications may be obtained from the Treasurer. Both individual and institutional members receive a subscription to the FLORIDA SCIENTIST. Direct subscription is available at $10.00 per calendar year.

Original articles containing new knowledge, or new interpretation of knowledge, are welcomed in any field of Science as represented by the sections of the Academy, viz., Biological Sciences, Conservation, Earth and Planetary Sciences, Medical Sciences, Physical Sciences, Science Teaching, and Social Sciences. Also, contributions will be considered which present new applications of scientific knowledge to practical problems within fields of interest to the Academy. Articles must not duplicate in any substantial way material that is published elsewhere. Contributions from members of the Academy may be given priority. Instructions for preparation of manuscripts are inside the back cover.

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QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

Harvey A. Miller, Editor

Vol. 37 Fall, 1974 No. 4

Academy Symposium

FLORIDA'S ESTUARIES—MANAGEMENT OR MISMANAGEMENT?

WILLIAM H. TAFT, Chairman

Director of Research, University of South Florida, Tampa, Florida 33620

FOR the 1974 ANNUAL MEETING OF THE FLORIDA ACADEMY OF SCIENCES, *Florida's Estuaries—Management or Mismanagement?* was selected as the theme for a rather unique symposium. All other Academy activities were halted and attention was focused on this theme. Five papers dealing with the major estuarine systems in the state were presented. Four of those papers are contained in this edition and the intent is to focus attention on one of Florida's most precious resources—her estuaries.

These papers present an excellent resume of the state of the art of estuarine research in Florida. What is most important, however, are the data contained in these papers—much of which is presented for the first time.

For the most part, Florida has virtually ignored the need to manage these estuaries. Unfortunately, these resources have been viewed by and gobbled up by developers who have dredged and filled the shorelines to increase the density and stresses on these important areas. There has been almost no State leadership exercised to prevent their destruction except by the public who, until recently, have been almost totally frustrated in their attempts to leave something in these precious resources for future generations.

Hopefully, the results of this symposium will spark the necessary initiative so that Florida will recognize the value of her estuaries before they are paved.

BISCAYNE BAY: ITS ENVIRONMENT AND PROBLEMS

Martin A. Roessler (1) and Gary L. Beardsley (2)

(1) Tropical BioIndustries Development Company, 8966 SW 87 Court, Miami, Florida 33156
and (2) Rosenstiel School of Marine and Atmospheric Science,
University of Miami, 10 Rickenbacker Causeway, Miami, Florida 33149

Abstract: *Biscayne Bay is a semi-tropical lagoon adjacent to Miami, Florida. Tides are semi-diurnal and vary from about 2.5 ft amplitude at inlets to 0.5 ft in the interior basins. Nutrients are available in northern sections but relatively scarce in the southern bay. Primary productivity in the south is mainly from seagrasses and algae, while in the north phytoplankton is more important. Diverse invertebrate and fish populations occur, but few species are extremely abundant. Activities such as dredge and fill, sewage pollution, causeway construction and shoreline modifications have altered circulation and nutrient cycles. The greatest impact has been observed near Miami but changes are occurring in the southern regions as well. Hopefully, informed and active citizens and the Dade County, State and Federal governments will continue efforts such as creation of the Biscayne National Monument and the Florida Power and Light Cooling Reservoir to protect Biscayne Bay and to provide public access for recreation. Planning is needed now, and action must be taken, before options run out and cost escalates to the point where conservation and restoration is economically impossible.*

Biscayne Bay is a semi-tropical coastal lagoon, the upper two-thirds of which lies adjacent to the city of Miami (Fig. 1). The A-shaped Bay, plus Card Sound, extends about 35 miles in a north-south direction (25°20′-25°55′N) with a maximum width of 8 miles (80°10′-80°20′W). It is very shallow, averaging 6 ft with a maximum of 13 ft except in dredged channels. The Bay is partly enclosed on the east by a series of barrier islands, including Miami Beach on the north and Key Largo on the south. In the central portion there is a shoal area, The Safety Valve, which is approximately 9 miles wide and forms the largest connection with the ocean. The northern barrier islands are sand with mud flats; the southern islands are coralline rock. The mainland side of the Bay was bordered by mangrove swamps and very soft, organic rich sediments. The Bay consists of a northern, central and southern basin, plus Card Sound. The northern basin includes the Miami area south to Virginia Key-Key Biscayne. The central basin extends southward to Featherbed Bank. The southern basin extends to the Arsenicker Keys, and Card Sound extends south to Card Bank. South of this a series of basins connect to Florida Bay. The city of Miami extends southward from the northern part of the shoreline for about one-half to two-thirds the length of the Bay.

The major tributaries are Arch Canal, Biscayne Canal, Little River, Miami River, Coral Gables Waterway, Snapper Creek Canal, Black Creek, Goulds Canal, North Canal, Florida City Canal, and Model Land Canal. Of these, Miami River is the largest. It has been estimated that 4,500 gal of water per sec pass the water plant at Hialeah; increasing another 20% from that point to the mouth of the River. Maximum discharge is generally in October; minimum in June (Morrill and Olson, 1953).

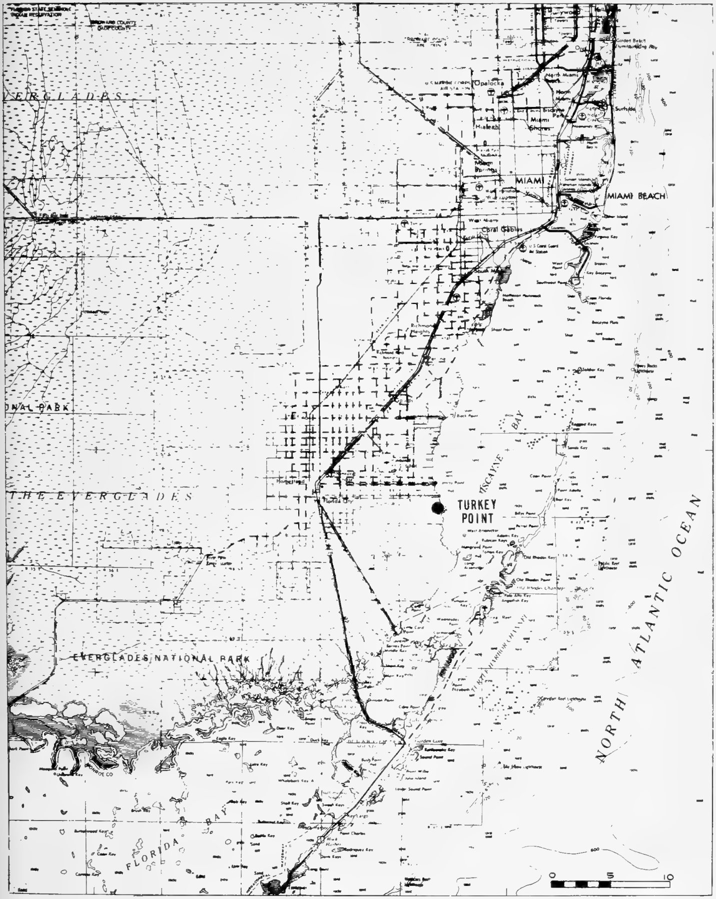

Fig. 1. Location of Biscayne Bay, Florida.

Tidal flow enters the Bay via Baker's Haulover, Government Cut, Norris Cut, Bear Cut, The Safety Valve, Sands Cut, Ceasar's Creek, Broad Creek and Angelfish Creek.

Physical and Chemical Characteristics—In the northern part of the Bay tidal flow enters through Baker's Haulover and flows southward to the 79th Street Causeway. Government Cut and Norris Cut waters flow northward to the 79th Street Causeway and southward toward Coconut Grove. Bear Cut and The Safety Valve inlets flow southward in the general direction of Coconut Grove and Black

Point (Hela, et al., 1957). Inlets south of Featherbed Bank tend to exchange the eastern side of the Bay while the western portion receives only a north-south sloshing effect, except when wind driven circulation causes a southward net transport (Lee and Rooth, 1972).

The mean high tide elevation is 2.5 ft at the Government Cut Harbor entrance. As one proceeds southward the amplitude of the tide is reduced and there is more lag time. Schneider (1969) has found the elevation of mean high tide at mid-bay to be 1.5 ft and in Card Sound 0.6 ft. The tidal lag is about 1.5 hr at Coconut Grove to 3.25 hr in Card Sound. The highest recorded hurricane tide was 10.1 ft.

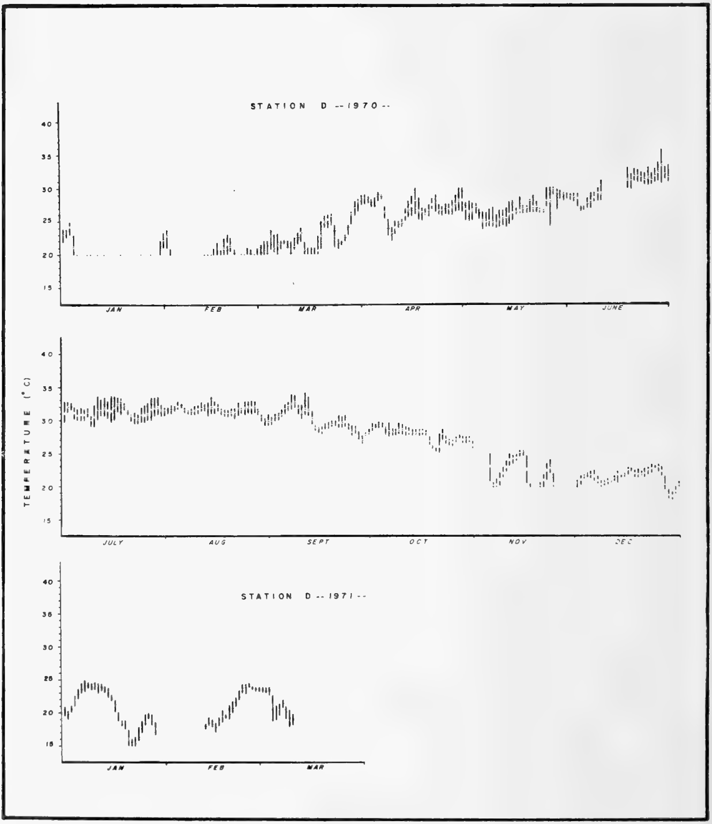

Fig. 2. Daily maximum, minimum and average (–) temperature in mid Biscayne Bay, 1970-71.

Sediments vary from fine silt to coarse carbonate gravel of broken shell and rock fragments, with parts of the bottom covered by extensive grass flats. The sand of the northern portion is 35% silica and 65% carbonate, grading southward to approximately 20% silica and 80% carbonate. Wanless (1969) and Early and Goodall (1968) have discussed sediment grain size and composition.

Temperature in Biscayne Bay averages about 17°C in winter and 31°C in summer. Extremes observed during a 5 yr study in southern Biscayne Bay were 9°C to 35°C at shallow stations in mid-bay. Figure 2 provides data on daily

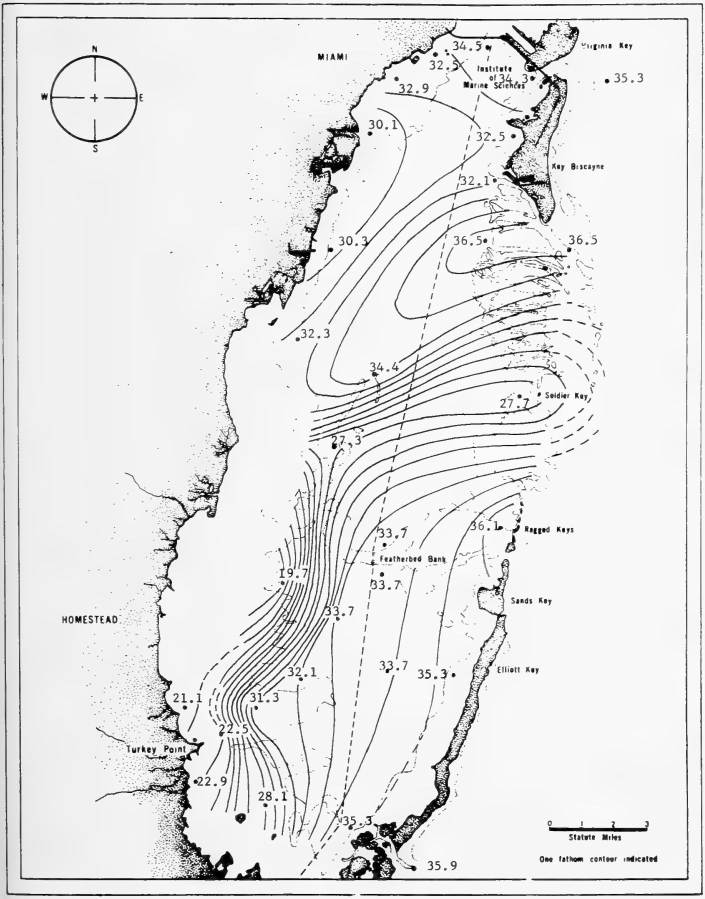

Fig. 3. Distribution of winter salinity in parts per thousand, from de Sylva, 1970.

observations of maximum, minimum and average temperatures from a station on Pelican Bank. Diurnal variations of 2-3°C are common. Moore (1970) has summarized observations made at the Rosenstiel School of Marine and Atmospheric Science dock for over 20 yr and the monitoring is continuing.

Stratification is rare and appears to occur only during periods of calm (0-5 mph) winds which last for a period of 12 hr or more. Based on Homestead Air Force Base wind data, such low wind speeds are uncommon and occur only 13% of the year.

Salinity in Biscayne Bay is correlated with rainfall, but this relation is modified by the influence of runoff when flood control gates on the numerous canals are opened to enhance drainage. Normally there is a salinity gradient with low salinities near the western shore and higher salinities as one proceeds eastward (Fig. 3). During drought periods this gradient can be reversed and hypersaline conditions (up to 50‰) can exist along the western shore.

Measurements of dissolved oxygen indicate that the water is generally well oxygenated. Diurnal cycles are particularly evident on calm days. A typical diurnal cycle for a summer day in the area of Turkey Point is shown in Fig. 4. Extreme oxygen values recorded on this day were 3.4 and 11.1 mlO_2/1 representing 83% and 230% saturation. Data from de Sylva (1970) show generally high levels throughout the central and southern Bay area (Fig. 5).

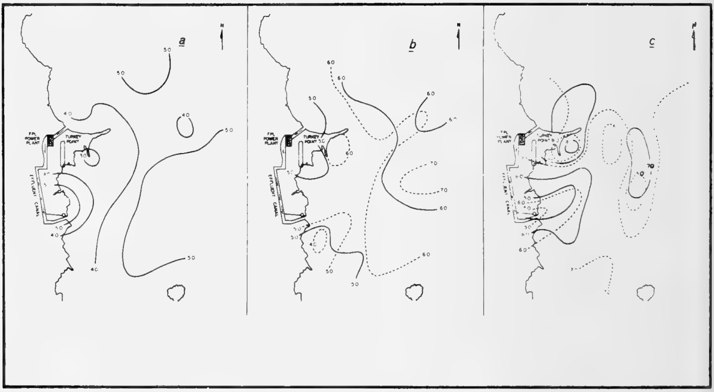

Fig. 4. Diurnal variation of dissolved oxygen (ml O_2/1): a. 0810-0945; b. 1154-1306; c. 1455-1625 hours DST, August 1969. Solid lines are surface values; dashed lines are bottom values.

Turbidity levels are generally high near the city of Miami decreasing as one proceeds southward (Fig. 6). The most striking exception is the high (9 JTU) values observed in the navigation channel through Featherbed Bank. This is a shallow passage in which larger boats often stir the bottom with their prop wash.

Table 1 presents a summary of other chemical data collected over a 5 yr period in conjunction with environmental analysis of the effect of a power plant on south Biscayne Bay and Card Sound (Segar, et al., 1971). Comparable data for north Biscayne Bay does not exist, but an examination of the load of material sampled in the Miami River at Hialeah (Meyer, 1972) and the background data from D'Amato (1973) indicates nutrients and trace metals are more abundant in the areas surrounding urban Miami. The reader is referred to Segar et al. (1971) for seasonal and spacial variations in the chemical parameters shown in Table 1.

TABLE 1. Chemical data for southern Biscayne Bay[1] and the Miami River[2] at Hialeah.

Chemical	Southern Biscayne Bay	Miami River
Nitrate	0.00025-0.050	0.3 ppm
Nitrite	0.0005 -0.045	0.06 ppm
Ammonia		0.07 ppm
Inorg. PO_4	0.0003 -0.015	
Total PO_4	0.006 -0.035	0.08 ppm
Silicate	0.025 -0.40	6.2 ppm
pH	8.05 -8.10	6.4
Spec. alk.	0.120 -0.145	
Total Dissolved Inorganic Carbon		24-38 ppm
Total Dissolved Organic Carbon		10-16 ppm
Cu	0.005 -0.020	0.02
Fe	0.050 -0.100	0.25
Zn	0.0001 -0.019	
Dissolved Gross alpha	<2-3.0 (p.Ci/g Res)	
Particulate Gross alpha	<2-21.2 (p.Ci/g Ash)	
Dissolved Gross Beta	1.6-12 (p.Ci/g Res)	
Particulate Gross Beta	<2-238.4 (p.Ci/g Ash)	

[1]Data from Segar, Gerchakov and Johnson, 1971.
[2]Data from F. W. Meyer, 1972.

Biocides in the water itself are low, but Meyer (1972) found 30 μg/kg DDD, 120 μg/kg DDE, 6.5 μg/kg DDT, 0.5 μg/kg dieldrin, 1 μg/kg Silvex and 600 μg/kg PCB in sediments in the Miami River. No aldrin, endrin, heptachlor, lindane, *2,4-D, 2,4,5-T,* or chlordane were found.

The western shore of Biscayne Bay was once a mangrove area backed by *Juncus* marsh. Today the area south of Featherbed Bank contains the only significant acreage of mangroves, and this region too is being developed. Drainage, salt water intrusion dams and roads have so altered the drainage patterns that the remaining mangroves contribute little biomass, but may still contribute essential organic substances needed by other sources of primary productivity. The Keys, many of which are protected via the Biscayne National Monument, retain their mangrove fringes, but often the rocky nature of the islands limits the amount of mangrove forest.

It appears that benthic micro and macroalgae, together with the seagrasses *Thalassia testudinum* and *Diplanthera wrightii* and their associated epiphytes, are the major source of primary production in the Bay south of Featherbed Bank. Further north grasses appear to be limited by turbidity and siltation. Figures 7, 8, 9 and 10 from Roessler, et al. (1974) show the major distribution of seagrasses from Card Bank to Macarthur Causeway. Generally the grasses are most abundant near the shoreline.

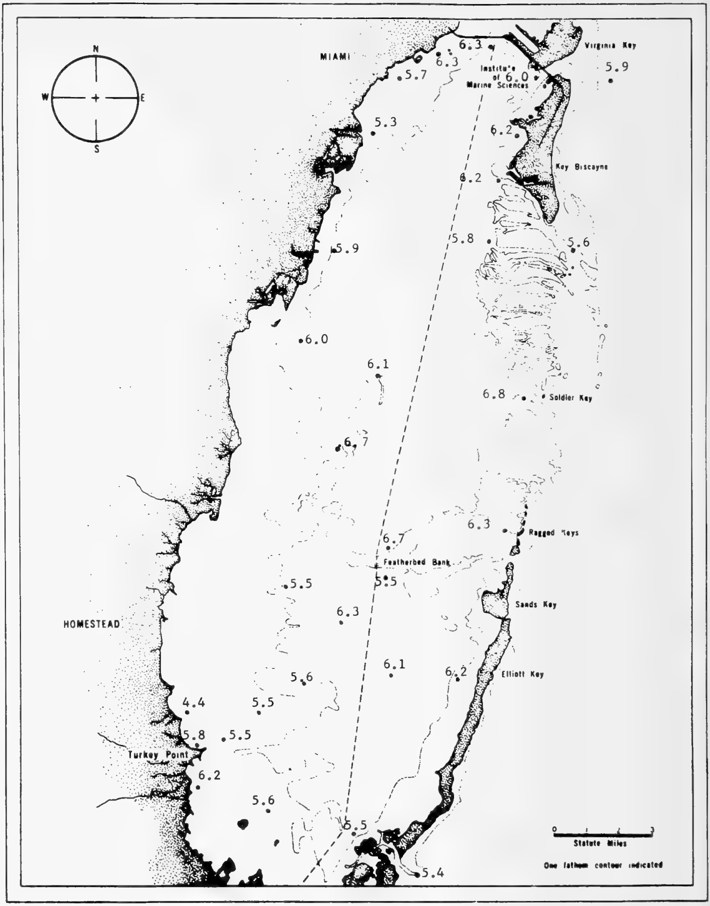

Fig. 5. Distribution of surface dissolved oxygen (ml O_2/1) in summer, from de Sylva, 1970.

Data from Odum (1957), Jones (1968), Zieman (1970), Bunt et al. (1972), and Thorhaug et al. (1973) indicate that in the southern part of the Bay seagrasses (*Thalassia*) produce about 400-2000 gC/m^2 per yr; microalgae in the sediment about 500-600 gC/m^2 per year; *Laurencia*, an epiphytic red alga, about 1300 gC/m^2 per yr; green algae about 450 gC/m^2 per yr; and phytoplankton about 13-15 gC/m^2 per yr.

Reeve and Cosper (1972) found low chlorophyll concentrations in the southern Bay (0.3-0.5 mg/m^3) while Sprogis (personal communication) finds 4-5

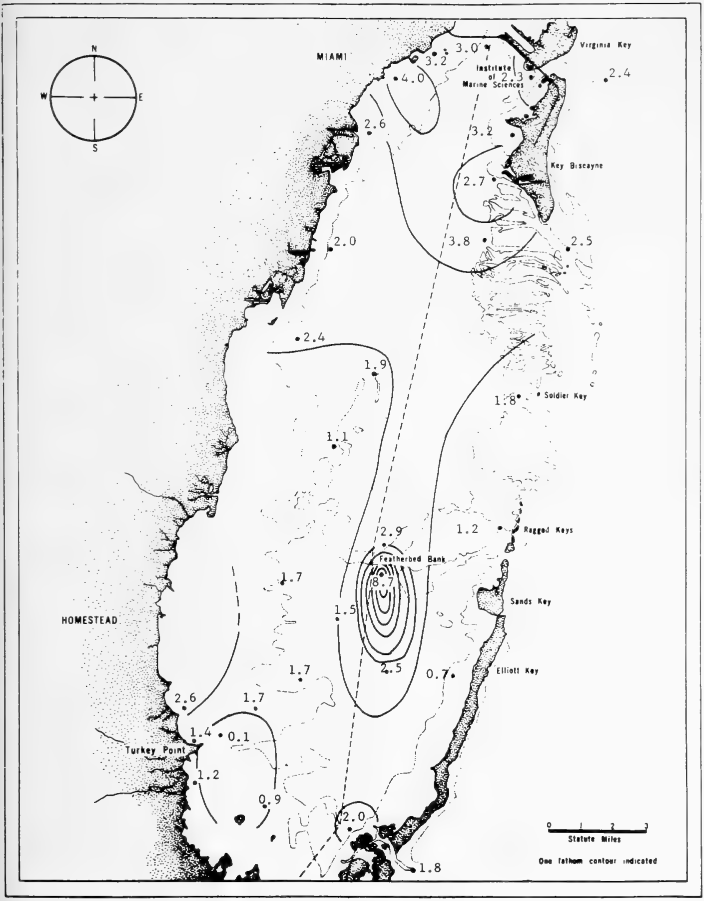

Fig. 6. Distribution of surface turbidity (JTU) in summer, from de Sylva, 1970.

mg/m^3 off the RSMAS dock, indicating the greater importance of phytoplankton in the north Bay where nutrient enrichment is evident.

Further lists of species and seasonal distribution of algae can be found in Humm (1964), Zieman (1970), Thorhaug (1971), Reyes-Vasquez (1965), and Sprogis (1971).

Reeve (1964) and Reeve and Cosper (1972) have studied zooplankton near RSMAS and in the vicinity of Turkey Point. Other studies have included Woodmansee (1958) and Smith, et al. (1950). As shown by de Sylva (1970), there is a

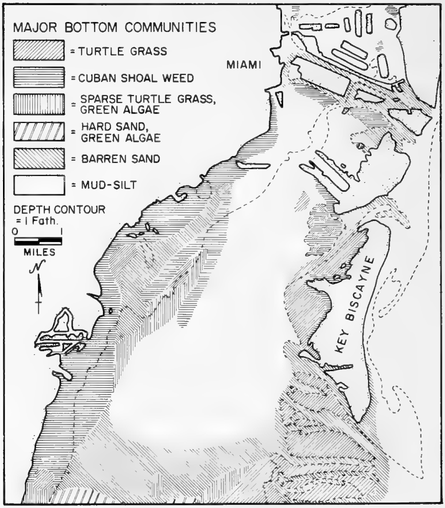

Fig. 7. Major bottom communities in Biscayne Bay, MacArthur Causeway to Key Biscayne.

great deal of variability in plankton biomass distribution, but generally higher volumes are found in the northern part of the Bay (Fig. 11).

Although the classical phytoplankton to zooplankton to higher consumers food-web appears to be of minor importance, it must be emphasized that the zooplankton is vital because it is often dominated by the larval forms of benthic invertebrates and fishes.

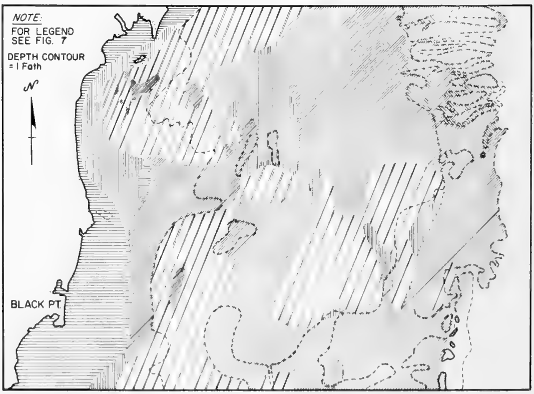

Fig. 8. Major bottom communities in Biscayne Bay, Key Biscayne to Black Point.

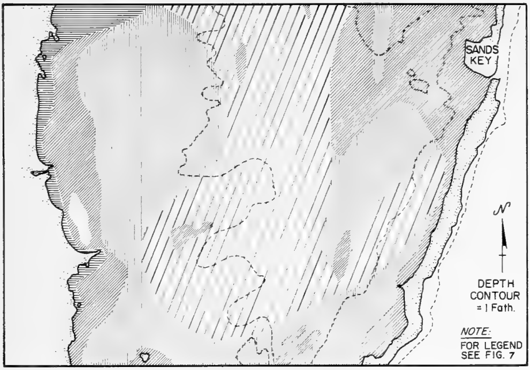

Fig. 10. Major bottom communities in Biscayne Bay, West Arsenicker Key to Card Bank.

McNulty et al. (1962) and McNulty (1970) have described the north Bay fauna from grab samples. Voss and Voss (1955) have discussed the Bay fauna adjacent to Soldier Key, and Voss et al. (1969) have described the fauna of the Biscayne National Monument, including part of southern Biscayne Bay. Roessler et al. (1971) have reported on trawl catches of invertebrates and fishes in southern Biscayne Bay and Card Sound, where a 5 yr study on seasonality and effects of power plant effluent on benthic animals was conducted. Unfortunately the difference in habitats between north and south Bay necessitated different sampling gear. Values on weight and calories for the organisms is not completed so meaningful comparisons are not yet possible.

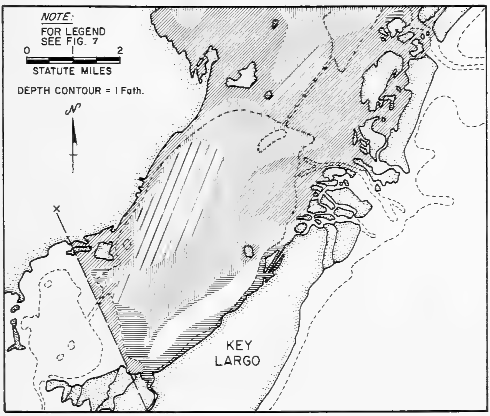

Fig. 9. Major bottom communities in Biscayne Bay, Sands Key to West Arsenicker Key.

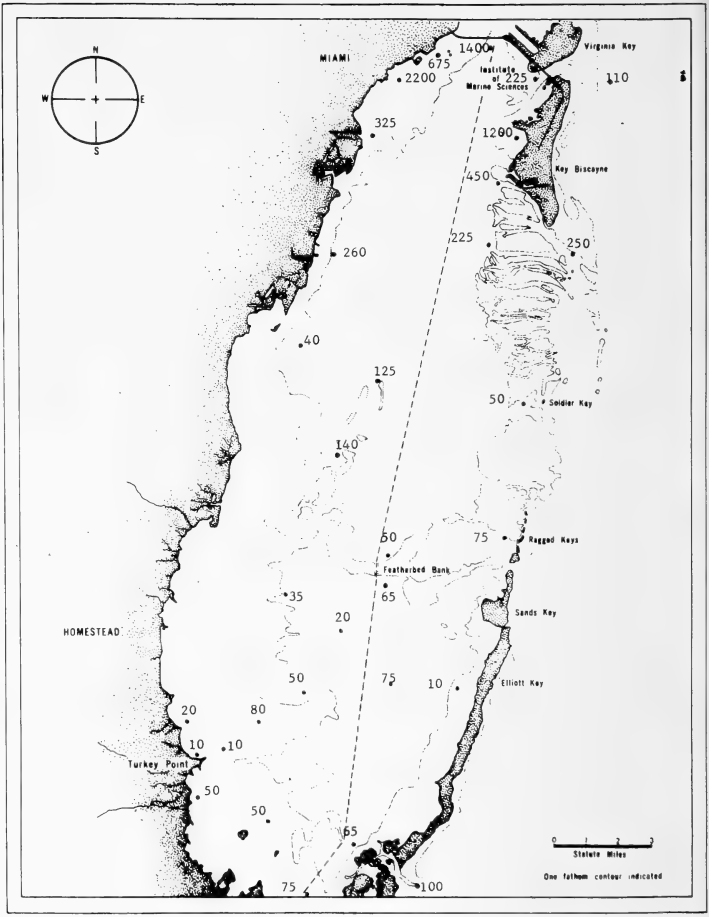

Fig. 11. Distribution of plankton biomass vol (cc) in summer, from de Sylva, 1970.

Fishes of the bay system are varied but few are abundant. Tabb and Kenny (1969) list fishes taken in mid-bay by shrimp trawlers, Roessler (1965) lists fishes from near Key Biscayne taken in trawls, Low (1973) lists shore fishes from the Key Biscayne region, Roessler et al. (1971) list fishes from trawl samples in southern Biscayne Bay, and Voss et al. (1969) list fishes from the Biscayne Monument.

Mammals in the Bay consist of manatees, *Trichechus latirostris*, and occasional porpoise, *Tursiops truncatus*. Reptiles include the loggerhead turtle, *Caretta*

caretta, hawksbill turtle, *Eretmochelys imbricata*, green turtle, *Chelonia mydas*, American crocodile, *Crocodylus acutus*, with occasional invasions of alligator, *Alligator mississipiensis*, diamondback terrapin, *Malaclemys terrapin*, and mangrove water snake, *Natrix sipedon compressicauda*, during heavy rain periods when the mainland edge of the Bay can become fresh (Kohout and Kolopinski, 1964).

Birds, including brown pelicans, white pelican, frigate bird, cormorants, lesser scaup, red breasted merganser, osprey, common egret, snowy egret, great blue heron, great white heron, Louisiana heron, little blue heron, green heron, glossy ibis, white ibis, roseate spoonbill, oyster catchers, plovers, sandpipers, turnstones, herring gulls, ringbilled gulls, laughing gulls, least tern, common tern, royal tern, and kingfishers, have been seen utilizing food sources from the Bay and its tributaries. Other land birds overfly the Bay back and forth between the Keys and the mainland.

Nesting ibis, herons and cormorants are prevalent on the Arsenicker Keys, which are also favored roosts for frigate birds during certain seasons. Additionally, Pumpkin Key in Card Sound is used as a roosting area for white crowned pigeons.

Changes Within the bay System—Upon completion of Mr. Flagler's railroad to Miami in 1896, a demand for filled land and a deepwater seaport was created. The first channel to the sea was dug from the Miami River across the shallows to Cape Florida in the late 1890s. By 1915 the channel was deepened to 5.5 m and widened to 46 m between Government Cut and Miami. In 1925 the channel was again widened and deepened. In 1961 the Port of Miami (Dodge Island) was created and the channel dredged to 8 m. In 1973 work began on further deepening the channel and turning basin to 12 m.

In the boom years following World War I Miami and Miami Beach experienced rapid growth and much dredging for fill occurred (Compton, 1970). The reader is directed to La Gorce (1930) for "before" pictures. McNulty (1970) depicts the major dredging in the 1920s and 1930s and the 1961 Dodge Island Seaport, and Comptom (1970) shows the extent of filling. Since that time Burligame (Chris) Island, Fair Island, Dinner Key and other areas have been further dredged for fill or marine facilities.

Between 1900 and 1950 Miami's population increased from 2,000 to 250,000, and much of the domestic sewage was discharged directly into Biscayne Bay or the Miami River. In 1955 the Virginia Key City of Miami Treatment Plant was opened and the discharge of 36-60 MGD (million gallons per day) was transferred to the plant. Sewage from boats, effluent of local industry, and street runoff continued to enter the River from the Bay. Secretary Stone's efforts in the Miami River Restoration have reduced these sources. However, recent work by D'Amato (1973) shows that even with the Virginia Key outfall, located 4,500 ft offshore, there is significant movement of the effluent into the Bay via Bear Cut, Norris Cut and Government Cut. The proposed extension of the pipeline to 17,500 ft would reduce the problem but not eliminate it. Furthermore, there are plans to increase the plant's capacity to 85 MGD (D'Amato, 1973) and onshore wind conditions would continue to bring the effluent into the Bay via Government Cut or Baker's

Haulover. A recommended extension of the discharge to a depth of 300-400 ft seems reasonable.

In addition to the Miami River-Virginia Key sources of effluent, smaller treatment plants in Dade County, population 1,268,000, contribute effluent to the Bay via canal systems. The Coral Gables plant discharged into the Coral Gables Waterway until recently. Other plants further south discharge into Black Creek, Military Canal, etc., and the infamous "whirling fish kill" may have resulted in part from the nutrient enrichment from effluent and subsequent bluegreen algal bloom.

The interconnections of the above-mentioned canals and the location of these drainage canals is shown by the Central and Southern Florida Flood Control District (1973:18-19). Most are regulated by salinity barriers and discharge at irregular intervals creating point sources of fresh water, nutrients, and occasionally pesticide residues from agricultural areas in southern Dade County.

Almost all the Bay north of Rickenbacker Causeway is seawalled. The mainland shore from Rickenbacker to Coral Gables by-the-Sea has about 75% seawall. Further south only small areas of scattered individual lots are walled.

Bridges spanning Biscayne Bay include Sunny Isles, Broad, 79th Street, Julia Tuttle, Venetian, Macarthur and Rickenbacker Causeways. The first six connect Miami with Miami Beach; the last connects Miami to Virginia Key and Key Biscayne. In addition, a causeway and railroad bridge run from downtown Miami to Dodge Island Seaport, and small bridges connect to Fair Island and Burligame Island.

Figure 12 from the Dade County Planning Board shows the extent of southward movement from 1960 to 1970 and projects the increase of residential development to Cutler Ridge by 1990. Recent enlightenment has favored preserving the red mangrove fringe along the shoreline, but developments such as IT&T and Saga Bay are building as far south as Cutler Ridge, and developments were planned for the Card Sound area until Florida Power and Light Company purchased this land to serve as a cooling reservoir for their nuclear and fossil fuel power plant at Turkey Point.

Economic Value—The commercial fisheries of Biscayne Bay were reviewed by Idyll (1967) and he found over 600,000 pounds of seafood valued at $250,000 per yr, were taken from the Bay. About 95% of the value comes from bottom living invertebrates, including spiny lobster, stone crab and sponges. In addition Tabb and Kenny (1967) have reported on the bait shrimp fishery which is worth about $400,000 per yr. Juvenile stages of fishes and shellfishes caught in offshore waters are also common constituents of the Bay fauna. Sport fishing is known to exist but, except for an unpublished study by Dr. Wade summarized briefly in Voss et al. (1969), little documentation exists. Fishing for mackerel and bluefish occurs in winter. The flats of Key Biscayne, the Arsenicker Keys and along the Florida Keys produce bonefish and occasional permit. Trout are taken in shoreline grassbeds. Snapper, grunt, grouper, jack and panfish are taken from bridges, seawalls and small boats, supplying recreation for tourists and natives alike. Lobsters are taken by divers, and snapper and grouper are caught in the

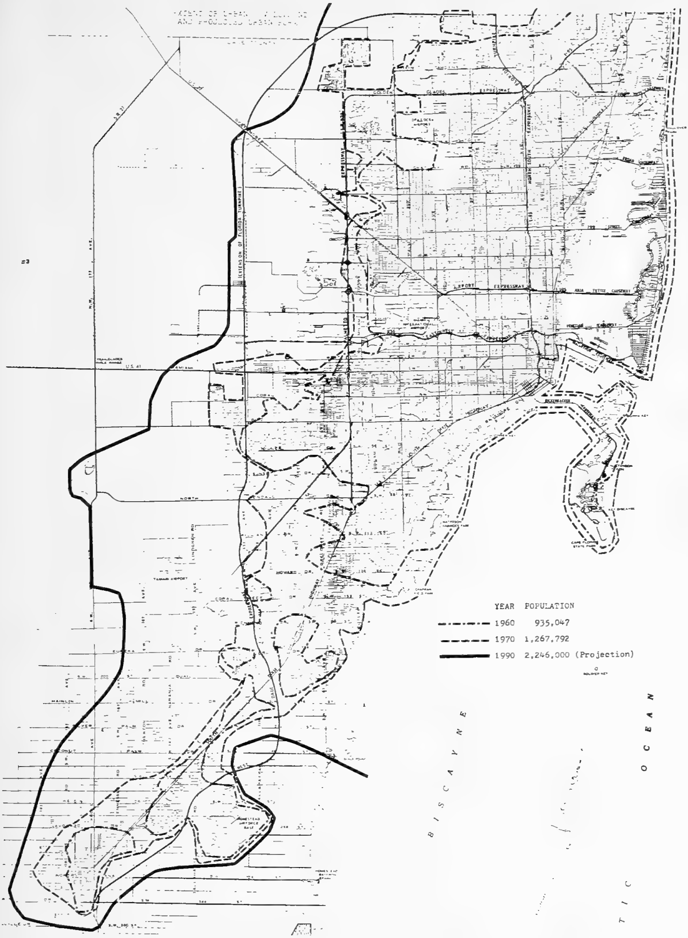

Fig. 12. Distribution of population in 1960, 1970 and expected distribution in 1990. Dade County Planning Board.

channels between the Keys. Unfortunately studies of the economic value of the sport fishery, which were proposed to Sea Grant by the University of Miami, have not been funded.

In addition to the value of adult animals actually captured the Bay has an important role as a nursery area. The economics of this function cannot presently be evaluated.

Swimming beaches are located along Rickenbacker Causeway, at Matheson Hammock, and at Homestead Bayfront Park. Sailing and cruising the Bay is very popular—many boats pass through the Intracoastal Waterway, and many more put in at launching ramps along the mainland to go reef or Gulf Stream fishing.

Major Problem Areas—The Dade County Chamber of Commerce in 1967 listed potential projects proposed for the Bay area. A review of this list with comments on the fate of the proposals should illustrate the major problem areas and point out management decisions for the past 5 yr.

In the first category—Seaports—Dodge Island has been enlarged and Government Cut is being dredged to 35 ft. The South Dade Seaport, proposed for the west shore of Card Sound, and an associated ship channel across the Bay through Ceasar's Creek and out across the reef tract, have been virtually eliminated by the Florida Power and Light Company's purchase of land adjacent to Card Sound for cooling canals.

The second category—Channels—includes plans for deepening the Intracoastal Waterway to 12 ft north of Miami and to "project depth" further south. Deepening the channel would produce silt and spoil but should be a one-time operation which would, in turn, reduce turbidity caused by boat traffic stirring the bottom in shallow areas such as Featherbed Bank.

Deepening of Government Cut to Dodge Island and the turning basin in Miami has begun. Silt problems exist but the effects should be temporary except for the possible loss of Government Cut jetties as a habitat for spotted lobster, *Panulirus guttatus*. We have observed that the spawning cycle of *P. guttatus* was disrupted and that it has become less cryptic and hence more vulnerable to predation by man and natural predators. In addition, the availability of food has been reduced while dredging is in process.

Opening Norris Cut as a navigation channel would create siltation problems and might enhance sewage inflow from the Virginia Key plant outfall. It would seem that improvements in Government Cut should be sufficient for shipping interests to minimize their difficulties.

A South Dade Ship Channel is shown on the Dade County Master Plan and was recognized by the U. S. Government in founding of the Biscayne National Monument. The purchase of the Card Sound shoreline by Florida Power and Light Company, and their promise to set aside the mangrove fringe as a preserve area and buffer zone for the cooling canals associated with Turkey Point, virtually eliminates the need for a channel in this area.

The Homestead channel from Bayfront Park public launching ramp to the Intracoastal Waterway was deepened several years ago with no apparent damage to the surrounding Bay.

The improvement of Baker's Haulover Inlet, including plans for sand bypassing to keep the Inlet clear of sand bars, is needed by small boat operators, but study of the entire beach erosion-littoral sand drift problem in the Miami Beach region must be completed before feasibility of such plans can be evaluated. The work of Lee (1972) and D'Amato (1973) indicates that eddies and wind induced onshore currents can have considerable effect on the long shore drift, and these data should be considered in modeling for beach nourishment, dredge spoil disposal, and sand bypassing projects. One such beach nourishment proposal is underway on Key Biscayne.

Proposed causeways include: (1) a bridge between Miami Beach and Fisher Island, (2) a causeway from Fisher Island to Virginia Key, (3) widening of Rickenbacker Causeway between the mainland and Virginia Key-Key Biscayne, (4) a bridge from the mainland to Burligame Island, (5) a north-south causeway from Key Largo to the Ragged Keys, (6) a causeway from the mainland to the upper Florida Keys, and (7) the mid-bay causeway from the mainland to the Keys.

The first three proposed causeways are designed to relieve traffic problems caused by the popularity of the Crandon Park-Cape Florida Park-Rickenbacker Causeway bathing area-Miami Marine Stadium-Seaquarium tourist attractions, coupled with a rapidly expanding residential-high rise condominium complex on Key Biscayne. The solution, of course, is to increase the number of areas accessible for public swimming and picnicking. However, available oceanfront or bayfront areas for public beach are severely limited and the remaining waterfront property is expensive.

South Miami Beach has some public swimming area, while downtown Miami "Bayfront Park" is dredged for shipping and the water is considered by some to be unsafe for contact sports. Further south an area near Coconut Grove could, by filling, become a small beach area. Tahiti Beach is a small, privately run beach, the success of which indicates that more of these small areas would be useful. Matheson Hammock could probably be enlarged and the area south of Matheson Hammock to Snapper Creek Canal could be developed into a wading beach. Further south beaches could be built from near Fender Point to Homestead Bayfront Park.

The proposed Bayshore Parkway and associated Park-marine complexes would accomplish some of these objectives, and a beach similar to Matheson could protect some of the larger mangroves.

If the beach and boating areas were more diversified the need for causeways to Virginia Key-Key Biscayne would be reduced.

One other possibility would be to build the Miami Beach-Virginia Key Causeway and purchase Fisher Island and use it, together with Virginia Key, as public swimming and recreational parks.

Causeway number 4 mentioned above has been completed and Burligame (=Claughton's Island) is being developed with high rise apartments and perhaps a shopping center.

The purchase of "Islandia" by the U. S. Government and the creation of the Biscayne National Monument has lessened the demand for the last three causeways mentioned above (5, 6 and 7).

One other causeway from the Coconut Grove area to Miami Beach is occasionally discussed by the Corps of Engineers, chiefly as a hurricane barrier to reduce potential flooding in the downtown area. This causeway would, of course, reduce exchange in non-hurricane conditions and would aggrevate the existing relatively stagnant circulation pattern.

Shoreline development by both small and large developers is taking place all along the mainland coast from Miami south to the Dade County line. Generally the State has fought to preserve mangrove fringe areas, reduce access channels to private marinas, maintain low density, and refuse high-rise housing. This is a noble endeavor but it isn't enough. If future generations are to have options of shoreline recreation it is suggested that the County, State, or Federal government purchase this land now (while it is still relatively cheap) and plan to maintain, or improve, water quality to permit contact sports.

To summarize the problem areas on a geographic basis one could say that the Florida Keys from Key Largo northward to Soldier Key seem to be protected by the creation of the Biscayne National Monument; from Key Biscayne northward to Baker's Haulover and the mainland south from this inlet to Matheson Hammock, the major problems are storm and industrial runoff, dredging and causeway construction, and enrichment from recirculated sewage effluent. Further south the flood control canals occasionally carry sewage effluent and agricultural pesticides and there is generally a lack of planning for future recreational needs. In addition, almost the entire shoreline of Card Sound and Biscayne Bay from Homestead Bayfront Park south is owned by Florida Power and Light Company for use as a power generating station and canals to cool the effluent water from the station. As shown by Bader (1969), Bader and Tabb (1970), and Bader and Roessler (1971, 1972) the effluent of this plant caused damage to Biscayne Bay. An alternate cooling method that involved 7,000 acres of cooling canals and dikes and a closed recirculating system with only minor makeup water requirements, was approved in a Consent Decree signed by Judge C. Clyde Atkins in September 1971.

This recirculating system prevents much of the degradation of the Bay ecosystem, prevents the construction of a seaport and/or refinery, preserves the fringing mangroves, and prevents the area from being developed. However, it also limits the options of the Dade County Planning Board, which has just completed its resource assessment and formulated a master plan, from utilizing this area for recreation parks.

The above synopsis of the Bay ecosystem indicates there is much we don't know about the system. However, there is a considerable body of knowledge pertaining to the Bay, and a fair number of scientists now working on pragmatic problems. It is essential that government agencies responsible for management decisions utilize the expertise available to provide information on long-term commitments and insist that missing data be obtained either through funding of additional research or by demanding complete impact statements from proposed projects. On the other hand, the scientist must become involved with his community and offer to interpret data and draw the best conclusion he can from the limited data available. Seeking "truth" is a noble academic pursuit but rationally and honestly interpreting incomplete data with insight gained by experience is essential if planned use is to be made of our estuaries. Unplanned use, as we have seen, can cause the loss of one of our most valuable resources.

LITERATURE CITED

Bader, R. G. (ed.). 1969. An ecological study of south Biscayne Bay in the vicinity of Turkey Point. Rosenstiel School of Marine and Atmospheric Science, Report to the U. S. Atomic Energy Comm. (AT-(40-1)-3801-1) 63 pp. (mimeographed)

________, and M. A. Roessler (eds.). 1971. An ecological study of south Biscayne Bay and Card Sound, Florida. Rosenstiel School of Marine and Atmospheric Science, Report to the U. S. Atomic Energy Comm. (AT-(40-1)-3801-3) 378 pp. + 201 Appendix pp. (mimeographed)

________, and ________ (eds.). 1972. An ecological study of south Biscayne Bay and Card Sound, Florida. Rosenstiel School of Marine and Atmospheric Science, Report to the U. S. Atomic Energy Comm. (AT-(40-1)-3801-4) 334 pp. (mimeographed)

________, and D. C. Tabb (eds.). 1970. An ecological study of south Biscayne Bay in the vicinity of Turkey Point. Rosenstiel School of Marine and Atmospheric Science, Report to the U. S. Atomic Energy Comm. (AT-(40-1)-3801-2) 81 pp. (mimeographed)

Bunt, J. S., C. C. Lee, B. Taylor, P. Rost and E. Lee. 1972. Quantitative studies on certain features of Card Sound as a biological system. Rosenstiel School of Marine and Atmospheric Science, Report 72011. 13 + xii pp. (mimeographed)

Compton, G. 1970. Beautiful blue Biscayne Bay. The Miamian, October 1970:28-30.

CSFFCD. 1973. Central and Southern Florida Flood Control District, 24th Annual Report for July 1, 1972-June 30, 1973. CSFFCD, West Palm Beach, Florida. 35 pp.

D'Amato, R. 1973. The movement of effluent from the city of Miami sewage ocean outfall. Univ. Miami Sea Grant Tech. Bull. 27:91 pp.

deSylva, D. P. 1970. Ecology and distribution of postlarval fishes of southern Biscayne Bay, Florida. Rosenstiel School of Marine and Atmospheric Science Report ML 71015. 198 pp. (mimeographed)

Early, C. F. and H. G. Goodell. 1968. The sediments of Card Sound, Florida. J. Sed. Petrol. 38:985-999.

Hela, I., C. A. Carpenter, Jr. and J. K. McNulty. 1957. Hydrography of a positive, shallow, tidal bar built estuary. Bull. Mar. Sci. 7:47-99.

Humm, H. J. 1964. Epiphytes of the sea grass, *Thalassia testudinum*, in Florida. Bull. Mar. Sci. 14:306-341.

Idyll, C. P. 1967. Economically important marine organisms in Biscayne Bay. Unpublished manuscript.

Jones, J. A. 1968. Primary productivity by the tropical marine turtle grass, *Thalassia testudinum* König, and its epiphytes. Ph.D. Dissertation. Univ. Miami. Coral Gables. (mimeographed)

Kohout, F. A. and M. C. Kolipinski. 1964. Biological zonation related to ground water discharge along the shore of Biscayne Bay, Miami, Florida. pp. 488-499. *In* G. H. Lauff (ed.). Estuaries. Publ. 83. Amer. Assoc. Adv. Sci. Washington, D. C.

La Gorce, J. O. 1930. Florida—the fountain of youth. Nat. Geogr. Mag. 57(1):1-93.

Lee, T. N. 1972. Florida current spin-off eddies. Ph.D. Dissertation. Florida State Univ. Tallahassee.

________, and C. Rooth. 1972. Exchange processes in shallow tidal estuaries. Univ. Miami Sea Grant Spec. Bull. 4:1-15.

Low, R. A., Jr. 1973. Shoreline grassbed fishes in Biscayne Bay, Florida, with notes on the availability of clupeid fishes. Master's Thesis. Univ. Miami. Coral Gables. (mimeographed)

McNulty, J. K. 1970. Effects of abatement of domestic sewage pollution on the benthos, volumes of zooplankton, and the fouling organisms of Biscayne Bay, Florida. Univ. Miami Press. Coral Gables.

________, R. C. Work and H. B. Moore. 1962. Level sea bottom communities in Biscayne Bay and neighboring areas. Bull. Mar. Sci. 12:204-233.

Meyer, F. W. 1972. Supplemental data collected for the Miami River Restoration Project, March-September 1971. U. S. Geol. Survey, Report to Sec. Richard Stone, Jan. 20, 1972. 7 pp. (mimeographed)

Moore, H. B. 1970. Miami sea temperatures and salinities. April, 1970. Rosenstiel School of Marine and Atmospheric Science Tech. Rept. ML 70038. 9 pp. (mimeographed)

Morrill, J. B., Jr. and F. C. W. Olson. 1953. Literature survey of the Biscayne Bay area. The Oceanographic Institute, Florida State University, Tallahassee. 134 pp. (mimeographed)

Odum, H. T. 1957. Primary production measurements in eleven Florida springs and a marine turtle grass community. Limnol. Oceanogr. 2:85-97.

Reeve, M. R. 1964. Studies on the seasonal variation of the zooplankton in a marine subtropical in-shore environment. Bull. Mar. Sci. 14:103-122.

_________, AND E. COSPER. 1972. VI. Plankton of the Biscayne Bay/Card Sound system. pp. VI-1-VI-9. *In* BADER, R. G. AND M. A. ROESSLER (eds.). An ecological study of south Biscayne Bay and Card Sound, Florida. Rosenstiel School of Marine and Atmospheric Science, Rept. 72060. (mimeographed)

REYES-VASQUEZ, G. 1965. Studies on the diatom flora living on *Thalassia testudinum* Konig in Biscayne Bay. Master's Thesis. Univ. Miami. Coral Gables. (mimeographed)

ROESSLER, M. A. 1965. An analysis of the variability of fish populations taken by otter trawl in Biscayne Bay, Florida. Trans. Amer. Fish. Soc. 94:136-145.

_________, G. L. BEARDSLEY, AND R. SMITH. 1974. Benthic communities of Biscayne Bay, Florida. Univ. Miami Sea Grant Coastal Zone Management Bull. (in press)

_________, R. G. REHRER AND J. GARCIA. 1971. Studies of the effects of thermal pollution in Biscayne Bay, Florida. Rosenstiel School of Marine and Atmospheric Science, Report to the Environmental Protection Agency, Grants WP-01351-01-A1 and 18050 DFU. 211 pp. (mimeographed)

SEGAR, D., S. GERCHAKOV AND T. JOHNSON. 1971. IV. Chemistry. pp. IV-1-IV-64 + 201 pp. Appendix. *In* BADER, R. G. AND M. A. ROESSLER, eds. An ecological study of south Biscayne Bay and Card Sound, Florida. Rosenstiel School of Marine and Atmospheric Science, Rept. ML71066 (mimeographed)

SCHNEIDER, J. J. 1969. Tidal relations in the south Biscayne Bay area, Dade County, Florida. U. S. Geol. Surv. Open File Rept. 16 pp.

SMITH, F. G. W., R. H. WILLIAMS AND C. C. DAVIS. 1950. An ecological survey of the subtropical inshore waters adjacent to Miami. Ecology 31:119-146.

SPROGIS, J. 1971. VII. Diatoms. pp. VII-1-VII-28. *In* BADER, R. G. AND M. A. ROESSLER (eds.). An ecological study of south Biscayne Bay and Card Sound, Florida. Rosenstiel School of Marine and Atmospheric Science, Rept. 71066. (mimeographed)

TABB, D. C. AND N. KENNY. 1969. A brief history of Florida's live bait shrimp fishery with description of fishing gear and methods. Proc. World Sci. Conf. Biol. and Culture of Shrimps and Prawns. FAO Fish. Report 57, 3:1119-1134.

THORHAUG, A. 1971. X. Grasses and macroalgae. pp. X-1-X-63. *In* BADER, R. G. AND M. A. ROESSLER (eds.). An ecological study of south Biscayne Bay and Card Sound, Florida. Rosenstiel School of Marine and Atmospheric Science, Rept. 71066. (mimeographed)

THORHAUG, A., D. SEGAR AND M. A. ROESSLER. 1973. Impact of a power plant on a subtropical estuarine environment. Mar. Poll. Bull. 4:166-169.

VOSS, G. L., F. M. BAYER, C. R. ROBINS, M. GOMON AND E. T. LAROE. 1969. The marine ecology of the Biscayne National Monument. Institute of Marine and Atmospheric Sciences, Report to U. S. Nat. Park Service, September 20, 1969. 128 pp. + 40 figs.

_________, AND N. VOSS. 1955. An ecological survey of Soldier Key, Biscayne Bay, Florida. Bull. Mar. Sci. 5:203-229.

WANLESS, H. R. 1969. Sediments of Biscayne Bay—distribution and depositional history. Rosenstiel School of Marine and Atmospheric Sciences. Rept. ML 69110, 260 pp. (mimeographed)

WOODMANSEE, R. A. 1958. The seasonal distribution of the zooplankton off Chicken Key in Biscayne Bay, Florida. Ecology 39:247-262.

ZIEMAN, J. C., JR. 1970. The effects of a thermal effluent stress on the sea grasses and macroalgae in the vicinity of Turkey Point, Biscayne Bay, Florida. Ph.D. Dissertation. Univ. Miami. Coral Gables.

Florida Sci. 37(4):186-204. 1974.

THE CHARLOTTE HARBOR ESTUARINE SYSTEM[1]

JOHN L. TAYLOR

Taylor Biological Company, Postal Drawer 730, Lynn Haven, Florida 32444

ABSTRACT: *The estuary is about 35 by 30 miles at the extremes with more than 200 miles of shoreline and comparatively little contamination. Vegetation includes salt marsh, mangrove and other peninsular Florida Gulf Coast communities which are highly productive. Of 246 fish species, 18 produce a harvest with a dockside value of ca. $3,000,000. Dredging and development have had an adverse effect on more than 11,000 acres near Port Charlotte, Punta Gorda, Cape Coral and Fort Myers. An additional 25,300 acres are closed to shellfishing because of pollution. Further manmade changes threaten the value of the estuary as a fishing ground and hatchery for commercially valuable marine fishes.*

IN THE OPINION of two eminently qualified observers, Charlotte Harbor is one of the largest and perhaps the least contaminated of the estuarine complexes in the state of Florida (Wang and Raney, 1971). It has a length of approximately 35 miles, and extends from San Carlos Bay at the southern boundary (26°27'12"N), north to the upper end of Gasparilla Sound (26°52'00"N). Maximum width of the complex covers an unbroken distance of more than 20 miles between the Caloosahatchee River east of Fort Myers and Sanibel Island.

Total shoreline, exclusive of small mangrove islands, amounts to more than 200 miles, and measurements reported by Huang (1966), show that the estuary covers a water area of at least 280 sq miles. He also noted that the deepest point is 51 ft, just inside Boca Grande Pass, and that elsewhere the complex contains a predominance of areas 6 ft deep or shallower, areas between 6 and 12 ft deep in natural depressions and along channel margins, and a number of channels and anchorages deeper than 12 ft. Overall, average depth is 10 to 12 ft (Wang and Raney, 1971; Brooks, 1973), and calculated volume at mean high water is nearly 2.4 million acre-ft (McNulty et al., 1972).

The entire estuarine system is separated from the Gulf of Mexico by a series of barrier islands, and is connected to it by a deep water channel at Boca Grande, and four other principal passes. The Intracoastal Waterway route through the estuary is shown at a scale of 1:40,000 on National Ocean Survey Charts 856-SC and 857-SC, and at 1:80,000 on Chart 1255.

GEOLOGY AND SEDIMENTS—Deeper regions of the complex represent drowned river valleys in the Florida Plateau that were alternately eroded and flooded during glacial and interglacial periods of Pleistocene time (Brooks, 1973). Its present shape and depth resulted from a rise in mean sea level estimated at 10 ft over the past 4,000 years (McNulty et al., 1972).

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[1]In modified form, this report was submitted to the U. S. Army Engineers, Jacksonville District, as part of an environmental assessment which treated five estuarine areas on the Florida west coast between the Caloosahatchee and Anclote Rivers.

As shown diagrammatically by Dragovich et al. (1968), surrounding uplands consist of Eocene or more recent deposits that have been referred to the following formations:

1. Bone Valley
2. Hawthorne
3. Caloosahatchee Marl
4. Late Pleistocene terrace materials
5. Fort Thompson
6. Lake Flint Marl
7. Buckingham Marl

Through land drainage, these formations are a source of estuarine sediments, as well as solutes in the form of nutrient substances and trace elements. Other sources of sediment include calcareous remains of marine organisms and a heterogeneous mixture of quartz sand and shell fragments transported landward by tidal currents (Huang, 1966).

Unconsolidated sediments of recent age have been measured to depths of 10 ft, and may be deeper in other areas. They consist almost entirely of quartz sand, and have a mean grain size of 2.01 phi (fine sand). Coarse, shelly sands are largely limited to passes and channels, while sediments containing high percentages of silts and clays are restricted to areas near mouths of major tributaries (Huang, 1966). Toward the coast, these rivers run at a very low grade, and do not add large sediment loads to the estuary except during flood stage periods (Huang and Goodell, 1967; Brooks, 1973).

Huang's (1966), data on sediment chemistry showed that samples from throughout the complex contained between zero and 9.03% phosphate, on a dry wt basis, while 86% of them contained between 1.00 and 2.50% phosphate. Nitrogen levels ranged between 0.01 and 0.25%, and the mean was 0.05%. Values for organic carbon showed that 90% of his samples contained amounts in a range between 0.10 and 1.00%, while absolute limits of the range were 0.08 and 3.06%. The greatest concentrations of organic carbon were recorded from San Carlos Bay and the overall mean was 0.66%.

CLIMATE—Over the Charlotte Harbor estuarine system climate is humid and subtropical. Rainfall amounts to about 53 in per yr, as an ave, but large yr-to-yr variations are not unusual. As a rule, more than 60% of the precipitation falls between June and September when it is associated with thunderstorms and tropical depressions. About 100 thunderstorms may be expected each year, and hurricane records show that 38 have passed through this area in the last 70 years. Two of these were severe, and created tidal surges 9 to 14 ft above normal (Jordan, 1973). Inland areas that can anticipate flooding from such storms have been delineated on maps prepared by the Florida Coastal Coordinating Council (1972).

Normally, wind direction over the estuary is southerly during spring, summer, and fall, and northerly in winter. Wind velocity seldom exceeds 15 kn, and waves usually run 4 ft high or less (Jordan, 1973).

Air temperature during July and August varies between an average maximum of about 90°F and an average minimum of 75°F. In January and February, respective averages are about 77° and 55°F. Day-to-day air temperature variations are negligible in summer, however, in winter, periodic cold fronts may be accompanied by a sudden drop in temperature followed by several days of abnormally cool weather. Sea fog occurs about 12 days per yr between fall and spring when warm, moist tropical air moves in over coastal waters chilled by frontal activity (Jordan, 1973).

TRIBUTARIES—Major rivers in the complex include the Myakka and Peace which flow into Charlotte Harbor proper, and the Caloosahatchee which discharges into San Carlos Bay. The first two are under administrative control of the Southwest Florida Water Management District, while the Caloosahatchee comes under the jurisdiction of the Central and Southern Florida Flood Control District.

Together, the Myakka and Peace Rivers drain a land area of nearly 3,000 sq miles and have an average combined flow of about 2,000 cu ft per sec (cfs). The Caloosahatchee watershed covers about 1,200 sq miles and has a flow that can be controlled by a system of flood gates and locks. Even so, its average flow is approximately 1,300 cfs, and maximum design flow is 4,500 cfs (Gunter and Hall, 1965; Connell Associates, Inc., 1972; McNulty et al., 1972; Ross, 1973). As one might expect, periods of peak river flow coincide with the regional pattern of seasonal precipitation already noted (Huang, 1966). The Myakka River originates about 45 miles inland, the Peace begins more than 70 miles from the coast, and the Caloosahatchee runs for 63 miles between Lake Okeechobee and Fort Myers.

In their courses, all three rivers are polluted to some degree from pasture land, citrus groves, and cultivated ground. In addition, the Peace traverses a large area containing phosphate strip mines, and the Caloosahatchee receives considerable amounts of industrial and domestic sewage in its lower reaches (Gunter and Hall, 1965; McNulty et al., 1972).

During a period of low river flow and high tide, Gunter and Hall (1965), recorded a saline wedge of bottom water some 38 miles upstream in the Caloosahatchee River. Under similar circumstances, salt water wedges have also been recorded well upstream in the Myakka and Peace Rivers. However, when conditions are reversed, river water causes a reduction in surface salinity throughout the estuary as well as offshore to a distance of several miles (Gunter and Hall, 1965; Alberts et al., 1970).

As part of continuing studies of the Florida red tide organism, *Gymnodinium breve*, a great deal of information has been obtained about physical and chemical properties of springs, streams, and rivers that eventually enter the Charlotte Harbor estuarine system, and subsequently influence its hydrographic characteristics (Finucane and Dragovich, 1959; Florida Board of Conservation, 1967; Dragovich et al., 1968; Martin, et al., 1971; McNulty et al., 1972). By way of a summary, various factors investigated have been listed together with respective values of means and ranges for the Myakka, Peace, and Caloosahatchee Rivers (Table 1).

In comparison with other rivers, and estuaries and oceans as well, these three rivers are as rich or richer than most natural waters in terms of substances of importance to biological production. At present, the principal factor that limits further increases in their productivity is a relatively low level of nitrogen as compared to phosphorus (Alberts et al., 1970; Corcoran, 1973; La Roch and Bittaker, 1973; Steidinger, 1973).

TABLE 1. Hydrographic data for the Myakka, Peace, and Caloosahatchee Rivers (Finucane and Dragovich, 1959; Florida Board of Conservation, 1967; Dragovich, Kelly, and Goodell, 1968; Martin, Doig, and Pierce, 1971).

	Myakka River		Peace River		Caloosahatchee River	
Factor	Mean	Range	Mean	Range	Mean	Range
Temperature, °C	24.1	16.0-29.0	25.6	16.0-30.5	27.0	18.5-32.8
Salinity, ‰		0.0-30.0		0.0-30.0		0.0-30.0
pH, Std. Units		4.4-8.5		4.0-8.5		5.5-8.5
Turbidity, JTU	50	7-100	47	10-90	30	5-60
I-PO_4-P, μg at/l	3.9	0.3-6.9	16.7	0.0-26.6	2.9	0.5-5.5
T-PO_4-P, μg at/l	6.4	2.0-12.4	19.4	0.9-33.7	7.2	1.4-23.2
Nitrite-N, ppm	0.009	0.0-0.008	0.10	0.0-0.005	0.009	0.0-0.050
Nitrate-N, ppm	2.11	0.2-6.0	1.78	0.1-4.5	1.7	0.5-5.0
T-organic-N, μg at/l	21.94	8.68-56.70	16.91	5.01-50.40	19.32	8.88-30.18
Chlorophyll *a*, mg/m^3	5.25		8.74		12.13	
Primary Prod., gC/m^2/day	0.87	0.46-1.58	1.44	0.56-2.91	2.28	0.97-8.40
Calcium, ppm	25	5-75	69	20-120	139	93-260
Magnesium, ppm	20	5-50	56	18-150	74	18-280
Humic Acid, mg/l	4.3		5.47		2.02	
Carbohydrate, mg/l arabinose equiv.	4.4	2.1-13.6	3.2	0.8-7.2	4.2	0.7-11.2
Protein, mg/l tyrosine equiv.	6.5	0.4-22.3	4.2	1.0-12.5	5.2	0.0-12.6
$B_{12}\mu$mgB_{12}/ml of test organism		15.5-42.6				12.0-24.7
Copper, μg at/l	0.14	0.00-0.65	0.13	0.00-0.72	0.15	0.60-0.76
Iron, μg/l	299.2	179-393	392.7	42-800	320.9	95-1266
Chloride, ppm	19.2	8.0-42.5	22.0	12.5-32.0		
Sulphate, ppm	18	3-48	61	13-100	127	29-300
Chromate, ppm	0.01	0.0-0.25		0.0-0.2		0.0-0.29
Silica, ppm	2.27	0.30-6.40	9.12	1.8-14.0	3.76	1.60-6.40
Boron, ppm	0.39	0.0-1.0	0.4	0.0-1.1	0.58	0.0-1.8
Manganese, ppb	54		28		20	
Zinc, ppb	10		15		14	
Dissolved oxygen, ml/l		2.0-7.0		1.8-7.0		1.0-5.8

TIDES AND CURRENTS—Tides in the Charlotte Harbor region are of a mixed diurnal and semidiurnal type, and have a maximum amplitude of 3 ft or less except under severe weather conditions (Connell Associates, Inc., 1972; McNulty et al., 1972). Flood tide at San Carlos Pass precedes rising water at Boca Grande by about 15 min (Huang, 1966). The flood and ebb currents at San Carlos move in a north and south direction, while at Boca Grande and all other major inlets the directions of tidal flow are east and west. Maximum flood and ebb velocities at San Carlos Pass are about 1.0 and 0.9 kn, and at Boca Grande, rates at corresponding stages are 2.2 and 1.8 kn (Huang, 1966).

Outside the estuary currents exhibit a net southerly flow. Consequently, Gulf beaches immediately south of inlets are effected to some degree by sediments and solutes flushed from the estuary during ebb tide.

PHYSICAL AND CHEMICAL PARAMETERS—Many of the hydrographic factors tabulated for regional tributaries have also been measured in estuarine and nearshore Gulf waters (Finucane and Dragovich, 1959; Phillips and Springer, 1960; Dragovich et al., 1961; Dragovich et al., 1966; Finucane, 1966; Florida Department of Conservation, 1967; Alberts et al., 1969; Alberts et al., 1970; Wang and Raney, 1971; McNulty et al., 1972). These studies have shown that within the estuary hydrographic parameters are quite variable from time to time and place to place because of tidal oscillations, weather phenomena, river flow, bathymetry, and for other reasons as well. In order to portray the horizontal and vertical flux of salinity and phosphorus, in parts per million (ppm), were plotted at tide stages on outline charts of Charlotte Harbor by Alberts et al. (1970). For these and other factors, means and ranges have been tabulated from surface water measurements at stations centrally located (or nearly so), in Charlotte Harbor proper, Pine Island Sound, and San Carlos Bay (Table 2). In addition, some data are available for heavy metals and persistent pesticides in the Punta Gorda area (Connell Associates, Inc., 1972). Maximum values reported by that consulting firm are as follows: Arsenic, 0.03 ppm; Cadmium, 0.02 ppm; Mercury, 0.01 ppm; DDT, 0.1 ppb; and DDE, 6.0 ppb.

TABLE 2. Hydrographic data for Charlotte Harbor, Pine Island Sound, and San Carlos Bay, (Finucane and Dragovich, 1959; Dragovich, Kelly, and Finucane, 1966; Florida Board of Conservation, 1967).

	Charlotte Harbor		Pine Island Sound		San Carlos Bay	
Factor	Mean	Range	Mean	Range	Mean	Range
Temperature, °C	24.7	16.5- 30.9	25.5	19.7-31.2	25.4	19.7-31.6
Salinity, ‰	28.6	20.0- 34.2	34.3	28.5-36.2	32.6	25.5-36.2
pH, Std. Units	7.8	7.3- 8.1	8.0	7.6- 8.3	8.1	7.8- 8.3
Light Trans, % deck cell	49.0	10.4- 72.0	58.4	37.6-80.9	53.2	28.8-66.6
I-PO_4-P, μg at/l	8.0	2.4- 22.0	0.5	0.1- 1.4	1.9	1.2- 3.3
T-PO_4-P, μg at/l	1.1	0.0- 1.7	1.1	0.1- 4.2	1.3	0.6- 2.7
NO_2-NO_3-N, μg at/l	0.6	0.0- 1.8	1.4	0.1- 8.7	0.7	0.0- 1.8
T-organic-N, μg at/l	20.5	15.7- 26.4			20.3	18.4-22.3
Chlorophyll *a*, mg/m^3	3.8	1.0- 11.9	6.0	1.4-16.1	5.6	2.5-13.3
Carbohydrate, mg/l glucose equiv.	1.0	0.5- 1.9			0.8	0.5- 1.5
Carbohydrate, mg/l arabinose equiv.	3.1	0.0- 26.2	1.4	0.7- 2.7	1.4	0.5- 2.6
protein, mg/l tyrosine equiv.	1.6	0.0- 10.2	1.3	0.0-10.0	1.0	0.0- 4.8
B_{12}, umgB_{12}/ml *C. nanna*	8.1	0.0- 18.9				
B_{12}, umgB_{12}/ml *Euglena* sp.	18.5	7.6- 28.5				
Copper, ug at/l	0.2	0.0- 0.7	0.1	0.0- 0.6	0.1	0.0- 0.6
Iron, ug/l	93.3	2.4-452.7				
Dissolved oxygen, ml/l	4.3	3.4- 5.2	4.1	2.8- 4.9	4.4	3.7- 5.3

In comparison with river water, these data show that within the estuary there is a general increase in salinity and pH, accompanied by a decrease in nutrients and planktonic chlorophyll *a*. This situation is caused largely by processes of flocculation and precipitation, dispersion, and dilution, as fresh water meets and mixes with saline tide water.

EMERGENT VEGETATION—Most native, terrestrial plants of the Charlotte Harbor complex are included among species recorded for the Tampa Bay area by Lakela and Long (1970). Of these, more than 200 species occur on natural and spoil islands or along the coast where they are exposed to salt spray, as well as saline ground water in some areas (Carlson, 1970; Hilsenbeck and Hilsenbeck, undated; John B. Morrill and Barbara Beaman, personal communication).

This coastal flora comprises a number of major plant associations, or communities, that include: salt marsh, mangrove, coastal strand, salt barren, sabal-juniper hammock, oak-persea hammock, and pine woods. At the edge of estuarine waters, however, the first two are the most common and conspicuous ones.

The salt marsh community covers nearly 186,000 acres, and consists of one or more of the following species; *Spartina alterniflora*, *Juncus roemerianus*, and *Spartina patens*. Typically, these three plants exhibit a distinct zonation in which *S. alterniflora* is followed at progressively higher elevations by *J. roemerianus*, and *S. patens* (McNulty et al., 1972; Humm, 1973a). The mangrove community is more widespread and covers over 46,000 acres. It contains red mangrove, *Rhizophora mangle*, black mangrove, *Avicennia germinans*; and white mangrove, *Laguncularia racemosa* mixed with buttonwood, *Conocarpus erectus*. Zonation is also a feature of the mangrove community. Red mangrove lives from the level of low tide, or slightly deeper, to about the mean high water mark. Landward, it is replaced by black mangrove, which is followed by a mixed stand of white mangrove and buttonwood (McNulty et al., 1972; Humm, 1973b). Acreages vegetated by both salt marsh and mangrove communities throughout the Charlotte Harbor subarea were illustrated by McNulty et al. (1972), and the Florida Coastal Coordinating Council (1973).

Ecologically, plants of both communities are of great importance because they stabilize coastlines and provide habitats for a variety of animals and other plants. Furthermore, they produce a large amount of organic material that may be utilized as a source of food for organisms in food webs that ultimately lead to the production of seafoods and other marine resources harvested by man. From studies of mangrove and salt marsh productivity, it is evident that organic production in the mangrove community amounts to about 8,000 lb per acre per yr, while that of salt marsh plants approaches 20,000 lb per acre per yr, on a dry wt basis (Odum, 1961; Teal, 1962; Heald, 1969). Thus, in this estuary, yearly production of dry organic matter by marsh vegetation is on the order of 186,000 tons, and for the mangrove community, an average annual yield would be approximately 184,000 tons.

Submerged Vegetation—From a few in below the level of mean low tide to depths of 6 ft or more, benthic vegetation covers some 53,220 acres, or roughly 30% of Charlotte Harbor estuary. This flora consists of five sea grasses and more than 200 species of algae. Among the recorded algae there are nearly 40 species of browns (Phaeophyta), more than 100 reds (Rhodophyta), and over 50 greens (Chlorophyta) (Florida State Board of Conservation, 1959a and 1959b; Phillips and Springer, 1960; Woodburn, 1960a, 1960b, and 1960c; Dawes, 1967; Earle, 1969; McNulty et al., 1972; Humm, 1973c). Sea grasses, however, are the most conspicuous floristic feature and include turtle grass (*Thalassia testudinum*), shoal grass (*Diplanthera wrightii*), widgeon grass (*Ruppia maritima*), manatee grass (*Syringodium filiforme*), and *Halophila engelmanni* (Humm, 1973d).

On the basis of biomass and productivity estimates, sea grasses and attached algae in the estuary probably produce about 0.5 million tons of dry organic matter annually (Taylor and Saloman, 1968; Morrill and Beaman, personal communication). In addition to their important role as primary producers, these plants also stabilize sediments and provide a habitat for large numbers of invertebrate animals and fishes (Humm, 1973d).

Turtle grass is the most abundant sea grass in the estuary and commonly occurs in all shallow waters where salinity is 20‰ or greater. Shoal grass generally forms a narrow fringe above the turtle grass, and can tolerate more brackish water where it is often associated with another euryhaline species, widgeon grass. Manatee grass and *Halophila* grow mainly in lower levels of the turtle grass zone since both are limited by brackish water and tidal exposure (McNulty et al., 1972).

As with marsh and mangrove vegetation, dredging and development have had a marked adverse effect on grass beds in some parts of Charlotte Harbor estuary. Calculations by McNulty et al. (1972), indicate that more than 11,000 acres of coastal and submerged land have been modified for channels, spoil islands, residential and commercial developments, and drainage projects. Areas of greatest destruction are located near Port Charlotte, Punta Gorda, Cape Coral, Fort Myers, and in the San Carlos Bay segment of the Intracoastal Waterway.

PHYTOPLANKTON—Since early investigations by Davis (1950), and King (1950), the most thorough studies of phytoplankton in Charlotte Harbor estuary and vicinity have been done by Saunders et al. (1967), and Steidinger et al. (1967). Other studies of microalgae in the complex include works by Connell Associates, Inc. (1972), and McNulty, Lindall, and Anthony whose unpublished data are filed at the National Marine Fisheries Service Laboratory at Panama City.

In their report on diatoms, Saunders' group noted that *Skeletonema costatum* was the most common and abundant species recorded. For all species, cell counts numbered more than 1,000 per ml sample, and averaged on the order of 10,000 cells per ml in the period of greatest abundance from January through October. Working on dinoflagellates, Steidinger's team found that cell counts were generally less than 20,000 per l in unpolluted waters. However, during plankton blooms they recorded much higher numbers at Boca Grande (September), and off Sanibel Island (January).

Phytoplankton comprise another group of photosynthetic plants which produce oxygen and organic matter essential for animal respiration and nutrition. Based on data presented by May (1966), and Steidinger (1973), net primary production by microalgae in the Charlotte Harbor estuary amounts to about 25 g of dry organic matter per m^2 per yr—a figure that compares quite favorably with estimates from highly productive fresh and marine waters throughout the world.

ZOOPLANKTON AND PLANKTONIC LARVAE—Apart from the study of fish eggs and larvae, and juvenile crustaceans reported by Finucane (1966), the only systematic study of zooplankton and meroplankton for this estuary is the unpublished one filed at Panama City by McNulty, Lindall, and Anthony. In the latter report, authors list 27 categories of invertebrate plankters as well as separate listings for fish eggs and fish larvae. Respective totals for 12 mo showed that more than 100 larvae were netted in each of the following groups:

Portunid crabs (178)	Copepods (7,911)
Miscellaneous brachyuran crabs (606)	Barnacles (1,927)
Miscellaneous shrimps (377)	Gastropods (256)
Miscellaneous anomuran crustaceans (310)	Chaetognaths (160)
Cladocerans (6,850)	Miscellaneous fish eggs (278)

In terms of seasonal abundance, sums of monthly figures for each group showed that around 1,000 or more plankters were present in samples collected during June (923), February (1,267), December (2,816), October (5,080), and September (7,823). Since many members of the zooplankton depend on microscopic algae for food, it is not surprising to find that September and October were also found to be months of peak phytoplankton abundance in Charlotte Harbor estuary (Saunders et al., 1967; Steidinger et al., 1967).

INVERTEBRATES AND INVERTEBRATE FISHERIES—To date, there has been no systematic study of invertebrates throughout the Charlotte Harbor region. Even so, since about 1958, nearly 200 species have been reported in a variety of studies by the Florida State Board of Conservation (1959b), Woodburn (1960b, 1960c, 1961a, and 1961b), Gunter and Hall (1965), Connell Associates, Inc. (1972), and McNulty, Lindall, and Anthony.

The only quantitative investigation of invertebrates was the one by Morrill's students on natural bottoms at Devilfish Key. Working in the sea grass zone with a 1/64 m^2 plug sampler and 0.7 mm mesh screen, they recorded an ave of 10 species and 44 individuals from the shoal grass zone and 11 species and 28 individuals from the turtle grass zone. Taxonomic analysis of samples provided a list of 29 mollusks, 5 polychaetes, 1 sipunculid, 2 echinoderms, and 5 crustaceans.

As adults some invertebrates are harvested in commercial fisheries, and at some time in life they are all part of food webs that lead to the production of food and industrial fishes. In this estuary invertebrates taken directly in the commercial catch include pink shrimp *(Penaeus duorarum)*, stone crab (*Menippe mercenaria)*, blue crab (*Callinectes sapidus)*, oyster (*Crassostrea virginica)*, hard clam (*Mercenaria campechiensis)*, and bay scallop (*Argopecten irradians concentricus)*. Taken for food as well as bait, the pink shrimp is by far the most important invertebrate harvested in terms of both money and poundage.

In 1972, statistical data from local ports showed that total invertebrate landings amounted to more than 5.8 million lb and had a dockside value of over $4,500,000 (Florida Department of Natural Resources, 1973). No doubt this amount of production would be increased significantly if oysters could be taken from the 25,300 acres of water area now closed to shellfishing because of pollution (McNulty et al., 1972).

FISHES AND SPORT AND COMMERCIAL FISHERIES—As early as 1959, the Florida State Board of Conservation began systematic studies of fishes in Charlotte Harbor estuary as part of ecological surveys related to coastal development proposals. In that year more than 20 species were recorded from the vicinity of Sanibel Island and Piney Point (Florida State Board of Conservation, 1959a and 1959b). The following year additional fishes were listed from surveys in Pine

Island Sound, and at Regla Island and Port Charlotte (Woodburn, 1960a, 1960b, and 1960c). The report from Port Charlotte listed more than 40 fishes, and was one of the first state supported studies that emphasized many of the ecological dangers associated with unregulated coastal modifications. In the same year, Phillips and Springer (1960), studied fishes in the Caloosahatchee River and adjacent estuarine waters, where they recorded 46 species. They also found that lower reaches of the river were an important nursery area for red drum (*Sciaenops ocellatus*), and that catches containing the greatest number and variety of fishes generally came from areas of relatively high salinity in San Carlos Bay. In 1961, further work included studies of fishes around Little Pine Island and inside Gasparilla Island (Woodburn, 1961a and 1961b).

Three major papers on fishes of the estuary appeared in 1965. The one by Clark and von Schmidt (1965), provided data on 16 species of sharks taken from estuarine and nearshore waters; Finucane (1965), reported on 89 fishes collected from Charlotte Harbor proper and Pine Island Sound; and Gunter and Hall (1965), listed 94 species collected at a large number of stations in both fresh and saline waters from the Caloosahatchee River to the Gulf of Mexico. Finucane noted that the bay anchovy (*Anchoa mitchilli*), was the most common fish in brackish waters of Charlotte Harbor proper, while the pinfish (*Lagodon rhomboides*), proved to be the dominant species in more saline waters of Pine Island Sound. He also showed that summer and fall were seasons when fishes appeared in greatest variety and abundance. Furthermore, together with Gunter and Hall, he confirmed earlier observations that the estuary is an extremely valuable nursery ground for fishes of importance in both sport and commercial fisheries.

The next, and perhaps most important ichthyological investigation, was done by Wang and Raney (1971). They surveyed the entire estuary and recorded 125 fishes. In addition, they reviewed all previous reports, as well as collections in the Mote Marine Laboratory, and compiled a composite list of fishes for the estuary that contained 246 species. These authors also concluded that the bay anchovy and pinfish are the most common fishes in the complex, and in order of lesser abundance they ranked the following additional species: silver perch (*Bairdiella chrysura*), pigfish (*Orthopristis chrysopterus*), silver jenny (*Eucinostomus gula*), and sand seatrout (*Cynoscion arenarius*). From a comparison of collections at all stations, they also found that the largest resident and migratory fish populations occur in Gasparilla Sound, Placida Harbor, and northern Pine Island Sound. However, even in those areas they found a decline in numbers and kinds of fishes during periods of high river flow (reduced salinity), and in winter when water temperature was low.

McNulty, Lindall, and Anthony took fishes by seine and trawl over a 12 mo period at the northern end of Pine Island near Bookelia in their recent study. The pinfish was the dominant species in their samples, and they found that the time of greatest overall fish abundance was the 6 mo period from April through September.

Many of the species reported in studies referred to above are harvested in sport and commercial fisheries of the estuary. The most highly prized sport fishes include tarpon (*Megalops atlantica*), snook (*Centropomis undecimalis*), sheepshead (*Archosargus probatocephalus*), spotted seatrout (*Cynoscion nebulosus*), gray snapper (*Lutjanus griseus*), and red drum (*Sciaenops ocellata*).

Among the commercially important species there are at least 18 that have an annual dockside value in excess of $1,000 (Heald, 1970), and in terms of poundage, the most important species include mullet, spotted seatrout, groupers, king and spanish mackerels, red drum, mojarra, pompano, and jacks (Florida Department of Natural Resources, 1973). For the entire estuary, the annual harvest of finfish amounts to about 15.9 million lb, and has a dockside value of approximately $3,000,000. Based on rough estimates, the catch of sportfishes amounts to between one-third and one-half of the poundage reported for commercial species, but money spent by sportfishermen probably equals or exceeds the annual wholesale value of commercial fishes (Taylor et al., 1973). Obviously, this level of natural production represents an extremely important natural resource. However, as Lindall (1973), pointed out, regional fisheries for both sport and commercial species may be seriously degraded by estuarine modifications in the form of drainage projects, domestic and industrial pollution, pesticide contamination, thermal additions, and dredging and filling.

AMPHIBIANS, REPTILES, BIRDS, AND MAMMALS—As yet, no surveys have been made of amphibians and reptiles that inhabit the Charlotte Harbor subarea, and even though no report on birds is available, Oliver Hewitt (personal communication) of the Mote Marine Laboratory has recorded some 300 species from records and personal observations. More than 80 of these are closely associated with marine and estuarine habits (Woolfenden and Schreiber, 1973).

In addition to a large number of terrestrial mammals, six marine species have been recorded from estuarine and nearshore Gulf waters of the subarea. The marine forms include the bottlenosed dolphin (*Tursiops truncatus*), short-finned pilot whale (*Globicephala macrorhyncha*), sperm whale (*Physeter catodon*), antillean beaked whale (*Mesoplodon europaeus*), California sea lion (*Zalophus californianus*), and the manatee (*Trichechus manatus litirostris*). Of these, the manatee is the most vulnerable to manmade environmental changes as it seldom moves far from shore (Caldwell and Caldwell, 1973).

LITERATURE CITED

ALBERTS, J., A. HANKE, AND R. HARRISS. 1969. Studies on the geochemistry and hydrography of the Charlotte Harbor estuary. Mote Marine Laboratory, Sarasota. 6 pp.

———, R. HARRISS, A. HANKE, AND H. MATTRAW. 1970. Studies on the geochemistry and hydrography of the Charlotte Harbor estuary, Florida. Mote Marine Laboratory. Sarasota. 34 pp.

BROOKS, H. K. 1973. Geological oceanography. pp. IIE–1—IIE–49. *In* JONES, J. I., et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico, 1973. Martin-Marietta Aerospace. Orlando.

CALDWELL, D. K., AND M. C. CALDWELL. 1973. Marine mammals of the eastern Gulf of Mexico. pp. III-I-1—III-I-24. *In* JONES, J. I. et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico, 1973. Martin-Marietta Aerospace. Orlando.

CARLSON, P. R. 1970. Patterns of succession on spoil islands: a summary report. Nat. Sci. Found. Grant GY-9170. Washington, D. C. iv + 114 pp.

CLARK, E., AND K. VON SCHMIDT. 1965. Sharks of the central gulf coast of Florida. Bull. Mar. Sci. 15:13-83.

CONNELL ASSOCIATES, INC. 1972. Environmental assessment study, Punta Gorda Isles, Inc. Punta Gorda, Florida. Connell Associates, Inc. Miami. xv + 129 pp.

CORCORAN, E. F. 1973. Chemical oceanography. pp. IIC-1—IIC-7. *In* JONES, J. I. et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico, 1973. Martin-Marietta Aerospace. Orlando.

DAVIS, C. C. 1950. Observations of plankton taken in marine waters of Florida in 1947 and 1948. Quart. J. Florida Acad. Sci. 12:67-103.

DAWES, C. J. 1967. Marine algae in the vicinity of Tampa Bay, Florida. Contrib. No. 27. Dept. Botany and Bacteriology. Univ. South Florida. Tampa. 105 pp.

DRAGOVICH, A., J. H. FINUCANE, AND B. Z. MAY. 1961. Counts of red tide organisms, *Gymnodinium breve*, and associated oceanographic data from the Florida west coast, 1957-59. U. S. Fish Wildl. Serv. Spec. Sci. Rept. Fish. No. 369:i-iii; 1-175.

————, J. A. KELLY, JR., AND J. H. FINUCANE. 1966. Oceanographic observations of Tampa Bay, Charlotte Harbor, Pine Island Sound, Florida, and adjacent waters of the Gulf of Mexico, February 1964 through February 1965. U. S. Fish Wildl. Serv. Data Rept. 13:i-ii; 1-72.

————, ————, AND H. G. GOODELL. 1968. Hydrological and biological characteristics of Florida's west coast tributaries. U. S. Fish Wildl. Serv. Fish. Bull. 66:463-477.

EARLE, S. E. 1969. Phaeophyta of the eastern Gulf of Mexico. Phycologia 7:71-254.

FINUCANE, J. H. 1965. Faunal production project. pp. 12-14. *In* SYKES, J. E. (ed.) Report of the Bureau of Commercial Fisheries Biological Laboratory, St. Petersburg Beach, Florida, Fiscal Year 1966. U. S. Fish Wildl. Serv. Circ. 257.

————. 1966. Faunal production project. pp. 18-22. *In* SYKES, J. E. (ed.) Report of the Bureau of Commercial Fisheries Biological Station, St. Petersburg Beach, Florida, Fiscal Year 1965. U. S. Fish Wildl. Serv. Circ. 242.

————, AND A. DRAGOVICH. 1959. Counts of the red tide organism, *Gymnodinium breve*, and associated oceanographic data from Florida west coast, 1954-57. U. S. Fish Wildl. Serv. Spec. Sci. Rept. Fish. No. 289. 220 pp.

FLORIDA BOARD OF CONSERVATION. 1967. Red tide studies, Pinellas to Collier Counties, 1963-1966, a symposium. Florida Bd. Conserv. Mar. Lab. Prof. Paper Ser. No. 9:i-v; 1-141.

FLORIDA COASTAL COORDINATING COUNCIL. 1972. Florida coastal zone management atlas. Florida Coastal Coord. Council. Tallahassee.

FLORIDA DEPARTMENT OF NATURAL RESOURCES. 1973. Summary of Florida commercial marine landings. Florida Dept. Nat. Resour. Div. Mar. Resour. Bur. Mar. Sci. Tech. 62 pp.

FLORIDA STATE BOARD OF CONSERVATION. 1959a. Abraham Zemel-Piney Point (Lee County) bulkhead line survey. Florida State Bd. Conserv. Mar. Lab. 7 pp.

————. 1959b. Tarpon Bay, Sanibel I. bulkhead survey (Lee County). Florida State Bd. Conserv. Mar. Lab. 6 pp.

GUNTER, G., AND G. E. HALL. 1965. A biological investigation of the Caloosahatchee estuary of Florida. Gulf Res. Rept. 2:1-72.

HEALD, E. J. 1969. The production of organic detritus in a south Florida estuary. Ph.D. Dissertation, Univ. Miami. Coral Gables.

————. 1970. Fishery resources atlas II west coast of Florida to Texas. Univ. Miami Sea Grant Tech. Bull. No. 4:i-vi; 1-174.

HILSENBECK, R. A., AND P. C. HILSENBECK. [undated] Mullet Key: A floristic study. Unpublished Rept. Dept. Botany and Bacteriology. Univ. South Florida. Tampa.

HUANG, T. C. 1966. A sedimentologic study of Charlotte Harbour, southwestern Florida. M. S. Thesis. Florida State Univ. Tallahassee.

————, AND H. G. GOODELL. 1967. Sediments of Charlotte Harbour, southwestern Florida. J. Sed. Petrology 5:449-474.

HUMM, H. J. 1973a. Salt marshes. pp. IIIA-1—IIIA-6. *In* JONES, J. I. et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico, 1973. Martin-Marietta Aerospace. Orlando.

————. 1973b. Mangroves. pp. IIID-1—IIID-6. *In* JONES, J. I. et al. (eds.). A summary of knowledge of the eastern Gulf of Mexico, 1973. Martin-Marietta Aerospace. Orlando.

————. 1973c. Benthic algae of the eastern Gulf of Mexico. pp. IIIB-1—IIIB-16. *In* JONES, J. I. et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico, 1973. Martin-Marietta Aerospace. Orlando.

————. 1973d. Seagrasses. pp. IIIC-1—IIIC-10. *In* JONES, J. I. et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico, 1973. Martin-Marietta Aerospace. Orlando.

JONES, J. I., R. E. Ring, M. O. RINKEL, AND R. E. SMITH (eds.). 1973. A Summary of Knowledge of the Eastern Gulf of Mexico. Martin Marietta Aerospace. Orlando.

JORDAN, C. L. 1973. Climate. pp. IIA-1—IIA-22. *In* JONES, J. I. et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico, 1973. Martin-Marietta Aerospace. Orlando.

KING, J. E. 1950. A preliminary report on the plankton of the west coast of Florida. Quart. J. Florida Acad. Sci. 12:109-137.

LAKELA, O., AND R. W. LONG. 1970. Plants of the Tampa Bay area. Dept. Botany and Bacteriology. Univ. South Florida. Tampa. vii + 109 pp.

LA ROCK, P., AND H. L. BITTAKER. 1973. Chemical data of the estuarine and nearshore environments in the eastern Gulf of Mexico. pp. IIC-8—IIC-86. *In* JONES, J. I. et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico, 1973. Martin-Marietta Aerospace. Orlando.

LINDALL, W. N., JR. 1973. Alterations of estuaries of south Florida: A threat to its fish resources. Natl. Mar. Fish. Serv. Mar. Fish. Rev. 35:26-33.

MARTIN, D. F., M. T. DOIG, III, AND R. H. PIERCE, JR. 1971. Distribution of naturally occurring chelators (humic acids) and selected trace metals in some west Florida streams, 1968-1969. Florida Dept. Nat. Res. Mar. Res. Lab. Prof. Paper Ser. 12:i-vii; 1-52.

MAY, B. Z. 1966. Chemical environment project. pp. 15—17. *In* SYKES, J. E. (ed.) Report of the Bureau of Commercial Fisheries Biological Station, St. Petersburg Beach, Florida, Fiscal Years 1962-1964. U. S. Fish Wildl. Serv. Circ. 239.

McNULTY, J. K., W. N. LINDALL, JR., AND J. E. SYKES. 1972. Cooperative Gulf of Mexico estuarine inventory and study, Florida: Phase I, Area Description. Natl. Mar. Fish. Serv. Circ. 368:i-vii; 1-126.

ODUM, E. P. 1961. The role of tidal marshes in estuarine production. The Conservationist (New York), June-July, 1961:12-61.

PHILLIPS, R. C., AND V. G. SPRINGER. 1960. A report on the hydrography, marine plants, and fishes of the Caloosahatchee River area, Lee County, Florida. Florida State Bd. Conserv. Mar. Lab. Spec. Sci. Rept. 5:1-34.

ROSS, B. E. 1973. The hydrology and flushing of the bays, estuaries, and nearshore areas of the eastern Gulf of Mexico. pp. IID-1—IID-45. *In* JONES, J. I. et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico, 1973. Martin-Marietta Aerospace. Orlando.

SAUNDERS, R. P., B. I. BIRNHAK, J. T. DAVIS, AND C. L. WAHLQUIST. 1967. Seasonal distribution of diatoms in Florida inshore waters from Tampa Bay to Caxambas Pass, 1963-1964, pp. 48—78. *In* Red tide studies, Pinellas to Collier Counties, 1963-1966, a symposium. Florida Bd. Conserv. Mar. Lab. Prof. Paper Ser. No. 9.

STEIDINGER, K. A. 1973. Phytoplankton. pp. IIIE-1—IIIE-17. *In* JONES, J. I. et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico, 1973. Martin-Marietta Aerospace. Orlando.

———, J. T. DAVIS, AND J. WILLIAMS. 1967. Dinoflagellate studies on the inshore waters of the west coast of Florida. pp. 4—47. *In* Red tide studies, Pinellas to Collier Counties, 1963-1966, a symposium. Florida Bd. Conserv. Mar. Lab. Prof. Paper Ser. No. 9.

TAYLOR, J. L., D. L. FEIGENBAUM, AND M. L. STURSA. 1973. Utilization of marine and coastal resources. pp. IV-1—IV-63. *In* JONES, J. I. et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico, 1973. Martin-Marietta Aerospace. Orlando.

TAYLOR, J. L., AND C. H. SALOMAN. 1968. Some effects of hydraulic dredging and coastal development in Boca Ciega Bay, Florida. U. S. Fish Wildl. Serv. Fish. Bull. 67:213-241.

TEAL, J. M. 1962. Energy flow in the salt marsh ecosystem of Georgia. Ecology 43:614-624.

WANG, J. C. S., AND E. C. RANEY. 1971. Distributions and fluctuations in the fish fauna of the Charlotte Harbor estuary, Florida. Mote Marine Laboratory, Sarasota. 56 pp.

WOODBURN, K. D. 1960a. Charlotte County survey with special reference to Port Charlotte sports fishery. Florida State Bd. Conserv. Mar. Lab. 24 pp.

———. 1960b. Northernmost McKeever Key bulkhead survey (Lee County). Florida State Bd. Conserv. Mar. Lab. 3 pp.

———. 1960c. Pine Island Sound (Regla Island and vicinity north) bulkhead survey—Lee County. Florida State Bd. Conserv. Mar. Lab. 6 pp.

———. 1961a. Little Pine Island bulkhead survey (Lee County). Florida State Bd. Conserv. Mar. Lab. 9 pp.

———. 1961b. Bulkhead survey in various sections of township 43, range 20 (Gasparilla Island, Lee County). Florida State Bd. Conserv. Mar. Lab. 8 pp.

WOOLFENDEN, G. E., AND R. W. SCHREIBER. 1973. The common birds of the saline habitats of the eastern Gulf of Mexico: their distribution, seasonal status, and feeding ecology. pp. IIIJ-1—IIIJ-21. *In* JONES, J. I. et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico, 1973. Martin-Marietta Aerospace. Orlando.

Florida Sci. 37(4):205-216. 1974.

TAMPA BAY ESTUARINE SYSTEM—A SYNOPSIS

JOSEPH L. SIMON

Department of Biology, University of South Florida, Tampa, Florida 33620

ABSTRACT: *The tremendous surge in population and development in the area has placed a severe strain on the System which is comprised of five contiguous areas—1) Old Tampa Bay, 2) Hillsborough Bay, 3) Tampa Bay, 4) Boca Ciega Bay, and 5) Terra Ceia Bay. The System extends over some 346 square miles and includes 212 miles of shoreline. Coliform bacteria counts in Old Tampa Bay and Hillsborough Bay have been high enough to justify limiting contact sports and shellfishing. Water quality is affected by discharges from 55 sewage treatment plants, more than 90 industries and over 100 marinas. Primary productivity is among the highest in the world. A great diversity of marine life is present from both temperate and tropical regions. Projects in progress or proposed threaten every part of the System and a means for proper management must be established to avoid a degradation of its waters.*

PERHAPS the first European to see Tampa Bay was Ponce de Leon in June, 1513 (Lohse, et al., 1969). He was followed by a succession of Spanish explorers during the 1500's—notably Hernando de Soto, who landed in Tampa Bay in 1539. It took until 1821 before the United States acquired Florida from the Spanish and shortly thereafter founded Fort Brook at what is now downtown Tampa. Until that time, Indians dominated the scene. It is said that the name "Tampa" is from the Seminole language and means "plenty of split wood for quick fires" (Lohse, et al., 1969). If the Indians were to return today, they might have used a different word to describe the area.

Modern Tampa was started by Henry B. Plant, who brought railroads, steamship lines and industry to Tampa in the 1880's. Since then, Tampa has become the chief port and major industrial center of the Florida West Coast. The Port of Tampa has become the largest shipping port in the State, moving over 36 million tons of goods (50% of the State's total) during 1971, and over 40 million tons having a value of over $490 million in 1972 (Corps of Engineers, 1974).

Growth in the tri-county area (Pinellas, Hillsborough, and Pasco) surrounding Tampa Bay has been rapid over the past decade. Between 1960 and 1972, the population of the Tampa-St. Petersburg area grew from 809,000 to 1,219,000 (Tampa TRIBUNE, Feb. 24, 1974), to the point where the area now holds about one-sixth of Florida's total population. Pinellas County, with a population of more than 500,000 is the most densely populated county in Florida—2,000 people per sq mile. In addition to a high resident population, about 3 million tourists vacation in the Tampa Bay area each year. Tourism forms the largest source of income in the Tampa Bay area, more than $800 million per year. The combination of resident and tourist populations, and the tremendous surge in development (the subject of a recent CBS "60-Minutes Special") put severe stresses on the ability of the municipalities to provide basic needs, water, sewage, roads, schools, etc., and as a result, talk of building moratoria, etc., are rampant both at the local and state levěls.

The tremendous surge in population growth and subsequent accompanying strain on the environment can be well documented in the effects on Tampa Bay—the geographic feature responsible for shipping, industrial development, and the attractiveness of the area to population influx. Tampa Bay is rapidly becoming the "septic tank for the megalopolis", threatening to become a liability instead of the area's main asset.

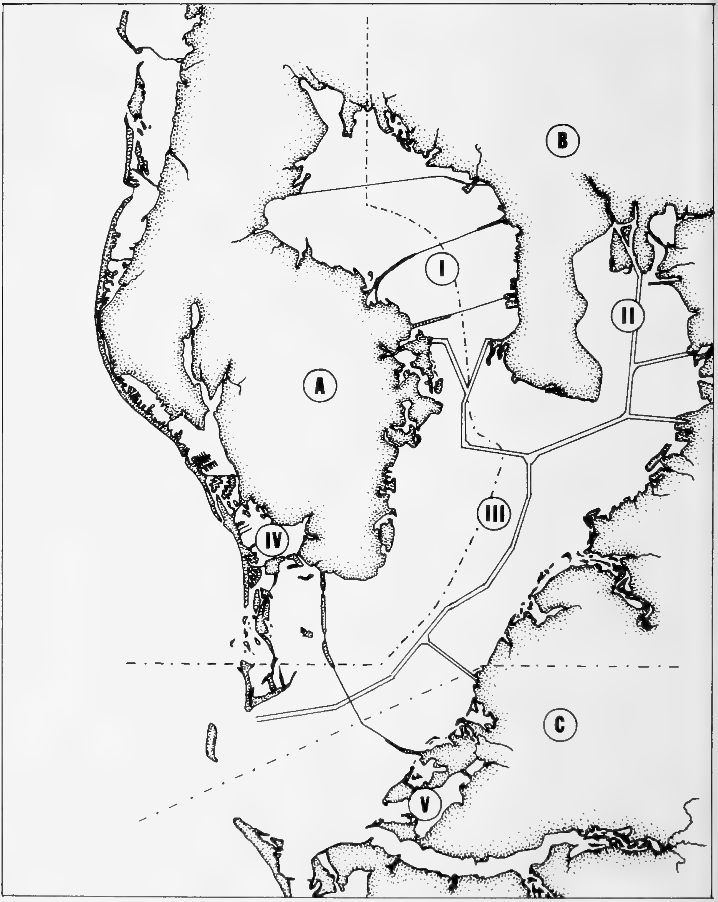

Fig. 1. The Tampa Bay Estuarine System. I. Old Tampa Bay; II. Hillsborough/MacKay Bay; III. Tampa Bay Proper; IV. Boca Ciega Bay; V. Terra Ceia Bay. A. Pinellas County; B. Hillsborough County; C. Manatee County. Major shipping channels are indicated within the Bay System.

THE TAMPA BAY ESTUARINE SYSTEM—*Description:* The Tampa Bay Estuarine System (Fig. 1), located on the west central coast of the Florida peninsula, can be divided into five sub-areas:

1) Old Tampa Bay
2) Hillsborough/MacKay Bay
3) Tampa Bay Proper (often subdivided into upper and lower, on the basis of differing salinity regimens)
4) Boca Ciega Bay
5) Terra Ceia Bay

The system forms a roughly Y-shaped configuration 35 miles long by about 10 miles wide, encompassing 346 sq miles total surface area with a shoreline of about 212 statute miles (Olson and Morrill, 1955). Various morphometric features of the Bay System Complex are summarized in Table 1.

TABLE 1. Morphometric features of the Tampa Bay System (modified from Olson and Morrill, 1955).

	Old Tampa Bay	Hillsborough Bay	Tampa Bay	Boca Ciega Bay	Total
Length (mi)	13	9	—	—	35
Ave Width (mi)	2-6	4.5	7-10	—	9.9
Area (sq mi)	78.3	40.4	200.4	21.5	340.6
Volume (cu miles)	—	—	—	—	0.687
Max. Depth (ft)	36	18	42	—	57
Mean Depth (ft)	—	—	—	—	11
Modal Depth (ft)	8	7	14	?2	9.7
Length of Shoreline (mi)	54	34.7	99	—	—
% of Total System	20	10	57	8	100

Tampa Bay is a shallow body of water, having a mean depth of 11 ft (modal depth of 9.7 ft), a maximum depth of 57 ft (channel area near bay mouth), with 90% of the area under 22 ft (Olson & Morrill, 1955).

Channels. As an important port of commerce, Tampa Bay is riddled with permanent navigation channels (Fig. 1, Table 2). A total of 42 nautical miles of channels with designed mean low water depths between 20 and 36 ft are present.

The main ship channel was first dredged in the 1880's and is now maintained by the Corps of Engineers at a depth of 34 ft and width of 400 ft. The channel

TABLE 2. Main navigation channels in the Tampa Bay Complex (Corps of Engineers, 1974).

	Depth (ft)	Width (ft)
Egmont Bar Cut	36	600
Mullet Key Cut	34	500
Tampa Bay & Hillsborough Channels	34	400
Port Sutton Channel	34	280
Port Tampa Channels	34	400
Branch Channels		
Sparkman	34	400
Ybor	34	400
Seddon	30	300
Gannon	30	300
Alafia	30	200

provides access to Port Manatee, Port Tampa, Port Sutton, the Alafia River, a number of electrical power generation stations, and Tampa Harbor. It should be noted that just a few months ago the Federal Government released $900,000 for the first phase of the Harbor Deepening Project, a venture of the Tampa Port Authority and the Army Corps of Engineers, to deepen and widen the main shipping channels. The Draft Environmental Impact Statement on the project was released in February, 1974.

Bridges & Causeways. Table 3 summarizes the major bridges and causeways in the Tampa Bay System.

TABLE 3. Major causeways and bridges in the Tampa Bay System (modified from Lohse et al., 1969).

	Length (yd)	Number of Openings	Total Open Space (yd)
OLD TAMPA BAY			
Courtney Campbell Causeway	14,000	2	1,200
W. Howard Franklin Bridge	12,500	1	5,350
Gandy Bridge	7,800	1	4,600
HILLSBOROUGH/MCKAY BAYS			
22nd Street Causeway	1,850	1	450
TAMPA BAY			
Sunshine Skyway	19,000	3	8,200
BOCA CIEGA BAY			
Pinellas Bayway	10,500	2	800

Tributaries. The freshwater drainage basin surrounding Tampa Bay covers an area of about 2,162 sq miles, and includes the major tributaries as cited in Table 4. About 138 million cu ft/day or 1 billion gal of freshwater daily flow into Tampa

TABLE 4. Tributaries entering the Tampa Bay System (modified from Corps of Engineers, 1974).

	Watershed Area (sq mi)	Mean Discharge (cfs)
OLD TAMPA BAY		
Sweetwater Creek	29.5	25
Rocky Creek	38.2	45
Double Branch Creek	19.2	40
Brookers Creek	68.3	28.6
Additional Area	117.1	ND
HILLSBOROUGH BAY		
Hillsborough River	646.4	671
Palm River	45.2	62
Alafia River	418.2	384
Additional Area	124.4	ND
TAMPA BAY		
Little Manatee River	202.2	186
Manatee River	365.3	109
BOCA CIEGA BAY	65.3	ND
TOTAL	2,235	1,550

Bay, with peak periods of stream flow corresponding to periods of greatest rainfall (summer and fall).

None of the streams entering the estuary carry appreciable quantities of sediments or detritus. However, the quantities of dissolved substances added to the estuary by tributaries is considerable. Depending on composition and concentration, dissolved materials have a marked influence on hydrological and biological characteristics of the system (Dragovich and May, 1962; Dragovich, et al., 1968; Martin, et al., 1971; McNulty, et al., 1972).

Gulf Opening. Coastal currents converge at the constricted entrance to Tampa Bay. North of the bay mouth, a series of islands formed by a littoral drift with a net southerly flow, almost close the mouth. To the south, a net northerly littoral drift forms Anna Maria Key. Thus, the entrance to the bay from the Gulf results in reduced estuarine tidal exchange (Olson and Morrill, 1955). Considerable beach erosion and, thus, the necessity of beach nourishment projects more or less continually on the Gulf Beaches, are an outcome of the littoral drift. The main tidal connections between Tampa Bay and the Gulf are the passes between Egmont Key and Mullet Key, forming Egmont Channel (approximately 1.5 miles wide with a depth of 30-70 ft) and the Southwest Channel located between Egmont Key and Anna Maria Key (3.0 miles wide with an aver depth of 21 ft and an extensive shoal area to the south adjacent to Passage Key). Two supplementary tidal passes, Pass-a-Grille and Bunces Passes connect Boca Ciega Bay to the Gulf.

Climate. The Tampa Bay area has a subtropical climate with average yearly temperatures about 22°C (72°F). During the summer months, air temperatures are normally under 28°C (82°F), but temperatures of 38°C (100°F) and higher have been recorded. Winter temperatures seldom drop below 12°C (54°F), although a few nights of subfreezing temperatures are usually recorded each winter, and record low of –7.7°C (18°F) has been recorded (Federal Water Pollution Control Administration = FWPCA, 1969; Jordan, 1973).

Rainfall averages about 51 in annually, with 60% falling between June and September. Much of the rainfall is accompanied by severe thunderstorms with high wind velocities. Aperiodic hurricanes have been reported to cause severe flooding of low lying areas. Various climatological parameters of the Bay area are summarized in Table 5.

TABLE 5. Climatological parameters for the Tampa Bay Region.

	Annual Ave	Maximum	Minimum
Rainfall (in)	51	76.5	29
Wind (kn)*	ND	10	7
Evaporation (in)	64		
Air Temperature (°F)	71.8	100+	18

*exclusive of hurricanes and storms.

PHYSICAL/CHEMICAL PARAMETERS—The Tampa Bay Estuarine System is one of the best studied bays in the world. Water chemistry has been documented since 1946 (Williams, 1954). The review of Olson and Morrill (1955) summarized data, and Hutton, et al. (1956) added further information. Since 1957, the National Marine Fisheries Service has supplied a continuous record of many parameters including temperature, salinity, phosphorus, nitrogen, pH, dissolved oxygen, turbidity, transparency, chlorophyll, carotenoid pigments, primary productivity, along with limited data on other parameters (Taylor and Saloman, 1968a; Saloman and Taylor, 1968, 1971a, b, 1972; McNulty, et al., 1972; Lindall, et al., 1973; Saloman, 1973a, b). Supplementary parameters have been added by the Florida Department of Natural Resources and various theses and dissertations (Stewart, et al., 1967; Taylor, 1971; Hall, 1972; Santos, 1972; Virnstein, 1972; Dauer, 1974; Turner and Hopkins, 1974). More recently, studies supported by Florida Power Corporation and Tampa Electric Company have provided additional data for waters adjacent to power generation stations in the Bay (Blake, et al., 1973). Additionally, for several years, the Hillsborough County Environmental Protection Commission (EPC) has been sampling 96+ stations throughout the Bay on a routine monitoring program (Shaw, 1972). Other agencies which collect hydrological information include the Pinellas and Manatee County Health Departments, U. S. Geological Survey (USGS), the University of Florida (UF), the University of South Florida (USF), and the Florida Department of Pollution Control (FDPC).

In connection with preparations for the Tampa Harbor Deepening Project, an extensive series of measurements of physical, chemical and geological parameters have been made by the U. S. Geological Survey under contract with the Corps of Engineers. This information has recently been made available in the form of a Draft Environmental Impact Statement (Corps of Engineers, 1974).

Tides: The tides of Tampa Bay may be classified as mixed—a combination of diurnal and occasional semi-diurnal components. The average tidal range is 2.3 ft, with a range about 3.5 ft to 0.2 ft or less (Corps of Engineers, 1974). The tidal heights are greatly influenced by wind direction and velocity, being elevated by strong winds from the southwest and reduced by gales from the northeast. The tidal lag from the mouth to the head of the bay is generally on the order of 4 hr. During the Corps of Engineers studies, a tidal gage network was established, simultaneously monitoring tidal heights at 12 stations every 5 min (information should be published shortly). Extreme tide conditions associated with hurricanes or tropical disturbances of magnitude are summarized in Table 6.

TABLE 6. Major hurricane and storm tide heights reported for the Tampa Bay System (Corps of Engineers, 1974).

Date	Tidal Height (ft)	Date	Tidal Height (ft)
September, 1848	14	October, 1946	3.3
October, 1848	9	August, 1949	3.9
September, 1919	5+	September, 1950	5.6
October, 1921	9.6	August, 1964	1-3
September, 1926	3.6	June, 1966	3-5
September, 1929	3.1	October, 1968	4-6
September, 1935	4.4	June, 1972	3-5
November, 1935	4-5		

Currents: Until recently, detailed knowledge of the complex current patterns in Tampa Bay were unavailable. With the past few years, at least three separate groups (Ross and Anderson, USF; USGS; Deans, UF) have constructed mathematical models of the currents within the Bay system. Only Ross (1973) has published data from his model, although limited information is available on the USGS Model (Corps of Engineers, 1974). In general, maximum currents exist at the mouth of the bay (in excess of 6.0 ft/sec on ebb tide; under 3.5 ft/sec during flood tides) and current velocities decrease markedly as one approaches the head of the bay system, such that in Hillsborough Bay and the northern parts of Old Tampa Bay currents of less than 10% of those at the bay mouth are observed. The pattern of circulation in the lower portion of the Bay has a net counterclockwise circulation, with the floodflow being concentrated toward the eastern side. The major component of the outflow, especially from Old Tampa Bay, is directed towards the western shore during ebb flow. Little circulation is apparent in Hillsborough Bay, which serves as a trap for the effluents entering from both municipal and industrial outfalls, as well as the Hillsborough River. This 'sink' for pollutants will become obvious in examining the chemical and biological parameters within the bay system.

Salinity: From the many recent studies, some over considerable time periods (including the National Marine Fisheries Service and Hillsborough County Environmental Protection Commission (EPC), the average annual salinity for the Bay system is 29.5‰. Means and ranges for various subareas are indicated in Table 7. The salinity gradient from the head to the mouth of the bay is gradual, and is affected markedly by seasonal weather conditions (e.g., rainfall amounts and runoff levels). Upper Old Tampa Bay and Hillsborough Bay have the lowest salinities due to the influx of freshwaters from various streams, creeks, and sewage treatment plants (McNulty, et al., 1972). Vertical salinity gradients have not been well documented. The greatest known vertical gradient showed salinity of 1.4‰ at the surface and 20.5‰ at the bottom (Finucane and Dragovich, 1966).

pH: Annually, the pH average for Tampa Bay waters is about 8.0 (Corps of Engineers, 1974) with little seasonal or geographic variation. The mean values (for 1962) and ranges for sub-areas are indicated in Table 8. More variation in pH has been recently reported by the EPC (1972), with a low value of pH 6.5 (for Alafia River Channel) and a high value of 9.5 (for Bishop's Harbor). Taft and Martin

TABLE 7. Mean and ranges for observed salinities in the Tampa Bay System (modified from Corps of Engineers, 1974).

	Mean (ppt)	Range (ppt)
Old Tampa Bay	22.5	0.9-30.3
Hillsborough Bay	20.9	7.4-31.9
Tampa Bay		
Upper	24.4	14.0-30.8
Lower	30.1	14.3-35.6
Tampa Bay Entrance	32.2	21.1-36.8
Boca Ciega Bay	31.2	14.5-35.0
Terra Ceia Bay	24.5	1.0-33.7
Offshore	34.1	22.6-39.0

(1974) indicated a pH of 3.2 at 1000 ft off the Gardenier phosphate plant on the eastern shore of Hillsborough Bay, an obvious indication of an industrial effluent having a marked effect, challenging the normally high buffering capacity of marine/estuarine waters.

TABLE 8. pH recorded for the Tampa Bay Complex (Saloman & Taylor, 1972; Corps of Engineers, 1974).

	Mean (pH units)	Range (pH units)
Old Tampa Bay	7.9	6.7-8.4
Hillsborough Bay	7.9	7.2-8.6
Tampa Bay		
Upper	8.0	7.3-8.4
Lower	8.1	7.6-8.4
Boca Ciega Bay	8.1	7.7-8.5
Terra Ceia Bay	7.9	7.6-8.2

Dissolved oxygen (DO): Available data on dissolved oxygen levels within the water column show that the yearly mean for the bay system as a whole is 4.1 ml/1 (5.9 mg/1), with saturation or supersaturation of oxygen occurring at most times and seasons (Table 9). It should be noted lower DO values were obtained during the warmest periods of the year when oxygen solubilities would be the lowest. Generally, DO becomes limiting to aquatic vertebrates and macroinvertebrates at levels about 2 ml/1 (2.8 mg/1). Although many organisms can withstand temporary exposure to lower DO levels, prolonged exposure can lead to fish kills and mass mortalities. Extended periods of low DO and accompanying fish kills have been recorded both within Hillsborough Bay and in blind end canals in Old Tampa Bay and Boca Ciega Bay (FWPCA, 1969; Taylor, et al., 1970; Taylor, 1971; Hall, 1972; Lindall, et al., 1973). In documented cases, the low DO values were associated with pollution sources releasing high BOD materials or with resuspension of anaerobic bottom sediments (the result of dredging operations or stirring up of bottom materials by ship propellers, etc.). Low dissolved oxygen levels have been reported by Dragovich, et al. (1968) in tributaries entering the bay system with pollution being cited as the cause.

TABLE 9. Dissolved oxygen levels recorded for the Tampa Bay System (Saloman & Taylor, 1972; Corps of Engineers, 1974).

	Mean (mg/1)	Range (mg/1)
Old Tampa Bay	6.3	2.7-10.6
Hillsborough Bay	6.4	0.9-11.6
Tampa Bay		
Upper	5.8	1.1- 8.1
Lower	5.7	1.4- 8.5
Boca Ciega Bay	5.4	1.6-10.6
Terra Ceia Bay	5.1	2.1- 7.4

Biochemical Oxygen Demand (BOD): It was not until 1969 (FWPCA) that BOD values were reported within the Tampa Bay complex. However, currently EPC routinely monitors the entire bay for this parameter. Mean and ranges on an annual basis for the various sub-areas of the Bay system are presented in Table 10.

The highest BOD values are reported for Hillsborough Bay. In 1969, the FWPCA data showed that the Technical Oxygen Demand (of intact sediments) ranged from 3 to 200 mg/g throughout Hillsborough Bay. Resuspension of the sediments has been found by Isaac (1965) to increase the oxygen demand by a factor of 8. Later the BOD of effluents currently being added to the sub-areas of the bay system will be examined.

TABLE 10. Biochemical oxygen demand (5 day values) for the Tampa Bay System (Shaw, 1972).

	Mean (mg/1)	Range (mg/1)
Old Tampa Bay	2.3	2.0- 5.0
Hillsborough Bay	3.1	0.8-22.0
Tampa Bay		
Upper	1.7	0.4- 8.5
Lower	1.7	0.4- 4.0
Boca Ciega Bay	1.7	0.4- 4.0
Terra Ceia Bay	1.7	0.4- 4.0

Nitrogen and Phosphorus: Taylor and Saloman (1968a) summarized data for total Kjeldahl nitrogen (N) and total phosphorus (P) available from 1952-1966 in the estuary, documenting the progressive enrichment. Subsequently available data (Saloman and Taylor, 1972; Shaw, 1972) indicate further increases in P, with N remaining at the same levels or decreased slightly. Data for various years and sub-areas of the bay system are presented in Table 11. The detailed analysis of Hillsborough Bay (FWPCA, 1969) indicated the primary source of N was through sewage treatment plants, while the Alafia River was responsible for the majority of the P concentrations. Generally, near the mouth of Tampa Bay, N and P levels are 4-5 times higher than values normal for offshore coastal waters. Within Hillsborough Bay, values are 10 times normal. Although some N and P are flushed into the Gulf by the estuarine circulation patterns, major quantities are accumulated within the estuary, contributing to massive eutrophication well documented in Hillsborough Bay and Boca Ciega Bay (Corps of Engineers, 1974).

TABLE 11. Total Kjeldahl nitrogen (N) and total phosphorus (P) (μg a./1) for the Tampa Bay System (modified from Taylor, 1973).

	1962		1972	
	N	P	N	P
Old Tampa Bay	45.0	23.1	32.1	35.5
Hillsborough Bay	56.6	25.9	37.7	71.0
Tampa Bay				
Upper	37.2	23.4	23.6	38.7
Lower	32.0	8.6	14.3	11.9
Boca Ciega Bay	34.2	7.0	ND	ND
Terra Ceia	ND	ND	ND	ND

Turbidity: Unpublished data on turbidity and water clarity in Tampa Bay assembled by Saloman and Taylor are on file at the National Marine Fisheries Service Laboratory at Panama City. Generally, water clarity increases and turbidity decreases as one moves from the head of the estuary to its mouth (Saloman and Taylor, unpublished; Griffin and Whitney, 1971). Table 12 indicates mean and ranges for turbidity in Jackson Turbidity Units (JTU) for each subarea of the estuarine system. According to Saloman and Taylor (1972) the ave turbidity within the estuary as a whole in 1969 was about 9 JTU. More recent information (Taylor, 1971; Saloman, 1973a; Shaw, 1972; Simon and Dyer, 1972) has indicated that an annual average turbidity within the system varies between 4 and 10 JTU. Locally and seasonally, turbidities may be much higher depending on plankton blooms or storm activity resuspending bottom sediments. The highest recorded turbidity levels in Tampa Bay have been reported within 100 yd of operations associated with the shell dredging industry (Simon and Dyer, 1972; Taylor, 1973a). The effects of turbidity on the system have been reviewed by Simon and Dyer (1972).

TABLE 12. Turbidity values (JTU) recorded for the Tampa Bay System (data collected for 1969 in Taylor and Saloman, 1972).

	Mean (JTU)	Range (JTU)
Old Tampa Bay	7.4	1.4-26.0
Hillsborough Bay	13.7	1.7-74.0
Tampa Bay		
Upper	7.9	1.0-64.0
Lower	10.6	2.1-82.0
Boca Ciega Bay	7.7	2.9-21.5
Terra Ceia Bay	9.8	2.0-68.0
TOTAL COMPLEX	ave @ 9	

Temperature: Water temperatures within the Tampa Bay system average between 22° and 25°C (Table 13). The average temperatures for each season are: summer, 30°C; fall, 23°C; winter, 16°C; spring, 27°C (Taylor, 1971; Saloman and Taylor, 1972; Turner and Hopkins, 1974; Shaw, 1972). The highest recorded temperature within the system was 36.9°C, while the lowest was 4.8°C (Phillips, 1960a; Taylor, 1971).

TABLE 13. Water temperatures recorded for Tampa Bay System (from Saloman & Taylor, 1972).

	Mean (°C)	Range (°C)
Old Tampa Bay	22.6	10.8-32.6
Hillsborough Bay	23.2	11.2-35.1
Tampa Bay		
Upper	22.6	11.8-32.0
Lower	21.5	8.8-32.0
Boca Ciega Bay	22.5	11.2-31.6
Terra Ceia Bay	21.8	12.5-29.6

Trace Metals: Until 1971, no information was available on trace metal concentrations within the waters, sediments, or organisms of Tampa Bay. Since that time, at least five agencies have been gathering such data. Most information has been obtained by the EPC and USGS. The available data is summarized by the Corps of Engineers (1974). The USGS sampled trace metal concentrations in sediments, waters, and selected organisms at various parts of the estuarine system, analyzing for zinc, lithium, cadmium, arsenic, mercury, copper, cobalt, manganese, and chromium. Only lithium exceeded 0.1 mg/1 in water samples. EPC studied the same metals, finding similar results for water samples. For sediments, the USGS data (Corps of Engineers, 1974) are presented in Table 14. Tampa

Electric Company (TECO) has recorded high levels of chromium (0.62 mg/1) off their Big Bend Power Plant (upper Tampa Bay).

TABLE 14. Highest trace metal concentrations (ppm) found in sediments of the Tampa Bay System (modified from Corps of Engineers, 1974).

		Tampa Bay	
Element	Hillsborough Bay	Upper	Lower
As	2.0	8	3.0
Cd	3.0	2	2
Co	8.0	5	6
Cr	18	27	10
Cu	5	9	6
Fe	5900	7600	5200
Hg	0.81	0.50	0.32
Mn	37	47	83
Ni	13	13	16
Pb	61	66	65
Zn	25	25	16

Pesticides & Biocides: To date, only TECO and USGS have analysed water, sediments, or organisms for pesticides. The USGS data are summarized in Table 15. TECO reported pesticide levels in oyster tissues collected in Cockroach Bay (upper Tampa Bay) as indicated in Table 16. Evidence for biological concentration and food chain magnification of pesticides within Tampa Bay system can be seen in the data of Blus et al. (1971) and Schreiber and Riseborough (1972) who examined egg shell thinning in the Brown Pelican. It should be noted that the USGS data indicate PCB concentrations in Hillsborough Bay as high as 10 ppb.

TABLE 15. Highest pesticide levels (ppm) in sediments of Tampa Bay (modified from Corps of Engineers, 1974).

Pesticide	Tampa Bay (upper)	Hillsborough Bay
DDD	.0077	.0002
DDE	.0016	.0002
DDT	.0004	ND
Dieldrin	.0004	ND
PCB's	.015	.0100

TABLE 16. Pesticide levels (ppb) in oyster tissues from Cockroach Bay (Tampa Bay) (modified from Taylor, 1973).

DDE	5
Dilan I	20
Heprachlor and Heptachlor Epoxide	387

BIOLOGICAL CHARACTERISTICS—*Coliform Counts*: In 1969, the FWPCA reported in detail on the fecal coliform bacteria concentrations in Hillsborough Bay, showing that the major source of contamination was the Tampa Sewage Treatment Plant. More recently, EPC has reported on coliform counts at stations throughout Tampa Bay (Shaw, 1972). Since coliform counts are a partial basis for the classification of waters within the estuary, they are important. For 1972, the highest recorded Most Probable Number (MPN)/100 ml was 240,000 at the northeastern end of Courtney Campbell Causeway in upper Old Tampa Bay.

Most of Hillsborough Bay had counts above 3300/100 ml, and indicated that there should be limitation on water contact sports and shellfish harvesting. Almost all of Old Tampa Bay, Hillsborough Bay, and Tampa Bay proper had MPN high enough to make shellfish harvesting hazardous for more than one month of the year (Shaw, 1972). A discussion of the sources of sewage in the bay system follows:

There are 55 sewage treatment plants discharging effluents into the Tampa Bay Complex. Table 17 indicates the various materials added to each subregion by these pollution sources. Of the pollution sources only the Tampa Sewage Treatment Plant offers primary treatment, all others, secondary. Note should be made that construction is underway on a 54 million gallons per day (MGD) advanced treatment system for the City of Tampa. Tampa Bay as a whole receives some 72.8 MGD in wastes. In addition to wastes from sewage treatment plants, 91 industries (ranging from small laundromats to seafood processing plants to oil companies) have requested permits to discharge waste materials into Tampa Bay (Corps of Engineers, 1974). Another significant source of effluents effecting water quality of the Bay are the over 100 marinas located along the shoreline.

TABLE 17. Selected sewage treatment plants and effluent parameters entering the Tampa Bay System (modified from Shaw, 1972).

	Number of Sewage Plants	Average Daily Flow (million gallons)	BOD_{20} load (lbs/yr)	Suspended Solids (lbs/yr)
Old Tampa Bay	14	8.621	510,481	1,003,755
Hillsborough Bay	6	35.643	23,589,674	8,435,702
Tampa Bay	4	26.193	835,375	1,314,802
Hillsborough River	6	ND	1,445,400	4,186,550
Manatee River	4	2.372	109,756	629,535
Palm River	0	ND	197,100	1,303,000
Alafia River	1	ND	1,734,480	6,117,400
TAMPA BAY COMPLEX TOTAL	55	72.8	28,422,266	22,990,724

Vegetation: Among the emergent vegetation types bordering Tampa Bay, mangrove and salt marsh assemblages are the most important. Mangroves and associated species cover approximately 17,500 acres of shoreline, while salt marsh vegetation occupies about 1,700 acres (McNulty, et al., 1972). Regions containing lush stands of mangroves or salt marshes are limited, due to the presence of seawalls and dredge-fill operations. It is well known that both mangroves and salt marshes are beneficial and productive communities (see, for example, Odum, 1971; Heald, 1971; McNulty, et al., 1972). Table 18 indicates the distribution of both emergent and submergent vegetation within the bay complex.

Submergent vegetation consists of five species of seagrasses and 216 species of algae (Phillips, 1960a, 1962b; Dawes, 1967, 1974; McNulty, et al., 1972; Humm, 1973c, 1973d). Taylor (1971) has indicated that about 10% or 21,000 acres of the Bay system are vegetated by seagrasses and/or conspicuous benthic algae.

In Hillsborough Bay and Old Tampa Bay, due to degradation of water quality (FWPCA, 1969; Humm, 1973d), many algal species have become reduced or eliminated, allowing obnoxious species such as *Gracilaria*, *Enteromorpha* and *Ulva* to be present in extraordinary quantities.

TABLE 18. Area of submergent and emergent vegetation in the Tampa Bay System (modified from McNulty, Lindall and Sykes, 1972).

	Submergent Vegetation (acres)	Emergent Vegetation Marshes (acres)	Emergent Vegetation Mangroves (acres)
Old Tampa Bay	6,809	533	5,024
Hillsborough Bay	383	203	1,077
Tampa Bay	7,890	843	8,949
Boca Ciega Bay	5,800	149	2,464
TOTALS	20,882	1,728	17,514

Phytoplankton and Primary Productivity: Primarily due to the presence of occasional outbreaks of the Florida Red Tide, *Gymnodinium breve,* studies on phytoplankton and primary productivity in Tampa Bay have been numerous since 1956 (Marshall, 1956). The most recent papers on these subjects are those of Steidinger (1973b) and Turner and Hopkins (1974). McNulty, et al. (1970) and Steidinger (1973b) indicated that gross annual phytoplankton productivity amounts to 314-427 gm C per M^2, as high or higher than any other area in the world. Measurements of primary production via the Chlorophyll *a* technique are a part of the routine monitoring program of the EPC (Shaw, 1972). Seasonality in primary production has shown that there is a peak of productivity in the spring and late summer, and that Hillsborough Bay always has the highest productivity within the Bay system (Kelly and Johnson, 1967).

Zooplankton: There is little published information available on the zooplankton of Tampa Bay. To date, the most comprehensive study was the yearly program of macrozooplankton conducted by Kelly and Dragovich (1967) (using a No. 000 mesh net; openings = 1.024 mm). Unpublished data on both phytoplankton and zooplankton are on file in class reports from USF summer courses and graduate student projects supervised by Thomas L. Hopkins. Hopkins (1973) lists the important species of plankters and mentions that microzooplankton numbers are regulated by heavy grazing by ctenophores and jellyfishes, most especially in the winter. In addition, TECO (1973) has presented data on zooplankton, routinely reporting on some 100 taxa. In a study on planktonic fish eggs and larvae, Finucane (1966, 1967) showed fish eggs most abundant between February and May, and the greatest numbers of larval fishes appeared during July.

Invertebrates: Taylor (1973b) has stated . . . "it is evident that the Tampa Bay system contains the greatest diversity and abundance of marine life recorded for any embayment between Chesapeake (Bay) and the Laguna Madre of Texas." The presence of this rich biota may be attributed to a combination of factors, notably, the geographic position of the estuarine system, lying at the biogeographic boundary between the temperate Carolinean Province and the subtropical to tropical Caribbean Province (Pulley, 1952). Winter water temperatures seldom drop low enough to kill tropical organisms, while many temperate species are able to withstand the higher summer water temperatures. The current structure along the Gulf is such that convergence occurs at the mouth of Tampa Bay, providing a continuous source of planktonic larval stages for colonization from both the north (temperate) and south (tropical). The salinity regime already discussed, is such that wide fluctuations are absent, thus allowing many truly marine species to coexist with truly estuarine forms. Additional factors contributing to the high diversity of invertebrates in Tampa Bay are the presence of extensive areas of shallow level bottom fine sand substrata and abundant seagrass beds—both habitat types which are known to support rich assemblages. The abundant supply of nutrients and high primary productivity, plus suitable sources of detrital materials (salt marshes, mangrove forests, sewage treatment plants, etc.) offer an abundant (presently perhaps almost unlimited) food supply to support both a variety of species and high densities within species.

The initial list of invertebrates from Tampa Bay was presented by Hutton, et al. (1956) and Dragovich and Kelly (1964) provided additional data. Extensive collections at some 400 stations throughout the bay system were started in 1963 by the NMFS (Taylor and Saloman, 1966a). From this massive effort, the molluscan, polychaete, echinoderm, and, to some extent, macrocrustacean faunas of the Bay have become reasonably well known. The Corps of Engineers (1974) presented checklists of the known molluscs, polychaetes, and echinoderms. With the exception of the highly degraded Hillsborough Bay subarea and blind end canals in various parts of the bay (upper Old Tampa Bay and Boca Ciega Bay), the system supports very "healthy assemblages". To date, only the studies of Bloom, et al. (1970), Santos (1972), Santos and Simon (1974), Simon and Dauer (1972a, 1972b, 1973), and Dauer and Simon (1973) been of a statistically adequate design to allow modern numerical analysis techniques to be applied.

The Corps of Engineers (1974) has compared the invertebrate faunas of various bottom types within the estuarine system and found that:

1) annelid worms dominate all habitat types (56.2%, ave)
2) crustaceans (isopods, amphipods and cumaceans) are second (16.2%)
3) molluscs (9.4%), amphioxus (6.9%), echinoderms (mostly ophiuroids) (1.6%), and "misc. minor phyla" (9.1%) make up the remainder.

Since substratum has been shown by numerous workers to be the single most important environmental parameter determining distribution and presence of benthic invertebrates, Taylor (1973b) divided the bay bottom into five sediment types (deep ship channel; soft spoil; firm spoil; soft undredged bottoms; firm undredged bottoms) and found the results listed in Table 19. It is clear from Table 19 that firm bottoms (combination of sand and shell) support the greatest number

TABLE 19. Mean values for various biotic assemblage parameters in different bottom types in the Tampa Bay Estuarine System (modified from Taylor, 1973, and Corps of Engineers, 1974).

Bottom Type	No. of Stations Sampled	No. of Species	No. of Individuals/m²	Diversity (Shannon's H')	Depth (m)
Channel	14	16.5	7,045	2.8	13.2
Soft Spoil	2	19	7,232	3.0	6.2
Firm Spoil	17	29.5	13,926	3.4	6.6
Soft Undredged	15	16.7	10,163	2.4	7.4
Firm Undredged	38	28.7	11,346	3.6	8.3

of species and individuals, while channel areas support the least. The method of sampling and number of stations in each bottom types may have influenced the above conclusions.

In intertidal regions of the bay, published quantitative faunal data is limited to that of Bloom, et al. (1972) who worked in Old Tampa Bay in three sediment types (clean sand, soft mud, intermediate sandy mud). Their analysis indicated that different biotic assemblages could be found in the sand and mud, while the intermediate substratum showed a mixed assemblage of infaunal invertebrates. Santos (1972) and Santos and Simon (1974) studied the distribution and abundance of polychaetes associated with various intertidal grass beds in Tampa Bay. Recently, Simon and Dauer (1972a, 1972b, 1973) and Dauer and Simon (1973) followed the course of repopulation of the benthic infauna in a sandy intertidal habitat after massive defaunation resulting from the 1971 redtide outbreak in Tampa Bay.

Taylor (1973b) compared data on the polychaete component of the subtidal fauna for stations sampled in 1963 and 1973, finding that many more species were present in the 1963 collections than those from 1973 (the highest similarity between years was 73%; the lowest, 40%). He pointed out the differences in sampling procedures could explain the differences in species composition, but added "of course there is always a possibility that the estuary has deteriorated from sewage pollution over the past 10 years." Taylor, et al. (1970) studied the molluscan fauna of Hillsborough Bay (collections made in 1963) noting that only small regions in the southern part of that subarea supported any living molluscs. Only 36 species were found, and of these, five species (*Mulinia, Amygadalum, Nassarius, Tagelus,* and *Melongena*) accounted for the majority of specimens. On the basis of their analysis, they divided Hillsborough Bay into "healthy, marginal, and unhealthy" zones.

Fishes: Tampa Bay fishes are well known, and include about 400 species (Springer and Woodburn, 1960; Springer and McErlean, 1961a, 1961b; Moe and Martin, 1965). Sykes and Finucane, 1966, found that at least 21 species of commercial importance use Tampa Bay as a nursery ground, predominately during the summer months. It is well documented in the Gulf in general that 90% or more of commercial or sports fishes require estuarine conditions to complete their life cycles (Sykes, 1964, 1968; Gunter, 1967). Taylor, et al. 1973, have stated that the most important fisheries in the Tampa Bay region depend on stocks renewed locally and in many instances annually. Sykes and Finucane, 1966, in comparing catch records, have shown that smaller catches of fewer species take place in Hillsborough Bay than Old Tampa Bay, indicating the importance of pollution and lack of seagrasses in depressing fish populations.

Marine Reptiles, Birds, and Mammals: Several species of marine turtles have been reported from Tampa Bay (Lindall, et al. 1973; Taylor, 1973b; Corps of Engineers, 1974).

Over 81 species of birds (five found locally only during the winter) are closely associated with the Tampa Bay estuarine system (Woolfenden and Schreiber, 1973). These authors have addressed themselves to the widespread elimination of nesting and feeding sites within the Bay complex due to dredge/fill operations, destruction of mangroves and marsh areas, and reviewed the effects of biological magnification of pesticides and heavy metals on local avifauna. An oil spill which occurred in Tampa Bay in 1970, severely effected shore birds (Woolfenden and Schreiber, 1973). The current redtide outbreak and the associated bird and fish kills should also be mentioned (St. Petersburg TIMES, March 16, 1974).

Marine mammals of importance in Tampa Bay and adjacent offshore waters have been reviewed by Caldwell and Caldwell (1973).

ECONOMIC VALUE—*Commercial Fisheries*: Economically, the pink shrimp, *Penaeus duorarum* is the most important invertebrate in the Tampa Bay system (Taylor, et al., 1973). Juveniles of this species are taken in large numbers for sale as bait shrimp. Other crustaceans of economic importance are the blue crab (*Callinectes sapidus*) and the stone crab (*Menippe mercernaria*). Adult shrimp are also landed within the Tampa Bay area. Table 20 lists the landings and dollar value for crustaceans since 1966.

Molluscs of economic importance include the oyster, (*Crassostrea virginica*), quahog (*Mercenaria campechiensis*), sunray venus (*Macrocallista nimbosa*) and bay scallop (*Argopecten irradians*). The fishery for molluscs is largely recreational, due to pollution (Butler, 1965; McNulty, et al., 1972) or mismanagement (Godcharles, 1971). Other invertebrates within the estuarine system are important food sources for fishes at some stage in their life cycle. Benthic invertebrates generally make up the principle food source for more than 95% of Florida's sport and commercial fish species (Sykes, 1968).

Commercial fisheries amounted to a total dollar value of $4,006,608 in 1967 (McNulty, et al., 1972). Landings for various species for 1970 are listed in Table 21. In addition to commercial fisheries, sport fishing, both by residents and

TABLE 20. Landings of commercially important crustaceans in the Tampa Bay Region (modified from Taylor, Feigenbaum, and Stursa, 1973).

		1966	1969	1972
BAIT SHRIMP	Individuals ($\times 10^6$)	22.98	25.2	12.0
	$1000	278	230	161
ADULT SHRIMP	Pounds ($\times 10^6$)	4.73	3.91	2.39
	$ millions	2.4	1.9	1.98
STONE CRAB	Pounds ($\times 10^3$)	24.6	78.6	241
	$1000	7	44.5	237
BLUE CRAB	Pounds ($\times 10^3$)	2224	199.6	23.8
	$1000	130	23.8	38.1

tourists is an important economic asset. On a weight comparison, it has been estimated that sport fisheries probably amount to between one-third and one-half the poundage reported for commercial fisheries (Taylor, 1973b). Economically, however, the sport fisheries are probably more important in terms of dollars spent (Taylor, 1973b).

TABLE 21. Commercial fishlandings in the Tampa Bay Region, 1970 (modified from Taylor, Feigenbaum, and Stursa, 1973).

	Thousands of pounds
Blue Runner	45
Grouper	3,701
King Mackerel	213
Black Mullet	5,875
Pompano	47
Spotted Sea Trout	344
Red Snapper	676
Spanish Mackerel	235

Shipping & Water Transportation: The Port of Tampa, on a tonnage basis is now the fourth largest export port and eighth largest port in the U. S. based on total tonnage (Corps of Engineers, 1974). During 1972, over 40 million tons, with a value of over $490 million, passed through the port. Customs collections are now over $18 million/year (Corps of Engineers, 1974).

MAJOR PROBLEM AREAS WITHIN TAMPA BAY SYSTEM

The rapid increase in population experienced by the Tampa Bay area over the past 20 yr has led to a number of well documented cases of environmental degradation. Only two such effects will be considered: (1) the effects of dredge/fill operations to create waterfront property, fingerfills and associated blind end canals; and, (2) the effects of population growth and increased sewage effluents on the processes of eutrophication within the Bay System.

1. THE BOCA CIEGA BAY STORY (a summary of the findings of Taylor and Saloman, 1968a).

Since 1950, when Pinellas County had a population of 159,249 people, approximately 3500 acres of Boca Ciega Bay have been filled by hydraulic dredging, reducing the bay area by about 20%. The resulting fingerfills have increased the length of shoreline from 26.3 miles (Olson and Morrill, 1955) to approximately 124 miles (measured directly from USGS Chart No. 858, dated 1971)—an 470% increase in waterfront property for development of homes, apartments, and condominiums. The loss of bay bottom by filling has resulted in the destruction of an annual standing crop of 1,133 metric tons (128 kg/hectare, dry wt) of seagrasses and about 1,812 metric tons (205 kg/hectare, dry wt) of associated infaunal invertebrates. Taylor and Saloman (1968a) have stated: "In terms of annual production, the loss of biological resources is far greater—minimum estimates are 25,841 metric tons of seagrasses, 73 metric tons of fisheries products, and 1091 metric tons of infauna . . . At an estimated value of $160/hectare/year, the worth of the estuarine area already eliminated is $1.4

million annually. In addition, inestimable secondary losses occur, principally from sedimentation, turbidity, and domestic sewage." It has been argued by many that dredge/fill operations only temporarily disrupt the ecosystem, and that repopulation of the biota occurs rapidly. Taylor and Saloman (1968a) found negligible recolonization of canal sediments after 10 yr and concluded that it was doubtful that the soft sediments of bayfill canals could ever support a rich or diverse infauna. In addition to the removal of bay bottom, the increase in population moving onto the fingerfills is of major importance to the quality of the bay system (Pinellas County population rose to 522,329 by 1970). Increased water usage and sewage waste elimination leads to a reduction in waste water quality, since most sewage treatment plants in the area are severely stressed and operating far above rated capacity. The Wilson-Grizzel Bill recently passed by the State Legislature, demanding "advanced waste treatment" for effluents entering Tampa Bay, if enforced, could lead to an alleviation of this problem. The economic benefits to the area from construction and taxes generated from additional homes, etc., have been touted as "worth the cost to the Bay environment" by politicians and developers. One can counter that, if the annual loss of $1.4 million (as estimated value of loss of bay bottom) were capitalized at 6%, a total natural investment of $23 million would result.

2. The Hillsborough Bay Story (summarized from FWPCA, 1969).

The FWPCA (1969) study of Hillsborough Bay has provided documentation of the effects of sewage effluents on increasing eutrophication and the accompanying degradation of water quality and bottom life. Water quality in Hillsborough Bay is consistently lower than that anywhere else within the Tampa Bay System (see FWPCA, 1969; Shaw, 1972). The high BOD's, low DO's, unsafe levels of fecal coliforms, high primary productivity, organically rich anaerobic sediments, frequent fish kills and obnoxious algal blooms that characterize the area can be directly related to inadequate sewage treatment facilities. The increased stress of the existing sewage facilities in the area can again be related to population increase—Hillsborough County had a population of 249,894 in 1950; 562,462 in 1973.

CURRENT STATUS OF THE TAMPA BAY ESTUARINE SYSTEM AND PROJECTIONS FOR THE FUTURE

Hillsborough Bay, Boca Ciega Bay, and various blind ending canals located in Old Tampa Bay and Tampa Bay proper have low water quality and silted bottoms almost devoid of living organisms. Based on the report of Taylor and Saloman (1968a) and the analysis of Barada and Partington (1972) it appears unlikely that water quality or benthic conditions can or will improve within dredge/filled canals. The City of Tampa has under construction a 54 MGD advanced waste treatment plant projected to go into operation in 1976-77. The effects of replacing the current volume of low quality effluents entering Hillsborough Bay with higher quality effluents are unknown. Much speculation has been made on the rate of recovery of estuarine regions once pollution is abated. Certainly, the quality of the water column should improve rapidly. However, the rate of recovery of the sediments and repopulation of the bottom with organisms cannot be predicted at this time. A major study should be initiated soon to provide baseline information (present benthic conditions: geological, chemical, and biological) and followup studies carried out to answer this vital question. I know of nowhere else in this country where the opportunity for such a study exists.

Old Tampa Bay, Tampa Bay, and Terra Ceia Bay appear to be in relatively healthy condition at this time. The upper portions of Old Tampa Bay, especially the northeast and southwest regions of Courtney Campbell Causeway, show signs of becoming degraded. The first region is degraded due to the existing current pattern causing accumulation of organic materials into a blind pocket (Ross, 1973); the second degraded region results from the much overloaded City of Clearwater sewage treatment plant which is currently being upgraded. Providing no introduction of additional quantities of pollutants and the upgrading of existing effluents takes place, the outlook for these areas is good. One cannot overlook, however, additional projects currently being planned which could have marked effects on the above prognostication.

There are three types of projects being planned or underway, which could have marked effects on the quality of Tampa Bay: 1. The Tampa Harbor Deepening Project; 2. the Belcher Oil Refinery and potential offshore oil development; and 3. continued approval by municipalities of large numbers of housing developments within the watershed area of the Bay.

1. Tampa Harbor Deepening Project

The Tampa Port Authority and the Army Corps of Engineers are planning the Tampa Harbor Deepening Project, a $180 million endeavour to enlarge the entire shipping channel from its entrance off Egmont Key at the mouth of the Bay to the new Holland Dock area of East Bay, a distance of about 35 miles. The depth of the channel will be increased to 43-45 ft, and its width extended by 100 ft or more. The area of actual channel construction will encompass 19,475 acres (78.81×10^6 m^2) with an additional 6890 acres (27.88×10^6 m^2) for spoil disposal (recalculated from Corps of Engineers, 1974). An estimated 72,298,000 cu yd of materials will be dredged—of this, 63,392,000 cu yd is expected to be "soft materials" with 8,906,000 cu yd of rock. Construction is expected to be phased over approximately 5 yr. Considering the destruction of bay bottom (approximately 12.32% of the total bay area), the damage to existing benthic organisms will be considerable. The Corps of Engineers (1974) estimates that there are an average of 10,900 benthic invertebrates per sq m in Tampa Bay. From the figures presented above, one can calculate that 11.62×10^{11} (1,162,975,000,000) individuals will be directly destroyed by removal or spoiling of the bottom.

Undoubtedly, the operation will create turbidity levels above background, at least within the immediate area of dredging. The studies of Taylor (1973a) and Simon and Dyer (1972), examining turbidity created by oyster shell dredging in Tampa Bay, have shown that excessive turbidities (defined as the State standard of 50 JTU above background) were limited to within approximately 100 yd of the dredge. Silt concentrations above background were detected up to 3 1/2 miles from the dredge at the surface and 1500 yd away near the bottom. Although the effects (both beneficial and detrimental) of increased turbidity can be argued (see Sherk and Cronin, 1970; Sherk, 1971), the Corps of Engineers (1974) has stated (p. 47): "in a clear water ecosystem such as the Tampa Bay Estuary, any major increases in turbidity would create unnatural conditions causing radical changes in resident organisms and a marked reduction in water recreation."

In light of the extremely degraded quality of bottom sediments within the Hillsborough Bay subarea, effects of dredging there should be of considerable concern. Given the tidal current structure within the Bay system, resuspended fine particles are carried in the water column and redeposited in areas of low current velocity. The high Technical Oxygen Demand of the Hillsborough Bay sediments (and their trace metals, pesticides, etc.) may create further serious problems (FWPCA, 1969). The arrangement of spoil islands may alter circulation patterns as well. It will remain to be seen what the overall effects of the Tampa Harbor Deepening Project will be, but as the St. Petersburg TIMES (March 15, 1974) stated, "Deepening of channels poses [an] ordeal for bay."

2. OFFSHORE OIL DEVELOPMENT AND THE BELCHER OIL REFINERY

The recent offshore oil leases by the U. S. Department of the Interior include sites off the Tampa Bay region. In addition, plans have been announced and permitting procedures initiated by Belcher Oil Company for an offshore bulk oil loading facility and an onshore refinery. To date, the Development of Regional Impact Statement (DRI) has been declared inadequate by those governmental bodies reviewing it. The refinery is projected for the Port Manatee area, in the southeast part of Tampa Bay. The effects of such developments on the Bay system cannot be predicted at this time.

3. CONTINUED POPULATION GROWTH OF THE BAY AREA

Growth of Florida in general, and the Tampa Bay Region in particular, has been spectacular during the past few years. It has been conservatively estimated that 7,000 people per week move into the state (St. Petersburg TIMES, Feb. 25, 1974). The State Legislature has been and will be addressing itself to the problems associated with continued growth. The old economic arguments that growth generated increased taxes, wages, need for additional goods and services, and thus stimulated the economy of an area are finally being laid to rest. It has become painfully clear to municipal and state governments over the past few years that the addition of homes, apartments and condominiums, and accompanying people dramatically increase the needs of municipalities to provide water, sewage treatment plants, electrical power, roads, schools, police and fire protection, etc. The increased costs to Hillsborough and Pinellas counties between 1970 and 1973 to provide such services amounted to $62,493,937. For these two counties, water consumption by people increased from 108 MGD in 1970 to 135 MGD in 1973 (St. Petersburg TIMES, Feb. 24, 1974). These are just a few of the available facts to support the concept that population growth and development no longer "pulls its own weight" in terms of providing the tax dollars necessary to provide needed services.

In the 1950's and early 60's, few private citizens or environmental groups within the Tampa Bay region expressed concern over environmental degradation. Permitting agencies and local/state governmental officials could approve piecemeal development at will, with little concern for the future of the ecosystem. Since the dawn of the environmental movement in the second half of the 1960's, the public, exposed in the popular press to the principals of ecology and now aware of environmental damage, has a grasp of the future implications of present governmental policies. Prior to 1968, it was rare indeed if more than a handful of private citizens attended public hearings on zoning changes, dredge/fill permit hearings, etc. Today, the story is quite different. The public has begun to express its concern to policy making bodies. As a result, the waters of Pinellas County have been declared an aquatic preserve, and it is difficult or impossible to obtain permits for dredging. If permits are granted at the local level, state agency personnel and the public hue and cry usually lead to subsequent withdrawal or denial—except when clearly in the public interest (not just the interest of a developer or special interest group). Similar procedures, although with less local political leadership and the necessity for more public arousal, have occurred in Hillsborough County.

Hillsborough County bay bottoms are not owned by the State of Florida, but are vested in the Tampa Port Authority—an agency devoted to developing the Port of Tampa. Projects which enhance port development are usually approved by the Port Authority granting themselves permits to carry out such projects. Although public hearings are held and citizens groups are becoming more and more vociferous, few changes from old behavior patterns have been noted.

Pinellas County, due to severe municipal water supply problems, has had to invoke growth moratoria recently. Hillsborough County has not, and several city, county, or regional governmental authorities have stated that water supply problems "will not limit growth."

Development has moved from the shoreline of Tampa Bay inland to the flood plain. Massive developments have been approved over the past several years. The stresses of building on the flood plain, thus creating problems in recharging freshwater sources, will create problems for Tampa Bay. Sewage from most approved developments will ultimately be added to the Tampa Sewage Treatment Plant, and thus find its way into Hillsborough Bay.

The problems which have led to the degradation of Boca Ciega Bay and Hillsborough Bay are mainly caused by people—too many of them in the wrong places. People, too, are the solution to the problem. Only with long range planning and sound management practices can the Bay be improved and degradation halted. An aroused citizenry from the Tampa Bay Region must demand from their political bodies slowed growth and phased planning based on hard, scientific facts. Each development, whether a housing project located on the 100 yr flood plain 20 miles from Tampa Bay, or the Tampa Harbor Deepening Project, or the Belcher Oil Refinery, should be examined via *proper* Environmental Impact Statements or Development of Regional Impact Statements—statements which clearly and precisely define the effects of the project on the entire Bay system. Only when all the facts are presented to the public should approval or denial of projects be appropriate. When the people feel that projects have not been carefully weighed and that improper decisions are made by their elected officials, they should express their concern loudly to those officials. Only when large numbers of individuals become involved—when they take the time to learn the facts and assess the implications of projects—can the political decision making system be expected to work *in the public interest.*

To speak of management or mismanagement of the Tampa Bay Estuarine System prior to the late 1960's is inappropriate—up to that time, there was simply development. Management implies control over a system. Mismanagement implies improper control. Only in the past few years has the public demanded management practices be applied to Tampa Bay. It is too soon to make the judgement whether these practices are going in the right direction (i.e., proper management) or whether governmental bodies are simply paying lip-service to the problems (i.e., mismanagement). The lack of willingness to slow growth until plans can be implemented to solve old and lingering problems would seem to imply we are headed towards mismanagement. Tampa Bay cannot wait much longer for advanced sewage treatment, nor can it tolerate more dredging without further degradation of its waters and bottoms. Hopefully, an irate citizenry will awaken policy making bodies to adopt sound management practices and will not accept mismanagement as an alternative. A recent article in the Tampa Tribune-Times (February 24, 1974), addressing the problem of uncontrolled growth, asked the question: "Will the ugly duckling lay the golden egg or will the golden egg hatch an ugly duckling." The outcome lies in the hands of the people.

LITERATURE CITED AND BIBLIOGRAPHY

(This bibliography includes most references on Tampa Bay since Olson & Morrill, 1955)

Barada, W., and W. M. Partington, Jr. 1972. Report of investigation of the environmental effects of private waterfront canals. Environmental Information Center of the Florida Conservation Found., Inc. Winter Park. Mimeo Rept. prepared for Board of Trustees of the Florida Internal Improvement Trust Fund. pp. 63 + appendices.

Black, A. P., and E. Brown. 1951. Chemical character of Florida's waters. Florida State Bd. Conserv. Div. Water Survey and Research. pp. 21-116.

Blake, N. J., L. J. Doyle, T. E. Pyle, and R. Zimmerman. 1973. Marine ecology program at the P. L. Bartow Power Plant, Weedon Island, Tampa Bay: progress report. pp. 95-116. *In* Rogers, J. L. (ed.) Environmental Status Report. Florida Power Corp. St. Petersburg.

Bloom, S. A., J. L. Simon, and V. D. Hunter. 1972. Animal-sediment relations and community analysis of a Florida estuary. Mar. Biol. 13:43-56.

Blus, L. J., R. G. Heath, C. D. Gish, A. A. Belisle, and R. M. Prouty. 1971. Eggshell thinning in the Brown Pelican: Implications of DDE. BioSci. 21:1212-1215.

Briggs, J. C. 1973. Fishes. pp. IIIH-1—IIIH-7. *In* Jones, J. I. et al. (eds.) A Summary of Knowledge of the Eastern Gulf of Mexico. Martin Marietta Aerospace. Orlando.

Brooks, H. K. 1973. Geological oceanography. pp. IIE-1—IIE-49. *In* Jones, J. I. et al. (eds.) A Summary of Knowledge of the Eastern Gulf of Mexico, 1973. Martin Marietta Aerospace. Orlando.

Bullock, R., and C. Boss. 1963. Ecological distribution of marine mollusks in Boca Ciega Bay, Florida. Mimeo Rept. Florida Presbyterian College. St. Petersburg.

Butler, P. A. 1965. Reaction of some estuarine mollusks to environmental factors. pp. 92-104. *In* Tarzwell, C. (ed.) Biological Problems in Water Pollution. U. S. Public Health Serv. Publ. 999-WP-25.

CALDWELL, D. K., AND M. C. CALDWELL. 1973. Marine mammals. pp. XXX-I-1—III-I-23. *In* JONES, J. I. et al. (eds.) A Summary of Knowledge of the Eastern Gulf of Mexico. Martin Marietta Aerospace. Orlando.

CALIFORNIA COMPANY, THE. 1953. Bibliography of Geology—Florida. California Co. New Orleans.

CARLSON, P. R. 1970. Patterns of succession on spoil islands. Natl. Sci. Found. Grant GY-9170. iv + 114 pp.

CARSLEY, J. B. 1950. Geology of Gulf coastal area and continental shelf. Amer. Assoc. Petrol. Geol. Bull. 34:361-385.

CHAPMAN, C. 1968. Channelization and spoiling in Gulf coast and south Atlantic estuaries. pp. 93-106. *In* NEWSOM, J. D. (ed.) Proc. Marsh and Estuary Management Symposium. T. J. Moran's Sons, Inc. Baton Rouge.

CLARKE, F. J. 1970. Survey-review report on Tampa Harbor, Florida. Dept. of the Army, Jacksonville District Corps of Engineers.

COLLARD, S. B., AND C. N. D'ASARO. 1973. Benthic invertebrates of the eastern Gulf of Mexico. pp. IIIG-1—IIIG-27. *In* JONES, J. I. et al. (eds.) A Summary of Knowledge of the Eastern Gulf of Mexico. Martin Marietta Aerospace. Orlando.

CONNORS, P. G., V. C. ANDERLINI, R. W. RISEBROUGH, J. H. MARTIN, R. W. SCHREIBER, AND D. W. ANDERSON. 1972. Heavy metal concentrations in Brown Pelicans from Florida and California. Cal-Neva Wildl. 1972:56-64.

COPELAND, B. J. 1970. Estuarine classification and responses to disturbances. Trans. Amer. Fish. Soc. 99:826-835.

CORPS OF ENGINEERS. 1974. Draft Environmental Impact Statement—Tampa Harbor Project. U. S. Army Engineer District, Jacksonville. pp. 220 with appendices.

DAUER, D. M. 1974. Repopulation of the polychaete fauna of an intertidal habitat following natural defaunation. Ph.D. Dissertation. Univ. South Florida. Tampa.

_________, AND J. L. SIMON. 1973. Repopulation of an intertidal habitat following defaunation: II. General aspects of the first year of study. Amer. Zool. 13:1329 (Abstract).

DAWES, C. J. 1967. Marine algae in the vicinity of Tampa Bay, Florida. Univ. South Florida, Contr. 27:105 pp.

_________. 1974. Marine Algae of the West Coast of Florida. Univ. Miami Press. Coral Gables.

DAWSON, C. E., JR. 1953. A survey of the Tampa Bay area. Florida State Bd. Conserv. Mar. Lab. Tech. Ser. 8:39 pp.

DEMBROSKI, T. M., J. C. FERGUSON, A. A. MURPHY, AND R. W. NEITHAMER. 1971. The sewage system of St. Petersburg, FL, a multidisciplinary assessment of its status and environmental effects. Boca-Ciega-Environ. Curric. Proj. Florida Presbyterian Coll. St. Petersburg. 104 pp.

DOWNEY, M. E. 1973. Starfishes from the Caribbean and the Gulf of Mexico. Smithsonian Contrib. Zoo. 126:vi + 158 pp.

DRAGOVICH, A. 1968. Morphological variations of *Gymnodinium breve* Davis. Quart. J. Florida Acad. Sci. 30:245-249.

_________, AND J. A. KELLY, JR. 1962. A biological study and some economic aspects of squid in Tampa Bay, Florida. Proc. Gulf Caribbean Fish. Inst. Annual Sess. 15:87-103.

_________, AND _________. 1964. Ecological observations of macroinvertebrates in Tampa Bay, Florida, 1961-1962. Bull. Mar. Sci. Gulf Carib. 14:74-102.

_________, AND _________. 1966. Distribution and occurrence of *Gymnodinium breve* on the west coast of Florida, 1964-65. U. S. Fish and Wildlife Serv. Spec. Sci. Rept. Fish. 541:15 p.

_________, _________, AND J. H. FINUCANE. 1966. Oceanographic observations of Tampa Bay, Charlotte Harbor, Pine Island Sound, Florida and adjacent waters of the Gulf of Mexico, February 1964-February 1965. U. S. Fish and Wildlife Serv. Data Rept. 66:72 pp.

_________, _________, AND H. G. GOODELL. 1968. Hydrological and biological characteristics of Florida's west coast tributaries. U. S. Fish Wildl. Serv. Fish. Bull. 66:463-477.

_________, _________, AND R. D. KELLY. 1965. Red water bloom of a dinoflagellate in Hillsborough Bay, Florida. Nature (London) 207:1209-1210.

_________, AND B. Z. MAY. 1962. Hydrological characteristics of Tampa Bay tributaries. U. S. Fish Wildl. Serv. Fish. Bull. 62:163-176.

_________, AND J. E. SYKES. 1967. Oceanographic atlas for Tampa Bay, Florida and adjacent waters of the Gulf of Mexico, 1958-1961. U. S. Fish Wildl. Serv. Circ. 255:466 pp.

EMERY, K. D., AND R. E. STEVENSON. 1957. Estuaries and lagoons. I. Physical and chemical characteristics. Geol. Soc. Amer. Mem. 67:673-693.

ELDRED, B. 1966. Plankton collections with pertinent data, Tampa Bay, Florida and Gulf of Mexico (July 1961 to June 1963) Florida State Bd. Conserv. Mar. Lab. Spec. Sci. Rept. 11.

———, R. M. INGLE, K. D. WOODBURN, R. F. HUTTON, AND H. JONES. 1961. Biological observations on the commercial shrimp *Penaeus duorarum* Burkenroad, in Florida waters. Florida State Bd. Conserv. Mar. Lab. Prof. Pap. Ser. 3:139 pp.

———, J. WILLIAMS, G. T. MARTIN, AND E. A. JOYCE, JR. 1965. Seasonal distribution of penaeid larvae and post larvae of the Tampa Bay area, Florida. Florida State Bd. Conserv. Mar. Lab. Tech. Ser. 44:iv + 47 pp.

ERNEST, R. G. 1968. A preliminary report on the echinoderms of Tampa Bay Florida. Student Rept. Mar. Sci. Inst. Univ. South Florida. St. Petersburg.

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION. 1969. Problems and management of water quality in Hillsborough Bay, Florida. Fed. Water Poll. Contr. Admin. Washington, D. C.

FINUCANE, J. H. 1965. Threadfin Shad in Tampa Bay, Florida. Quart. J. Florida Acad. Sci. 28:267-270.

———. 1966. Faunal production project. pp. 18-22. *In* Report of the Bureau of Commercial Fisheries Biological Station, St. Petersburg Beach, Florida, fiscal year 1965. U. S. Fish Wildl. Serv. Circ. 242.

———. 1967. Faunal production project. pp. 12-14. *In* Report of the Bureau of Commercial Fisheries Biological Laboratory, St. Petersburg Beach, Florida, fiscal year 1966. U. S. Fish Wildl. Serv. Circ. 257.

———, AND R. W. CAMPBELL II. 1968. Ecology of American oysters in Old Tampa Bay, Florida. Quart. J. Florida Acad. Sci. 31:37-46.

———, AND A. DRAGOVICH. 1966. Hydrographic observations in Tampa Bay, Florida and the adjacent Gulf of Mexico, 1963. U. S. Fish. Wildl. Serv. Data Rept. 14:81 pp.

FLORIDA BOARD OF CONSERVATION MARINE LABORATORY. 1967. Red tide studies Pinellas to Collier Counties, 1963-1966. A symposium. Florida State Bd. Conserv. Prof. Pap. Ser. 9:v + 141 pp.

FLORIDA DEPARTMENT OF NATURAL RESOURCES. Undated. Summary of Florida commercial marine landings, 1971. Florida Dept. Natur. Res. Tallahassee. 64 pp.

FLORIDA POWER CORPORATION. 1973. Environmental Status Report, October, November, December/January, February, March, 1972-73. Florida Power Corp. St. Petersburg. 120 pp.

FLORIDA STATE BOARD OF HEALTH. 1965. A study of the causes of obnoxious odors Hillsborough Bay, Hillsborough County, Florida. Florida State Bd. Health Bur. Sanitary Engineers. Jacksonville. 7 pp.

FUTCH, C. R. 1970. Contributions to the ecology of larval and juvenile lined sole, *Achirus lineatus*, in Tampa Bay, Florida. Dept. Nat. Res. Mar. Res. Lab. Leaf. Ser. IV, pt. 1, no. 17.

GALTSOFF, P. S. 1964. Gulf of Mexico, its origin, waters, and marine life. U. S. Fish Wildl. Serv. Fish. Bull. 55:1-604.

GODCHARLES, M. F. 1971. A study of the effects of a commercial hydraulic clam dredge on benthic communities in estuarine areas. Florida Dept. Nat. Resourc. Mar. Res. Lab. Tech. Ser. 65:viii + 51 pp.

GOODELL, H. G., AND D. S. GORSLINE. 1961. A sedimentologic study of Tampa Bay, Florida. 21st Internatl. Geol. Cong., 1960, pt. 23:75-88.

GRIFFIN, G. M., AND S. G. WHITNEY. 1971. Turbidity generation and distribution in Tampa Bay as monitored with a towable optical transmissometer. Trans. Gulf Coast Assoc. Geol. Soc. 21:97-106.

GULF UNIVERSITIES RESEARCH CORPORATION. 1969. Case studies of estuarine sedimentation and its relation to pollution of the estuarine environment. Fed. Water Poll. Contr. Admin. Contract 14-12-445.

GUNTER, G. 1957. How does siltation affect fish production? Natl. Fisherman 38(3):18-19.

———. 1967. Some relationships of estuaries to the fisheries of the Gulf of Mexico. pp. 621-638. *In* LAUFF, G. H. (ed.) Estuaries. Amer. Assoc. Adv. Sci. Publ. 83. Washington, D. C.

———. 1969. Reef shell or mud shell dredging in coastal bays and its effect upon the environment. Trans. 34th N. Amer. Wildl. Natur. Resourc. Conf. 1969:51-75.

HAGAN, J. 1969. Problems and management of water quality in Hillsborough Bay, Florida. Hillsborough Bay Technical Assistance Project, Tech. Prog. FWPCA. 86 pp.

HALL, J. R. 1970. Description of egg capsules and embryos of the squid, *Lollinguncula brevis*, from Tampa Bay, Florida. Bull. Mar. Sci. 20:762-768.

———. 1972. Mollusks and benthic environments in two Florida west coast bays. M. A. Thesis. Univ. South Florida. Tampa.

HARRIS, F. R. 1972. Planning/engineering/environmental review Tampa Harbor—Florida 43 foot dredging project East Bay/Port Sutton Channel/Cut "C". F. R. Harris, Inc., Consulting Engineers.

HEALD, E. J. 1971. The production of organic detritus in a south Florida estuary. Sea Grant Tech. Bull. 6:viii + 110 pp.

HIGMAN, J. B. 1955. Observations on the live bait shrimp industry of Pasco and Pinellas Counties, Florida. Florida State Bd. Conserv. Mar. Lab. Univ. Miami, 55-16:4 pp.

________, AND R. ELLIS. 1955. Investigation of sport and commercial fishery activities in Old Tampa Bay north of Gandy Bridge. Florida State Bd. Conserv. Mar. Lab. Univ. Miami, 55-20:5 pp.

HOPKINS, T. L. 1973. Zooplankton. pp. IIIF-1—IIIF-10. *In* JONES, J. I. et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico. Martin Marietta Aerospace. Orlando.

HUET, M. 1965. Water quality criteria for fish life. pp. 160-167. *In* TARZWELL, C. (ed.), Biological Problems in Water Pollution. U. S. Public Health Serv. Publ. 999-WP-25.

HUMM, H. J. 1964. Epiphytes of the sea grass, *Thalassia testidinum*, in Florida. Bull. Mar. Sci. Gulf Carib. 14:306-341.

________. 1973a. Salt marshes. pp. IIIA-1—IIIA-6. *In* JONES, J. I. et al. (eds.) A Summary of Knowledge of the Eastern Gulf of Mexico. Martin Marietta Aerospace. Orlando.

________. 1973b. Mangroves. pp. IIID-1—IIID-6. ibid.

________. 1973c. Seagrasses. pp. IIIC-1—IIIC-10. ibid.

________. 1973d. Benthic algae of the eastern Gulf of Mexico. pp. IIIB-1—IIIB-15. ibid.

HUTTON, R. F., B. ELDRED, K. D. WOODBURN, AND R. M. INGLE. 1956. The ecology of Boca Ciega Bay with special reference to dredging and filling operations. Florida State Bd. Conserv. Mar. Lab. Tech. Ser. 17:87 pp.

INGLE, R. M. 1952. Studies on the effect of dredging operations upon fish and shellfish. Florida State Bd. Conserv. Tech. Ser. 5:26 pp.

ISAAC, P. C. G. 1965. The contribution of bottom muds to the depletion of oxygen in rivers and suggested standards for suspended solids. pp. 346-354. *In* TARZWELL, C. (ed.) Biological Problems in Water Pollution. U. S. Public Health Ser. Publ. 999-WP-25.

JONES, J. I., R. E. RING, M. O. RINKEL, AND R. E. SMITH (eds.). 1973. A Summary of Knowledge of the Eastern Gulf of Mexico. Martin Marietta Aerospace. Orlando.

JORDAN, C. L. 1973. Climate. pp. IIA-1—IIA-22. *In* JONES, J. I. et al. (eds.) A Summary of Knowledge of the Eastern Gulf of Mexico. Martin Marietta Aerospace. Orlando.

JOSEPH, E. B., AND F. E. NICHY. 1955. Literature survey of the Tampa Bay area: Part II. algae, marine fouling and boring organisms. Florida State Univ. Oceanogr. Inst. Publ. (mimeographed)

JOYCE, E. A., JR. 1968. Current research. Mar. Res. Lab. Florida Bd. Conserv. St. Petersburg. 8 pp.

KELLY, J. A., JR., AND A. DRAGOVICH. 1967. Occurrence of macrozooplankton in Tampa Bay, Florida and the adjacent Gulf of Mexico. U. S. Fish. Wild. Serv. Fish. Bull. 66:209-221.

________, AND L. JOHNSON, JR. 1967. Chemical environment project (Primary production). pp. 11-72. *In* Report of the Bur. of Commercial Fisheries Biological Laboratory, St. Petersburg Beach, fiscal year 1966. U. S. Fish Wildl. Serv. Circ. 257.

KING, J. E. 1949. A preliminary report on the plankton of the west coast of Florida. Quart. J. Florida Acad. Sci. 12:109-137.

LAKELA, O., AND R. W. LONG. 1970. Plants of the Tampa Bay Area. Dept. Bot. Bacteriol. Univ. South Florida. Tampa. pp. vi + 109.

LINDALL, W. N., JR., J. R. HALL, AND C. H. SALOMAN. 1973. Fishes, macroinvertebrates, and hydrological conditions of upland canals in Tampa Bay, Florida. Natl. Mar. Fish. Serv. Bull. 71:155-163.

LOHSE, E. A., A. J. SCOTT, AND C. GROAT. 1969. Tampa Bay estuarine system-case study. *In* Gulf Universities, Research Corporation. Case Studies of estuarine sedimentation and its relation to pollution of the estuarine environment—a report to the FWPCA. FWPCA contract No. 14-12-445.

MARMER, H. A. 1954. Tides and sea level in the Gulf of Mexico. pp. 101-118. *In* GALTSOFF, P. S. (Coordinator) Gulf of Mexico, its Origin, Waters, and Marine Life. U. S. Fish Wildl. Serv. Fish. Bull. 55.

MARSHALL, N. 1956. Chlorophyll *a* in the phytoplankton in coastal waters of the eastern Gulf of Mexico. J. Mar. Res. 15:14-32.

MARTIN, D. F., AND A. B. CHATTERJEE. 1970. Some chemical and physical properties of two toxins from the red-tide organism, *Gymnodinium breve.* U. S. Fish. Wildl. Serv. Fish. Bull. 68:433-443.

________, M. T. DOIG, III, AND R. H. PIERCE, JR. 1971. Distribution of naturally occurring chelators (humic acids) and selected trace metals in some West Coast Florida streams, 1968-1969. Florida Dept. Nat. Resources Mar. Res. Lab. Prof. Pap. Ser. 12:1-52.

MCNULTY, J. K., L. JOHNSON, JR., E. A. ANTHONY, AND W. N. LINDALL, JR. 1970. Plankton ecology project. pp. 20-22. *In* Report of the Bur. of Commercial Fisheries Biological Lab., St. Petersburg Beach, Fla., fiscal year 1969. U. S. Fish. Wildl. Serv. Circ. 342.

———, W. N. Lindall, Jr., and J. E. Sykes. 1972. Cooperative Gulf of Mexico estuarine inventory and study, Florida: Phase I, area description. Natl. Mar. Fish. Serv. Circ. 368:pp. vii + 126.

Moe, M. A., Jr., and G. T. Martin. 1965. Fishes taken in monthly trawl samples offshore of Pinellas County, Florida, with new additions to the fish fauna of the Tampa Bay area. Tulane Stud. Zool. 12(4):129-151.

Nelson, G. E. 1968. Amphioxus in Old Tampa Bay, Florida. Quart. J. Florida Acad. Sci. 31:93-100.

Odum, W. E. 1971. Pathways of energy flow in a south Florida estuary. Sea Grant Tech. Bull. 7:xi + 162 pp.

Olson, F. C. W. 1953. Tampa Bay Studies. Florida State Univ. Oceanogr. Inst. Rept. 1, Contrib. 19:27 pp.

———, and J. B. Morrill, Jr. 1955. Literature survey of the Tampa Bay area. Part I. Oceanogr. Inst. Florida State Univ.

Paine, R. T. 1961. Observations on *Phoronis architecta* in Florida waters. Bull. Mar. Sci. Gulf Carib. 11:457-462.

———. 1963. Ecology of the brachiopod *Glottidia pyramidata*. Ecol. Monogr. 33:225-280.

Phillips, R. C. 1960a. Ecology and distribution of marine algae found in Tampa Bay, Boca Ciega Bay, and at Tarpon Springs, Florida. Quart. J. Florida Acad. Sci. 23:222-260.

———. 1960b. Observations on the ecology and distribution of the Florida Seagrasses. Florida State Bd. Conserv. Mar. Lab. Prof. Pap. Ser. 2:27 pp.

———. 1962. Distribution of seagrasses in Tampa Bay, Florida. Florida State Bd. Conserv. Mar. Lab. Spec. Sci. Rept. 6:12 pp.

Pierce, E. L. 1951. The chaetognatha of the west coast of Florida. Biol. Bull. 100:206-228.

———. 1965. The distribution of lancets (amphioxi) along the coast of Florida. Bull. Mar. Sci. Gulf Carib. 15:480-494.

Pomeroy, L. R. 1960. Primary productivity of Boca Ciega Bay, Florida. Bull. Mar. Sci. Gulf Carib. 10:1-10.

Pulley, T. E. 1952. A zoogeographic study based on the bivalves of the Gulf of Mexico. Ph.D. Thesis. Harvard Univ. Cambridge.

Rinckey, G. R., and C. H. Saloman. 1964. Effect of reduced water temperature on fishes of Tampa Bay, Florida. Quart. J. Florida Acad. Sci. 27:9-16.

Ross, B. E. 1973. The hydrology and flushing of the bays, estuaries, and nearshore areas of the eastern Gulf of Mexico. pp. IID-1—IID-45. *In* Jones, J. I. et al. (eds.) A Summary of the Knowledge of the Eastern Gulf of Mexico. Martin Marietta Aerospace. Orlando.

Rousenfell, G. A., and A. Dragovich. 1966. Correlation between oceanographic factors and abundance of the Florida red tide (*Gymnodinium breve* Davis) 1954-61. Bull. Mar. Sci. 16:404-422.

Saloman, C. H. 1964. The shrimp *Trachypenaeus similis* in Tampa Bay. Quart. J. Florida Acad. Sci. 27: 165.

———. 1965. Bait shrimp (*Penaeus duorarum*) in Tampa Bay, Florida—biology, fishery economics, and changing habitat. U. S. Fish Wildl. Serv. Spec. Sci. Rept. Fish. 520:iii + 16 pp.

———. 1968. Diel and seasonal occurrence of pink shrimp *Penaeus duorarum* Burkenroad, in two divergent habitats of Tampa Bay, Florida. U. S. Fish Wildl. Spec. Sci. Rept. Fish. 561:iii + 6 pp.

———. 1973a. Hydrographic observations in Tampa Bay, Florida—1970. Natl. Mar. Fish. Serv. Data Rept. 77:246 pp.

———. 1973b. Hydrographic observations in the Gulf of Mexico off Pinellas County, Florida (November 1970—January 1972). Natl. Mar. Fish. Serv. Data Rept. 78:224 pp.

———, J. H. Finucane, and J. A. Kelly. 1964. Hydrographic observations in Tampa Bay, Florida and the adjacent waters, August 1961–December 1962. U. S. Fish Wildl. Serv. Data Rept. 4:112 pp.

———, and J. L. Taylor. 1968. Hydrographic observations in Tampa Bay, Florida, and the adjacent Gulf of Mexico—1965-66. U. S. Fish Wildl. Serv. Data Rept. 24:393 pp.

———, and ———. 1969. Age and growth of large southern quahogs from a Florida estuary. Proc. Natl. Shellfish Assoc. 59:46-51.

———, and ———. 1971a. Hydrographic observations in Tampa Bay and the adjacent Gulf of Mexico—1967. Natl. Mar. Fish. Serv. Data Rept. 55:64 pp.

———, and ———. 1971b. Hydrographic observations in Tampa Bay and the adjacent Gulf of Mexico—1968. Natl. Mar. Fish. Serv., Data Rept. 63:204 pp.

———, and ———. 1972. Hydrographic observations in Tampa Bay, Florida—1969. Natl. Mar. Fish. Serv. Data Rept. 73:82 pp.

Santos, S. L. 1972. Distribution and abundance of the polychaetous annelids in Lassing Park, St. Petersburg, Florida. M. A. Thesis. Univ. South Florida. Tampa.

________, AND J. L. SIMON. 1974. Distribution and abundance of the polychaetous annelids in a South Florida estuary. Bull. Mar. Sci. 24:669-689.

SCHREIBER, R. W., AND R. W. RISEBROUGH. 1972. Studies of the brown pelican. Wilson Bull. 84:119-135.

SHAW, A. J. (ed.) 1973. 1972 Water quality-Hillsborough County, Florida. Hillsborough County Environmental Protection Commission.

SHERK, J. A., JR. 1971. The effects of suspended and deposited sediments on estuarine organisms. Chesapeake Biol. Lab. Contrib. 443:73 pp.

________, AND L. E. CRONIN. 1970. The effects of suspended and deposited sediments on estuarine organisms. An annotated bibliography of selected references. Chesapeake Biol. Lab. Ref. 70:19:vi + 73 pp.

SIMON, J. L. 1965. Feeding in the annelid *Eteone heteropoda*. Quart. J. Florida Acad. Sci. 28:370-372.

________, AND D. M. DAUER. 1972a. A quantitative evaluation of red-tide induced mass mortalities of benthic invertebrates in Tampa Bay, Florida. Quart. J. Florida Acad. Sci. 35(Suppl. 1):12. (Abstract)

________, AND ________. 1972b. A quantitative evaluation of red-tide induced mass mortalities of benthic invertebrates in Tampa Bay, Florida. Environ. Letters 3:229-234.

________, AND ________. 1973. Repopulation of an intertidal habitat following defaunation: I. Defaunation and initial colonization. Amer. Zool. 13:1329. (Abstract)

________, AND J. P. DYER, III. 1972. An evaluation of siltation created by Bay Dredging and Construction Co. during oyster shell dredging operations in Tampa Bay, Florida, Jan. 1, 1972 to March 31, 1972. Final Res. Rept. Dept. Biol. Univ. South Florida. Tampa. pp 60.

SIMS, H. W., AND R. J. STOKES. 1967. A survey of the hard shell clam (*Mercenaria campechiensis*) (Gmelin) population in Tampa Bay, Florida. Florida State Bd. Conserv. Mar. Lab. Spec. Sci. Rept. 17:6 pp.

SPRINGER, V. G., AND A. J. MCERLEAN. 1961a. Spawning seasons and growth of the code goby, *Gobiosoma robustum* (Pisces:Gobiidae), in the Tampa Bay Area. Tulane Stud. Zool. 9(2):87-98.

________, AND ________. 1961b. Notes on and additions to the fish fauna of the Tampa Bay area. Copeia 1961:480-482.

________, AND K. D. WOODBURN. 1960. An ecological study of the fishes of the Tampa Bay area. Florida State Bd. Conserv. Mar. Lab. Prof. Pap. Ser. 1:104 pp.

STATE UNIVERSITY SYSTEM OF FLORIDA, INSTITUTE OF OCEANOGRAPHY. 1973. JONES, J. I. et al. (eds.) A Summary of Knowledge of the Eastern Gulf of Mexico. Martin-Marietta Aerospace. Orlando.

STEIDINGER, K. A. 1971. *Gonyaulax balechii* sp. nov. (Dinophyceae) with a discussion of the genera *Gonyaulax* and *Heteraulacus*. Phycologia 10:183-187.

________. 1973a. Phytoplankton. pp. IIIE-1—IIIE-17. *In* JONES, J. I. et al. (eds.) A Summary of the Knowledge of the Eastern Gulf of Mexico. Martin Marietta Aerospace. Orlando.

________. 1973b. Phytoplankton Ecology: A conceptual review based on eastern Gulf of Mexico research. pp. 49-68. CRC Critical Reviews in Microbiology.

________, J. T. DAVIS, AND J. WILLIAMS. 1967. A key to the marine dinoflagellate genera of the west coast of Florida. Florida State Bd. Conserv. Mar. Lab. Tech. Ser. 52:45 pp.

________, AND R. M. INGLE. 1972. Observations on the 1971 summer red tide in Tampa Bay, Florida. Environ. Letters 3:271-278.

STEWART, V. N., H. WAHLQUIST, AND R. BURKET. 1967. Occurrence of vitamin B_{12} along the Gulf coast of Florida. pp. 79-84. *In* Red tide studies, Pinellas to Collier Counties 1963-66. A symposium. Florida State Bd. Conserv. Mar. Lab. Prof. Pap. Ser. 9.

SYKES, J. E. 1964. Requirements of Gulf and South Atlantic estuarine research. Proc. Gulf Carib. Fish. Inst. Ann. Ser. 16:113-120.

________. 1968. Commercial values of estuarine generated fisheries on the South Atlantic and Gulf of Mexico Coast. pp. 73-78. *In* NEWSON, J. D. (ed.) Proc. Marsh and Estuary Management Symposium. T. J. Morgan's Sons, Inc. Baton Rouge.

________. 1971. Implications of dredging and filling in Boca Ciega Bay, Florida. Environ. Letters 1(2):151-156.

________, AND J. H. FINUCANE. 1966. Occurrence in Tampa Bay, Florida of immature species dominant in Gulf of Mexico commercial fisheries. U. S. Fish. Wild. Serv. Fish. Bull. 65:369-379.

________, AND J. R. HALL. 1971. Comparative distribution of mollusks in dredged and undredged portions of an estuary, with a systematic list of species. U. S. Fish Wildl. Serv. Fish. Bull. 68:299-306.

TAFT, W. H., AND D. F. MARTIN. 1974. Sedimentary fluorite in Tampa Bay, Florida. Environ. Letters 6:167-174.

TAMPA ELECTRIC COMPANY. 1973. Ecological surveys of the Big Bend area—supplement. Tampa Electric Co. 3(5):iv + 137 pp.

TAYLOR, J. L. 1970. Coastal development in Tampa Bay, Florida. Mar. Poll. Bull. 1(10):153-156.

__________. 1971. Polychaetous annelids and benthic environments in Tampa Bay, Florida. Ph.D. Thesis. Univ. Florida. Gainesville.

__________. 1972. Some effects of oyster shell dredging on benthic invertebrates in Tampa Bay, Fla. Taylor Biol. Co. St. Petersburg Beach. pp. 16.

__________. 1973a. Studies of the effects of oyster shell dredging in Tampa Bay, Florida. Taylor Biol. Co. St. Petersburg Beach. pp. 7.

__________. 1973b. Biological studies and inventory. Tampa Harbor Florida Project. Rept. submitted to Corps of Engineers, Jacksonville District. pp. 101 + appendices. (mimeographed)

__________, D. L. FEIGENBAUM, AND M. STURSA. 1973. Utilization of marine and coastal resources. pp. IV-1—IV-63. *In* JONES, J. I. et al. (eds.) A Summary of Knowledge of the Eastern Gulf of Mexico. Martin Marietta Aerospace. Orlando.

__________, J. R. HALL, AND C. H. SALOMAN. 1970. Mollusks and benthic environments in Hillsborough Bay, Florida. U. S. Fish. Wildl. Serv. Fish. Bull. 68:191-202.

__________, AND C. H. SALOMAN. 1966a. Benthic project. pp. 5-8. *In* Report of the Bur. of Commercial Fisheries Biological Station, St. Petersburg Beach, Florida, fiscal years 1962-64, U. S. Fish Wildl. Serv. Circ. 239.

__________, AND __________. 1966b. Benthic project. pp. 4-9. ibid. fiscal year 1965. U. S. Fish Wildl. Serv. Circ. 242.

__________, AND __________. 1967. Benthic project. pp. 4-8. ibid. fiscal year 1966. U. S. Fish. Wildl. Serv. Circ. 257.

__________, AND __________. 1968a. Some effects of hydraulic dredging and coastal development in Boca Ciega Bay, Florida. U. S. Fish Wildl. Serv. Fish. Bull. 67:213-241.

__________, AND __________. 1968b. Benthic project. pp. 3-8. *In* Report of the Bureau of Commercial Fisheries Biological Laboratory, St. Petersburg Beach, Florida, fiscal year 1967. U. S. Fish. Wildl. Serv. Circ. 290.

__________, AND __________. 1968c. Rearing lugworms for fish bait. Commerc. Fish. Rev. 30:61-63.

__________, AND __________. 1969a. Sediments, oceanographic observations, and floristic data from Tampa Bay, Florida and adjacent waters, 1961-1965. U. S. Fish Wildl. Serv. Data Rept. 34:562 pp.

__________, AND __________. 1969b. Benthic project. pp. 3-10. *In* Report of the Bur. of Commercial Fisheries Biological Laboratory, St. Petersburg Beach, Florida, fiscal year 1968. U. S. Fish Wildl. Serv. Circ. 313.

__________, AND __________. 1970. Benthic project. pp. 3-10. ibid. fiscal year 1969. U. S. Fish Wildl. Serv. Circ. 342.

__________, __________, AND K. W. PREST, JR. 1973. Harvest and regrowth of turtle grass (*Thalassia testudinum*) in Tampa Bay, Florida. Natl. Mar. Fish. Serv. Fish. Bull. 71:145-148.

TURNER, J. T., AND T. L. HOPKINS. 1974. Phytoplankton of the Tampa Bay System, Florida. Bull. Mar. Sci. 24:101-121.

U. S. DEPARTMENT OF COMMERCE. 1951. Tidal current charts, Tampa Bay. U. S. Coast and Geodetic Survey.

VIRNSTEIN, R. W. 1972. Effects of heated effluent on density and diversity of benthic infauna at Big Bend, Tampa Bay, Florida. M. A. Thesis. Univ. South Florida. Tampa. 49 pp.

WILLIAMS, R. H. 1954. Distribution of chemical constituents of sea water in the Gulf of Mexico. pp. 143-151. *In* GALTSOFF, P. S. (Coordinator) Gulf of Mexico, its Origin, Waters and Marine Life. U. S. Fish Wildl. Serv. Fish. Bull. 89.

WOODBURN, K. D., B. ELDRED, E. CLARK, AND R. F. HUTTON. 1957. The live bait shrimp industry of the west coast of Florida (Cedar Key to Naples). Florida State Bd. Conserv. Mar. Lab. Tech. Ser. 21:33 pp.

WOOLFENDEN, G. E., AND R. W. SCHREIBER. 1973. The common birds of the saline habitats of the eastern Gulf of Mexico: Their distribution, seasonal status, and feeding ecology. pp. IIIJ-1—IIIJ-22. *In* JONES, J. I. et al. (eds.) A Summary of Knowledge of the Eastern Gulf of Mexico. Martin Marietta Aerospace. Orlando.

WRIGHT, A. A. 1890. *Amphioxus* in Tampa Bay. Amer. Nat. 24:1085.

Florida Sci. 37(4):217-244. 1974.

MAJOR FEATURES OF THE APALACHICOLA BAY SYSTEM: PHYSIOGRAPHY, BIOTA, AND RESOURCE MANAGEMENT

Robert J. Livingston (1), Richard L. Iverson (2), Robert H. Estabrook (2), Vernon E. Keys (3), and John Taylor, Jr. (3)

(1) Department of Biological Science, (2) Department of Oceanography, Florida State University, Tallahassee, Florida 32306;
(3) Department of Health and Rehabilitative Services, Florida Division of Health, P. O. Box 210, Jacksonville, Florida 32201

Abstract: *A review was made of various features of the Apalachicola Bay System. Unique physical, chemical, and biological features of this system combine to make it one of the most productive estuarine areas in the State of Florida. Primary productivity and secondary productivity are discussed in relation to various forcing functions (natural and man-induced). Problems associated with development include dredging, sewage effluents, pesticides and a number of up-river activities such as industrialization, cattle ranching, channelization, and damming. The Apalachicola Drainage System is viewed as one of the largest relatively unpolluted areas in the country. However, it is a neglected resource with little management or control; as such it is presently endangered by a number of activities. It is suggested that critical information necessary for the management and protection of this system be obtained, and that the impact of watershed alterations be viewed on a regional basis with coordinated participation of the involved states (Florida, Georgia, and Alabama).*

The Apalachicola Drainage System (Fig. 1) covers an area in excess of 19,500 sq miles (7,530 sq km) in three states (Florida, Georgia, and Alabama). It is composed of four major rivers (Flint, Chattahoochee, Apalachicola, Chipola) and numerous streams and creeks. The Flint and Chattahoochee rivers flow into Lake Seminole, a 37,500 acre reservoir formed by the Jim Woodruff Dam. Drainage from this reservoir forms the Apalachicola River which, together with the Chipola, is a major source of fresh water and nutrients for the Apalachicola Bay System (Fig. 2). For approximately 80% of its length (105 miles or 175 km), the Apalachicola River is bounded by a series of swamps and marshes, and represents the largest drainage in Florida with an average flow rate of 23,460 cfs (U. S. Geological Survey, 1971). The Apalachicola System is actually a multifold complex of interlocking wetland habitats that include river-stream-creek associations, wooded and shrub swamps, shallow and deep marshes, and an extensive estuarine-coastal area. The extensive flow is a significant factor in the ecology of the Apalachicola Bay System which serves as an interface between the fresh water upland areas and the Gulf of Mexico.

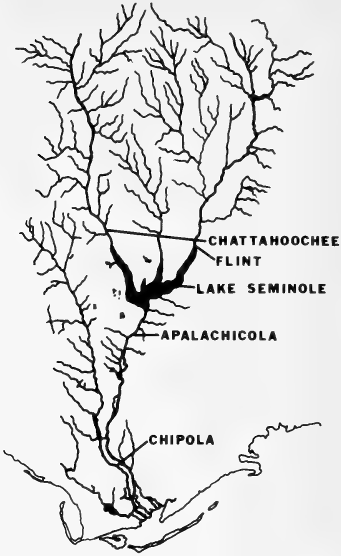

Fig. 1. The lower half of the Apalachicola Drainage System including the major rivers that contribute to the Apalachicola Bay System.

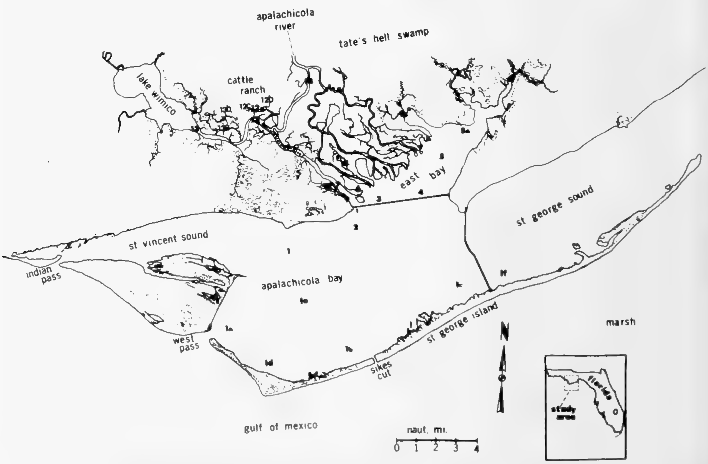

Fig. 2. The Apalachicola Bay System showing permanent sampling stations for current projects (Florida Sea Grant; and Franklin County).

There is a relative paucity of scientific information concerning the Apalachicola Drainage System. Physical, chemical, and qualitative biological data on the Apalachicola River are available (Cox, 1969; Cox, 1970; Cox and Auth, 1971; Cox and Auth, 1972; Cox and Auth, 1973). Some trace metal concentrations for the river have also been determined (Lawrence, 1968). Much of the present knowledge of the bay system is related to an interest in the extensive oyster industry of Apalachicola Bay. Early survey work (Swift, 1897; Moore, 1897; Danglade, 1917) was largely descriptive, and dealt with the extent and location of the oyster bars. Pearse and Wharton (1938) introduced some hydrological data and notes on the biota. More recent work (Ingle, 1951; Ingle and Dawson, 1950, 1952, 1953; Menzel et al., 1957, 1966) reviewed various influences on the oysters of Apalachicola Bay. Curl (1959) made a general hydrological survey of the Northeastern Gulf of Mexico and noted the influence of the Apalachicola River up to 160 miles (267 km.) to the south in the Gulf. Dawson (1955) completed a one year survey of the surface temperature and salinity conditions of Apalachicola Bay in anticipation of the completion of the Jim Woodruff Dam and the dredged boat channel through St. George Island (Bob Sikes' Cut). He found short-term and long-term salinity changes due to the cumulative effects of wind direction and velocity, local runoff, tidal conditions, and river discharge. Gorsline (1963) showed non-seasonal salinity variations in Apalachicola Bay; he estimated the residence time of river water in the area to vary from a few days to a month. Brooks (1973) found that fine grained sediments delivered by the Apalachicola River are almost entirely contained in the Bay. Menzel and Cake (1969) made one of the few comprehensive biological evaluations of the bay.

At present, several long-term studies of the Apalachicola Bay System are in progress. In accordance with the State of Florida's requirements according to the National Shellfish Sanitation Program, the Florida Division of Health maintains a continuing program of field collection and analysis of Group Coliform Indices of the area. Richard L. Iverson (Florida State University) is conducting a two year (1973-74) analysis of the nutrient budget and primary productivity of Apalachicola Bay. Robert J. Livingston (Florida State University) is running a three year (1972-74) study (Florida Sea Grant Program) of the macroinvertebrates and fishes of the Apalachicola Bay System, and is making an evaluation of the possible effects of human activities on the bay system. The following is a partial analysis of data collected by these three projects with an evaluation of present management policies associated with the Apalachicola Drainage System as a whole.

Material and Methods—Water temperature was determined by calibrated stick thermometers and a Beckman RS5-3 portable salinometer ($\pm$.5°C). Salinity was measured with a Beckman salinometer ($\pm$0.3‰) calibrated by a Bissett-Berman model 6230 laboratory salinometer ($\pm$.003‰) and rechecked prior to sampling with a 47 ohm resistor ($\pm$10%). Turbidity was analyzed using a Hach model 2100A laboratory turbidimeter ($\pm$2% of scale) and was expressed as Jackson Turbidity Units (J. T. U.). The extinction values for all nutrient samples, after filtration through pre-washed 47mm, Type A, Gelman glass fiber filters, were determined on a Coleman Perkin-Elmer model III, UV-VIS spectrophotometer. Ammonia was determined by the Solorzano (1969) method using triple distilled water and one ml perchloric acid per l of the final distillation. Orthophosphate (inorganic, soluble, reactive) was measured using the Murphy and Riley method (Strickland and Parsons, 1972). Nitrite was measured according to the Bendschneider-Robinson method (Strickland and Parsons, 1972), while nitrate determination was based on a modification of the Morris and Riley method (Strickland and Parsons, 1972). Reactive silicate was measured according to a Mullin-Riley method with modifications as shown in Strickland and Parsons (1972).

Chlorophyll *a* analysis included filtration of the 500 ml samples through 47 ml, Type A, Gelman glass fiber filters. Samples were processed according to Strickland and Parsons (1972). Samples were placed in a refrigerator (dark) for 2 hr and then were centrifuged. Extinctions were measured in a Colman spectrophotometer. The Parsons-Strickland equations were used to determine chlorophyll *a* concentrations. Phytoplankton productivity was determined using a radio-active carbon method (Steeman-Nielsen, 1952). Incubation was performed *in situ* for 3-4 hr and radioactivity was determined by liquid scintillation counting (Schindler, 1966; Wolfe and Schelske, 1967; Ward and Nakanishi, 1971) with a Beckman LS-100c Liquid Scintillation System. Two min plankton tows (80μ mesh #20 Nytex phytoplankton net) were used for qualitative phytoplankton determinations. Nutrient enrichment experiments (Ryther and Guillard, 1959; Menzel and Ryther, 1961) were also carried out. Nitrate, phosphate, and silicate were added singly and in combination, and carbon-14 activity was determined by scintillation counting. Microbiological samples for the determination of Group Coliform indices were regularly taken at fixed stations in Apalachicola Bay. Group + fecal coliform most probable numbers (MPN) were determined from 5 tube 3 dilution MPN tables based on the fermentation of lactose in the presence of brilliant green + 2% bile and the fermentation of lactose at $44.5 \pm 0.2°C$ respectively. Biological sampling was completed with seines, dipnets, and 16 ft otter trawls. Preliminary leaf utilization experiments were conducted by placing leaves from upland areas in closed wire mesh baskets lined with fiber glass screening: five weighted baskets were placed at station 4 on 15 December, 1973.

Baskets: $8 \times 8 \times 8$ in
Frame: 1/2 in galvanized hardware cloth
Liner: A/coarse—2 mm^2 nylon screen (4 cages)
Liner: B/fine—0.5 mm^2 nylon net (1 cage)

Samples were taken from the baskets in January and February, 1974.

THE APALACHICOLA RIVER SYSTEM—The drainage area below the Jim Woodruff Dam is sparsely populated with relatively little farmland or industrial development. Much of the land is composed of pine flatwoods, hardwood hammocks, swamps, and marshes. Major timber interests occupy the area with large portions having been cut over for lumber and pulp wood. The wetlands include rivers, streams, wooded and shrub swamps, shallow freshwater and brackish marshes, and various forms of emergent and submerged vegetation that contribute to an exceptionally productive ecosystem.

According to Cox (1969, 1970), Cox and Auth (1971, 1972, 1973), dredging activities and spoil bank practices have added to the naturally high turbidity. Seasonally high water conditions cause flooding, swift currents, and increased scouring and turbidity. Significant flow fluctuations occur on a seasonal and annual basis (U. S. Geological Survey, 1971). Rainfall is highest during the months of March, July, and August with flood-producing storms often occurring during late winter and early spring. During periods of high flow, the flood plain can be extensive. Overflows of the streams and rivers, and periodic flooding of large portions of the Apalachicola wetlands are considered to be important to the ecological balance of the area although little scientific information is available concerning the mechanism of nutrient flow and ecological relationships. The river is characterized by riffle areas, rocky (scoured) outcrops, and ox-bow lakes (Cox, 1969). Relatively low oxygen values from Lake Seminole are considered as a periodic stress factor. This, together with habitat destruction due to dredging and extreme flow rate fluctuations have caused a monotonous fauna characterized by relatively low productivity in some areas. Although stressed, the river is still relatively productive in most areas (Cox and Auth, 1971, 1972, 1973) with principle fish species including sunfish (*Lepomis* spp.), catfish (*Ictalurus* spp.), largemouth bass (*Micropterus salmoides*), atlantic sturgeon (*Acipenser oxyrhynchus*), striped bass (*Morone saxatilis*), skipjack herring (*Alosa chrysochloris*), and Alabama shad (*Alosa alabamae*). Due to relatively rapid flow rates, the movement of pollutants down river is possible although such movement would necessarily be complicated by the nature of the pollutant, turbidity variations, current characteristics, and bottom types. Brooks (1973) considers that fine grained sediments delivered by the Apalachicola River are almost entirely contained in the bay. Menzel and Cake (1969) estimate that substantial portions of the freshwater runoff that reaches the bay comes from upland swamp and marsh areas. The Tate's Hell Swamp, with runoff from the Little St. Marks, St. Marks, and East rivers contributes runoff from about 500 sq miles of swampland. The upland drainage system is thus inextricably linked with the bay. Surface runoff features, nutrient and detritus characteristics, salinity fluctuations, and levels of pollution of the Apalachicola Bay System are directly dependent on the river.

The Apalachicola Bay System

Geomorphological Factors—The Apalachicola Bay System (latitudes 29°35′N to 29°50′N; longitudes 18°15′W to 18°40′W) is a shallow coastal estuary bounded by a series of barrier islands. It has a total area of about 212 sq miles and is composed of East Bay, St. George Sound, Apalachicola Bay, Indian Lagoon, and St. Vincent Sound (Fig. 1). Approximately 20 sq miles of marshes are associated with this lagoon-and-barrier island complex. The enclosing series of barrier islands together with the (seasonal) fresh water inflows prohibit a stable non-tidal current system. The bay averages 9 ft (2.7 m) in depth at mean low water. A quartz sand base is covered with up to 20 m of sediment consisting primarily of silt and clay. Connections with the open Gulf consist of one dredged pass (Sike's Cut), two natural channels (Indian Pass and West Pass), and the St. George Sound.

Physical and Chemical Parameters—Swift (1897) discussed the significance of freshwater discharge from the Apalachicola River. Such discharge, together with wind speed and direction control the salinity distribution of the bay system. Dawson (1955) provided a detailed description of the hydrography of Apalachicola Bay based on monthly samples. During periods of high river discharge, the bay is fresh while during other times of the year, surface salinities are controlled by wind speed and direction. Winds over Apalachicola Bay are predominantly from the northwest during the winter and from the south during the summer (Jordan, 1973). Dawson (1955) considered that no significant vertical stratification occurred since the shallow bay is rapidly mixed by wind action. Our studies indicate that strong winds do mix the water column, but during periods of moderate wind speed (great enough to drive surface waters but not strong enough to mix the water column), the surface salinity is uncoupled from the bottom salinity (Estabrook, 1973). Tongues of high salinity water often extend into the bay along the bottom from both West Pass and Sikes' Cut (Fig. 3a and 3b). Average salinity values for Apalachicola Bay are shown in Fig. 4. Water temperatures usually parallel the air temperatures in a predictable fashion (Dawson, 1955). An annual range of monthly average water temperatures usually approximates 16.5°C. Tides in the bay are affected by winds and can be modified during periods of prolonged high winds (Gorsline, 1963). Maximum tidal range is approximately 1 m with a usual range of 0.5 to 0.7 m. Tides are semidiurnal with diurnal inequality.

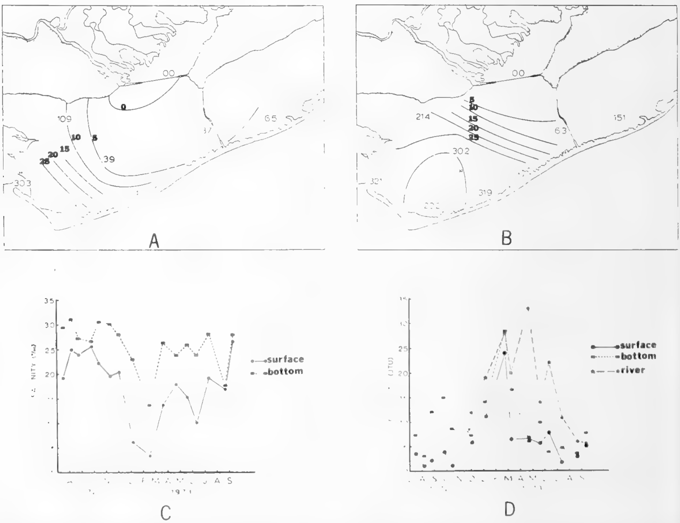

Fig. 3. (A) Surface salinities for 19 May, 1973. (Contour lines, 5‰; S. and S.W. winds, 8-12 kn; flood tide); (B) Bottom salinity for 19 May, 1973. (Contour lines, 5‰; S. and S.W. winds, 8-12 kn; flood tide); (C) Average seasonal variation in salinity for Apalachicola Bay; (D) Average seasonal variation in turbidity for the Apalachicola River-Bay System.

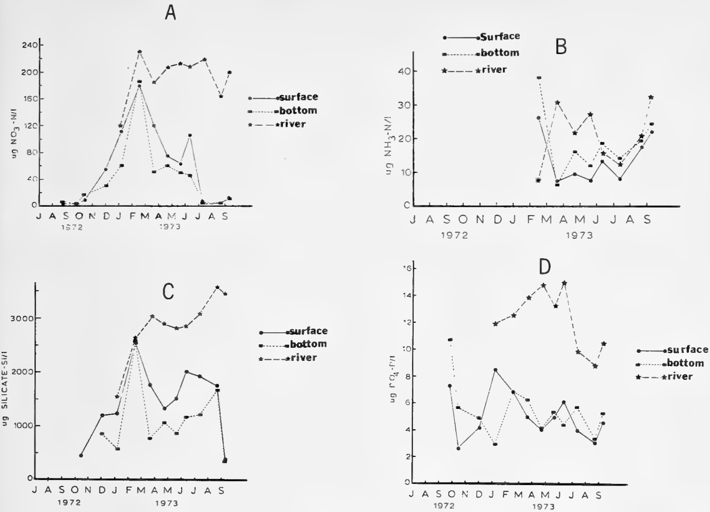

Fig. 4. Average seasonal variation for the Apalachicola River-Bay System in: (A) nitrate-nitrogen; (B) ammonia-nitrogen; (C) silicate-silica; and (D) orthophosphate.

Water turbidity (Fig. 3d) was strongly correlated with river discharge except during periods when bottom sediments were suspended in the water column as a result of wind mixing. At a given time, nutrients in the bay varied widely according to salinity with highest values usually associated with the freshest parts of the bay. Table 1 lists the correlation coefficients (r) of linear regressions of nitrate, orthophosphate, silicate, and ammonia on salinity. High negative correlation would indicate river water as a nutrient source. The narrow salinity range during February precluded the determination of a good linear relationship which explains the poor correlation of nutrients at this time even though nutrient values were high. Average bay values varied seasonally with highest nutrient concentrations found during high (winter) river discharge and low salinity. The nature of such variation is shown in Table 2.

Figure 4 shows the seasonal changes in the average nutrient values for bay and river water. Nitrate showed the greatest seasonal variation (180μ g/1 in February to 2-6μ g/1 in July). River nitrate concentration remained relatively stable however (180-220 μ g/1), thus indicating that decreased bay nitrate concentration was not due to decreased river concentrations but to decreased river flow rates and increased summer levels of biological activity. Ammonia values in the bay (7-25 μg/1) did not fluctuate to any degree during the year; there was no definite seasonal trend. The bay sometimes had greater ammonia concentrations than the river suggesting that zooplankton excretion or some similar source of ammonia may have existed. In contrast to nitrate, orthophosphate had no overt seasonality, and ranged from 4 to 8 μ g/1 for the entire year. The phosphate concentration in

TABLE 1. Correlation coefficients of linear regression of nitrate, orthophosphate, silicate, and ammonia on salinity.

Date		NO_3	PO_4	SiO_3	NH_3
Oct. 14, 1972	T	–.70	–.73		
	B	+.12	–.14		
Dec. 2, 1972	T	–.88	–.20	–.98	
	B	–.75	–.55	–.85	
Jan. 6, 1973	T	–.55	–.89	–.99	
	B	–.84	–.82	–.87	
Feb. 17, 1973	T	+.002	–.95	–.33	–.02
	B	+.58	–.11	–.002	–.15
Mar. 19, 1973	T	–.95	–.78	–.98	–.85
	B	–.97	–.60	–.998	–.45
Apr. 22, 1973	T	–.76	–.77	–.93	–.67
	B	–.62	–.62	–.80	–.93
May 19, 1973	T	–.88	–.54	–.998	–.48
	B	–.96	–.65	–.99	–.81
Jun. 11, 1973	T	–.60	–.01	–.995	–.55
	B	–.94	–.61	–.93	+.06
Jul. 12, 1973	T	–.82	–.10	–.97	–.82
	B	–.80	+.42	–.93	+.03
Aug. 22, 1973	T	–.90	+.04	–.95	–.50
	B	–.91	–.84	–.94	–.91
Sep. 10, 1973	T	–.99	–.29	–.995	–.83
	B	–.98	+.15	–.99	–.98

the river was always greater than that of the bay, but when the river flow decreased in the summer, the average phosphate concentration did not decline dramatically in the bay. Nutrient enrichment experiments showed stimulation of phytoplankton productivity by both nitrate and phosphate during August, 1973. This suggests that low concentrations of both nutrients were limiting phytoplankton productivity in the bay at that time. These nutrients were usually present in sufficient quantities during most of the year, although further study of this is necessary for any real conclusions to be formed. Silicate concentrations showed a seasonal trend similar to river discharge. Silicate concentrations in the

TABLE 2. Nutrient values for winter and summer for bay (mean $\pm$ standard deviation of 5 bay stations) and river water (station 2).

Nutrient	Site	Feb. 17, 1973	July 12, 1973
NO_3:	Bay T	179.53 ± 13.11	2.25 ± 2.84
(μg/1)	B	186.79 ± 19.48	4.24 ± 2.25
	River	232.90	219.54
NH_4^+:	Bay T	26.13 ± 18.53	8.05 ± 3.03
(μg/1)	B	38.15 ± 30.61	14.26 ± 4.40
	River	7.81	7.57
PO_4:	Bay T	6.92 ± 1.17	4.03 ± .76
(μg/1)	B	6.93 ± 1.29	5.78 ± 1.69
	River	12.63	9.53
Silicate:	Bay T	2531.80 ± 57.59	1939.66 ± 413.15
(μg/1)	B	2534.08 ± 62.88	1216.67 ± 802.98
	River	2632.55	3109.12

bay were great enough so that the amount incorporated into diatom frustules was insignificant and did not alter the concentration to any degree.

Biological Characteristics—Average chlorophyll *a* values for various Apalachicola Bay stations are shown in Fig. 5a. There was a range of 3-17 mg chlorophyll a/m^{-3} and bottom values often exceeded those on the surface. Average phytoplankton productivity as shown in Fig. 5b (measured with the carbon-14 method) ranged from 63 mg $cm^{-2}d^{-1}$ (February, 1973) to 1,694 mg $cm^{-2}d^{-1}$ (April, 1973). Minimal levels of chlorophyll *a* and productivity occurred during February and were associated with high river discharge and flushing of the bay. Except for a surface maximum during a calm day in January, productivity was uniform during the remainder of the year. *Chaetoceros lorenzianum, Bacteriastrum delicatulum* and *Thalassiothrix frauenfeldii* were dominant in the net plankton during spring and summer while *Skeletonema costatum, Rhizosolenia alata,* and *Coscinodiscus radiatus* were dominant during fall and winter months. Temperature was the primary limiting factor to phytoplankton growth while light, turbidity, nutrients, grazing, and flushing rates were additional controlling factors. Decreased river discharge in the summer could be associated with nutrient decreases. Apalachicola is a very productive bay, and is comparative to areas such as Tampa Bay (Sikes, 1970) and Long Island Sound (Riley, 1956). Estabrook (1973) has discussed these factors in considerable detail.

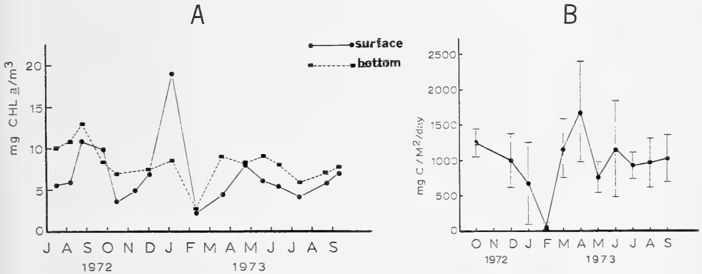

Fig. 5. (A) Average seasonal variation in chlorophyll *a* for Apalachicola Bay; (B) Average seasonal variation in productivity/m^2/day for Apalachicola Bay with 95% confidence intervals.

According to the National Estuary Study (1970), less than 7% of the bay bottom is covered by submergent vegetation (*Thalassia testudinum, Syringodium filiforme, Diplanthera wrightii, Halophila engelmannii*). The high turbidity of the area would account for the relative paucity of such benthic plant species. Major emergent plant species would include *Juncus roemerianus, Spartina alterniflora, Spartina patens, Distichlis spicata,* and *Salicornia perennis.* One of the major invertebrates species in Apalachicola Bay is the oyster (*Crassostrea virginica*) with large portions of bay bottom consisting of extensive oyster bars. Other dominant invertebrates would include the blue crab (*Callinectes sapidus*), white shrimp (*Penaeus setiferus*), brown shrimp (*Penaeus aztecus*), and the pink shrimp (*Penaeus duorarum*). Important finfishes would include the spot (*Leiostomus xanthurus*), croaker (*Micropogon undulatus*), redfish (*Sciaenops ocellatus*), and the seatrouts or weakfish (*Cynoscion* spp.). Various flatfishes are found such as Gulf flounder (*Paralichthys albigutta*), southern flounder (*Paralichthys lethostigma*), ocellated flounder (*Ancyclopsetta quadrocellata*), and hogchokers (*Trinectes maculatus*). Menhaden (*Brevoortia patronus*) are also present as well as striped (black) mullet (*Mugil cephalus*), silver (white) mullet (*Mugil curema*), and sheepshead (*Archosargus probatocephalus*). A list of fishes is shown in Table 3. As is the case in many estuarine areas, species diversity is relatively low (Buckley, 1973) but overall productivity is high. Stevenson (1969) has made observations of the bird populations in the vicinity of Apalachicola Bay. Various types of waterfowl have been observed although there was an unexplained decline in the number of such species over the period from 1954 to 1969 with the complete disappearance of canvasbacks and ruddy ducks. A number of trans-Gulf migrants such as common loons, grebes, pelicans, cormorants, herons, egrets, and geese

TABLE 3. Total numbers of fishes taken by otter trawls in Apalachicola Bay from March, 1972 to January, 1973—listed by rank.

Species	Number	Species	Number
Anchoa mitchilli	26,300	Gobionellus hastatus	11
Cynoscion arenarius	4,935	Syngnathus louisianae	10
Micropogon undulatus	3,672	Prionotus sp.	9
Menticirrhus americanus	845	Lepisosteus osseus	7
Bairdiella chrysura	737	Ictalurus natalis	6
Leiostomus xanthurus	664	Ictalurus punctatus	6
Chloroscombrus chrysurus	657	Selene vomer	5
Symphurus plagiusa	414	Sciaenops ocellatus	5
Etropus crossotus	407	Ophichthus gomesi	5
Arius felis	323	Micropterus salmoides	3
Prionotus tribulus	303	Caranx hippos	3
Trinectes maculatus	263	Alosa alabamae	2
Lucania parva	125	Anchoa hepsetus	2
Cynoscion nebulosus	83	Opsanus beta	2
Menidia beryllina	76	Urophycis floridanus	2
Lagodon rhomboides	69	Strongylura marina	2
Prionotus scitulus	65	Prionotus rubio	2
Dasyatis sabina	59	Monacanthus hispidus	2
Gobiosoma bosci	59	Centropristis philadelphica	2
Porichthys porosissimus	58	Peprilus burti	2
Gobiosoma robustum	55	Paralichthys albigutta	2
Microgobius gulosus	50	Chilomycterus schoepfi	2
Orthopristis chrysoptera	47	Ogilbia cayorum	1
Chaetodipterus faber	41	Hippocampus erectus	1
Eucinostomus gula	37	Aluterus schoepfi	1
Sphoeroides nephelus	35	Haemulon plumieri	1
Trachinotus falcatus	31	Scomber scombrus	1
Paralichthys lethostigma	31	Lutjanus griseus	1
Eucinostomous argenteus	31	Diplectrum formosum	1
Syngnathus scovelli	31	Microgobius thalassinus	1
Brevoortia patronus	29	Gobionellus sp.	1
Synodus foetens	38	Gobiosoma sp.	1
Dorosoma petenense	18	Myrophis punctatus	1
Syngnathus floridae	16	Rhinoptera bonasus	1
Archosargus probatocephalus	12	Dorosoma cepedianum	1
Monacanthus ciliatus	11		

utilize the area. During one 5.5 hr field trip, 84 species of such birds were sighted on St. George Island alone.

Commercial Fisheries—The economy of Franklin County is largely dependent on commercial fisheries associated with Apalachicola Bay. Various estuarine species comprise the bulk of such catches (Colberg and Windham, 1965; Colberg, et al., 1968). Major commercial species include oysters, blue crabs, shrimp, and various finfishes. Menzel and Cake (1969) state that at least three-fourths of the commercial landings are due to species that spend all or some part of their life history in Apalachicola Bay. According to the 1972 landings (Summary of Florida Commercial Marine Landings, Florida Department of Natural Resources, 1972) Franklin County ranked third in the state in the total value of marine landings, and is the foremost producer of oysters (Table 4). Rockwood (1973) has made a comprehensive analysis of the oyster resource of Apalachicola Bay. Oysters remain dependent on the bay system throughout their entire life. Because of their sedentary nature and mode of feeding, oysters are able to concentrate various types of pollutants. Oysters have an optimal salinity range of 15-25‰ Prolonged reduced salinities due to excessive rainfall can cause oyster mortality, while reduced runoff can cause lower levels of food as well as increased predation due to elevated salinities (Menzel and Cake, 1969). Shrimp are the second most valuable fishery in Franklin County, and according to Colberg et al. (1968), Apalachicola Bay is the major nursery for a large proportion of the local shrimp factory. This bay also serves as feeding grounds for the blue crab, black mullet, and numerous other commercially important species. An extensive sports fishery based on spotted seatrout, redfish, sheepshead, whiting, and flounder is also dependent on

TABLE 4. Comparison of oyster landings of Franklin County, the State of Florida, and the U. S.

Year	Franklin Co. (1000 lbs)	Florida (1000 lbs)	Ratio Co/State	United States (1000 lbs)	Ratio U.S./County
1950	695.957	895.248	77.7	76,415	0.98
1951	546.560	735.304	74.3	72,990	0.74
1952	451.145	562.987	80.1	82,242	0.54
1953	459.225	585.356	78.5	79,719	0.56
1954	553.946	685.496	80.8	81,922	0.66
1955	542.874	649.581	83.6	77,515	0.73
1956	722.046	888.735	81.2	75,134	0.95
1957	624.222	734.878	84.9	71,658	0.85
1958	713.230	824.729	86.5	66,396	1.05
1959	1,268.757	1,454.998	87.2	64,710	1.94
1960	1,744.760	1,975.400	88.3	60,010	2.94
1961	2,947.137	3,326.601	88.6	62,305	4.72
1962	4,366.700	5,019.771	87.0	56,037	7.75
1963	3,810.500	4,362.848	87.3	58,444	6.51
1964	2,252.377	2,885.123	78.1	60,534	3.71
1965	2,377.530	2,954.745	80.4	54,688	7.42
1966	3,809.941	4,291.925	88.8	51,223	7.42
1967	4,195.905	4,761.130	88.1	59,957	6.96
1968	4,825.668	5,568.773	86.7	61,886	7.76
1969	4,350.370	5,125.742	84.4	51,900	8.34
1970	3,044.401	3,786.519	80.4	53,603	5.64

Apalachicola Bay. Such species as pompano, jacks, bluefish, and spanish mackerel are also taken off the beaches and passes of the area.

Because of the social and economic circumstances in Franklin County, if anything should happen to the Apalachicola Bay System the consequences would be disastrous for the people of the area. Colberg et al. (1968) estimate that a clean bay that was worth $6.3 million in 1967 could be worth as much as $34.2 million by the year 2000. This would take into account the potential of the commercial and sports fisheries as well as tourist-oriented activities and recreation. The almost complete dependence of the people of Franklin County on the Apalachicola Bay System is an important factor when considering the value of the Bay since an entire way of life is at stake if the bay's productivity is reduced in any way.

AREAS OF POTENTIAL IMPACT

Domestic and Industrial Wastes—Coliform indicies have proven to be of value in measuring levels of domestic wastes and, in some instances, industrial wastes. With this background in view, USPHS has set a limit MPN value of 70 for Group Coliform organisms in approved oyster growing areas. Figure 6 shows prohibited and conditionally approved areas based on the aforementioned concepts. As the River flows along its pathway towards the Gulf, the system receives discharges from municipal, industrial and private sources. Thus, during periods of increased precipitation, runoff from these various sources increases. More fresh water is, therefore, discharged into the Bay system and one may measure this impact by computing Group Coliform MPN levels (Fig. 7). There appears to be a relationship between river heights and coliform MPN (Table 5). At times, coliforms coming from upriver areas do cause temporary halts in oystering in East Bay. No significant difference in Coliform Group MPN values exists between recent data and the studies by Wakefield et al. in the 1940's. However, as the human population grows along the river and bay systems, the possibilities for oyster

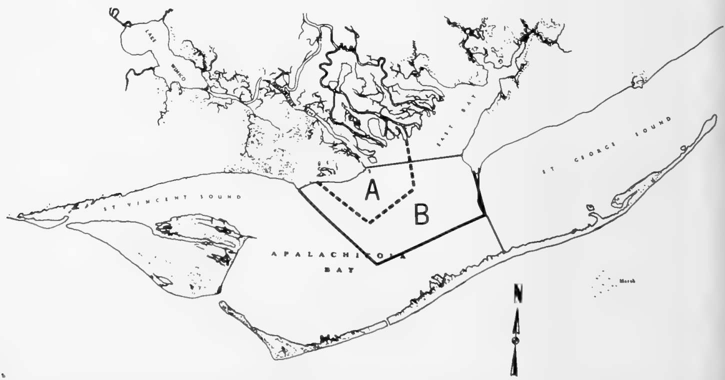

Fig. 6. Classification of the harvesting of shellfish in Apalachicola Bay (Area A = prohibited; Area B = conditionally approved).

contamination will increase unless adequate treatment facilities are available. Although the Coliform standard has been criticized as outdated and possibly too rigid, this problem could worsen if population pressure increases and septic tank usage is not curtailed. Since *E. coli* has been isolated from sources other than domestic sewage, the significance of Group MPN values as a method for differentiating sources of contamination does remain in question.

TABLE 5. Comparison of river height and MPN determinations from oysters taken from various stations in Apalachicola Bay.

River Stage (ft) 6.1-12.0		River Stage (ft) 12.1-18.0		River Stage (ft) 18.1-24.0
Group Fecal		Group Fecal		Group Fecal
*23 2	Median	*94 12	Median	*350 49
0 % ≧ 230 Group		20% ≧ 230 Group		53% ≧ 230 Group
0 % ≧ 76 Fecal		7% ≧ 76 Fecal		40% ≧ 76 Fecal

*NOTE: The above table is grouped data covering 17 stations (6.1-12.0 ft), 14 stations (12.1-18.0 ft), 13 stations (18.1-24.0 ft). River stage readings were obtained from the gauge located at Blountstown, Florida.

Waste Nutrients—In addition to the problem of sewage and septic tank runoff, other sources of nutrient enrichment should be considered. This would include industrial effluents, livestock operations, and fertilization programs of the agricultural and pulp mill interests. The situation in Escambia Bay would serve as an example of this potential problem (Livingston et al., 1972). Although water temperature appears to be a controlling factor for phytoplankton growth, excessive nutrients during critical periods of the year could cause an alteration in the phytoplankton composition from the present species. This could result in food chain phenomena characterized by high levels of primary productivity but low utilization by primary consumers as has been demonstrated in Escambia Bay (Livingston et al., 1972). As yet, there is no evidence that this is happening, and studies to date indicate that the bay is not in a state of cultural eutrophication (Estabrook, 1973). However, nutrient enrichment could provoke alterations in trophic relationships that might result in reductions in useful productivity of Apalachicola Bay. In such circumstances, the system would have a reduced utilizable resource even though the actual primary productivity would be increased.

Barrier Island Development—An important factor in the ecological constitution of the Apalachicola Bay System is the development of the barrier islands that ring the bay. St. Vincent Island, as a National Wildlife Refuge (under the management of the Bureau of Sports Fisheries and Wildlife), is not really a cause for concern since it is a managed area. Likewise, Dog Island, with limited access to the mainland and a consequent low growth potential, does not yet present formidable problems. St. George Island, however, is an area of high potential for ecological damage. This long, relatively narrow island of beaches and bayside marsh systems, occupies a strategic position as it encloses a considerable portion of Apalachicola Bay. Colberg et al. (1968), considered that the development of St. George Island was the most important growth prospect for tourism in Franklin County (Fig. 8). Access to the island by a toll bridge as well as the existence of a state park on the east end of the island are major factors for the optimistic outlook for development. The impact of the bridges remains unknown at this time although they could contribute to changes in current patterns and exchange rates. The present residential area on the island is growing at a relatively rapid rate, and

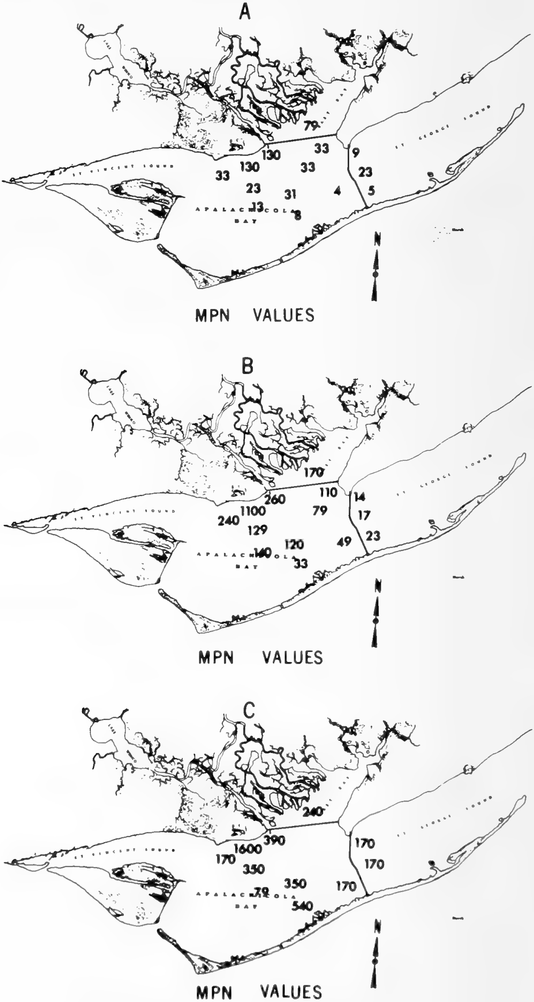

Fig. 7. Group Coliform levels at different river levels during 1973. (A) River Stage = 6.1–12.0 ft; (B) River Stage = 12.1–18.0 ft; and (C) River Stage = 18.1–24.0 ft.

is largely unplanned with no sewage facilities on the island. Because of its desirable natural setting and accessibility to the mainland, the future growth of St. George Island is virtually assured; this could eventually pose certain problems for the adjacent bay areas.

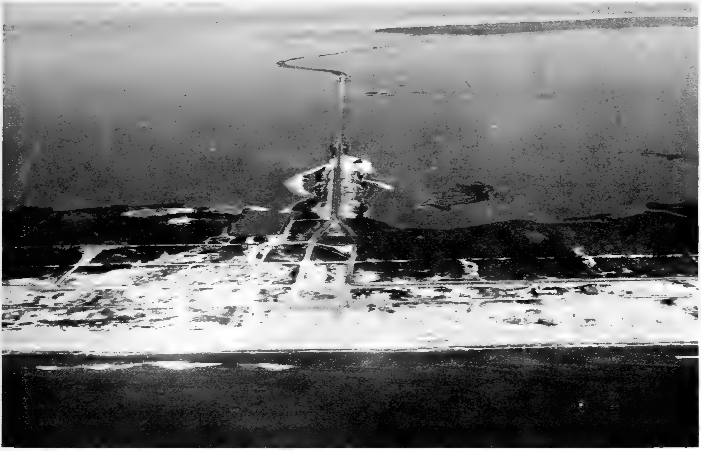

Fig. 8. Developed area of St. George Island and the bridge to the mainland.

Several factors should be considered in the development of the island. It is long and narrow which allows little room for natural filtering processes to work on human wastes and runoff. This situation could be aggravated by the restricted circulation of the bay system. In addition, some of the most productive oyster reefs are located in the immediate (bayside) vicinity of St. George Island, and there is an extensive shrimp fishery not far offshore. Sewage and fertilizer wastes, storm drainage and runoff from paved surfaces, destruction of the sand dunes and marshes, dredging and filling, and marina construction are potential problems that will have to be dealt with as the island is developed. Increased small boat operation in the bay could have an effect due to increased levels of oil, gas, trace metals, and nitrogenous wastes in the bay. Given the above considerations, St. George Island would have to be viewed as one of the most sensitive portions of the immediate bay area with regard to future development and impact. A combination of increased control of land areas by the State of Florida as well as a planned mode of development for the rest of the island will be essential to the compatibility of sustained use of the bay by commercial and recreational interests in the future. This will require careful consideration of such factors as density, roads, sewage, storm drainage, and maintenance of ecologically sensitive portions of the island such as marshes and beaches.

Pesticides—Agricultural and health agencies employ certain methods of insect control that include the use of various pesticides. Of these, the organochlorine insecticides (DDT, mirex, dieldrin, etc.) have been intensively monitored because of their persistence in the environment and adverse acute and chronic effects on certain forms of organisms. Preliminary results of a pesticide monitoring program (Livingston and Thompson, 1972-74) are shown in Table 6. It should be emphasized that these results are preliminary both in scope of analysis as well as duration of study. However, of approximately 100 samples, relatively low levels of DDT and its metabolites (DDE, DDD) are evident in sediment and animal samples. Increased population pressure often will create increased demand for public health insect control programs. In this area, this would include pests such as dogflies, sand-flies, and mosquitoes. Dogflies are a nuisance in the Apalachicola area, and are known to breed in windrows of seaweed deposited on the beaches; such areas are routinely sprayed with dibrom for dogfly control in north Florida. Since various larval and juvenile estuarine organisms nursery in areas of treatment, such control programs should be well-conceived and carefully monitored so that minimal damage is done to sensitive non-target organisms.

TABLE 6. Ranges of total DDT and Arochlor 1254 found in sediments and animals taken from Apalachicola Bay (1972-73).

Sample Type	Number of Samples	Range of Total DDT (ppm)	Range of Arochlor 1254 (ppm)
SEDIMENT	15	0-.028	0.080
CLAM			
whole animal	4	.019-.056	0- .023
Crassostrea virginica			
whole animal	6	.022-.155	.106
Penaeus spp			
whole animal	6	.003-.040	0- .176
Anchoa mitchilli			
whole animal	3	.067-.086	.088- .560
Leiostomus xanthurus			
muscle	5	.015-.202	0- .290
liver	5	.013-.314	0-1.400
Arius felis			
muscle	2	.003-.049	.018- .089
developing eggs	0	.180	.460
Ictalurus catus			
muscle	1	.048	.041
Trinectes maculatus			
muscle	4	.036-.216	0- .733
Archosargus probatocephalus			
muscle	1	.075	.025
Cynoscion nebulosus			
muscle	1	.052	.150

Dredging, Dyking, and Damming—Approximately 6 miles (10 km.) up-river from Apalachicola Bay, a 33,000 acre cattle ranch has been established (Fig. 1). In order to provide suitable conditions for this operation, much of the land was cleared, ditched, and drained (Fig. 9). Areas were ditched for drainage purposes (Fig. 10) and, to prevent flooding, a series of dykes were constructed (Fig. 11). For a certain period, water pumped out of the area caused increased levels of turbidity and settleable solids in surrounding creeks. One dyke was actually placed across a creek, and, although unverified scientifically, local fishing interests complained of reduced fishing potential in creeks adjacent to the dyked areas. Since this was not a feed-lot operation, it was thought that the possibilities for increased nutrient levels in surrounding aquatic areas were minimal, a supposition that was substantiated by subsequent monitoring. However, ditching, dyking, and pumping did result in adverse water quality conditions of the surrounding areas; such operations also reduced the natural filtering function of the marsh-swamp systems and restricted faunal exchanges across the dyked areas. The question of increased Coliform levels in Bay oysters due to drainage from the cattle ranch remains unanswered. There is also a program of ditching and draining of extensive wetlands that border the East Bay Area. This is related to clear-cutting operations by various paper-pulp mill companies. Local fishermen complain of low quality water being drained from vast (cleared) areas into the creeks of this system. Damage to shrimp, crabs, and gamefish has been reported although this remains unverified by scientific confirmation. However, it is true that relatively broad wetlands areas adjacent to East Bay are being clear-cut and drained by extensive canal systems. Highly colored (turbid) water can thus enter directly into the bay system. Fertilizer used by the pulp operations is also a potential problem. In addition to damage to organisms which nursery in the East Bay System, this type of development could aggravate the level of cultural eutrophication in this area.

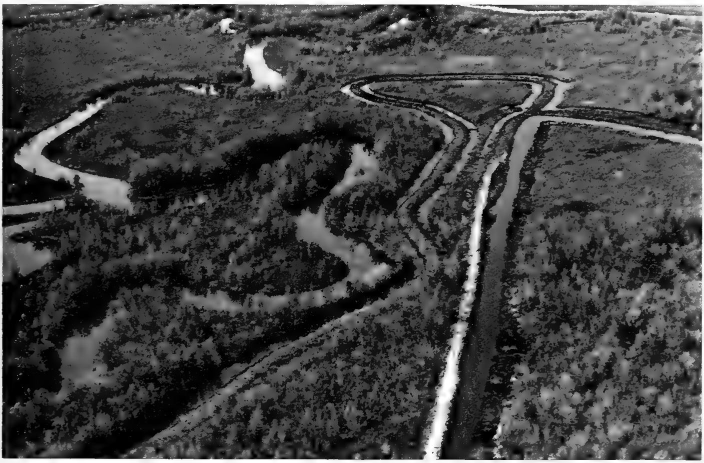

Fig. 9. Aerial photograph of dykes and ditches constructed by cattle interests in the Murphy Creek area of the Apalachicola Flood Plain (Spring, 1974).

In addition to serving as a habitat for terrestrial organisms such as bear, deer, turkey, squirrel, and birds of various types, these marsh areas and forests are thought to be a source of nutrients and detritus for the complex food webs of the adjoining streams, rivers, and estuaries. The periodic flooding of these wetlands is

Fig. 10. Ditched area near Murphy Creek in the Apalachicola Flood Plain.

part of a natural cycle whereby plant materials in upland systems are made available to surrounding aquatic areas. In this way, the potential importance of the upstream floodplain to the Apalachicola Bay System should not be underestimated. In the course of Sea Grant operations, it has been observed that during the spring floods, considerable quantities of leaves from the uplands areas are found in portions of East Bay and Apalachicola Bay. The exact mechanism of the utilization of such plant matter remains unknown although preliminary results of leaf basket experiments (Table 7) would indicate that there is a connection between the upland areas and the bay systems. It should be emphasized that these results are entirely preliminary, and further work is presently being carried out to establish their significance, if any. Most data concerning the contribution of leaf matter to aquatic systems have applied to fresh water areas (Nelson and Scott, 1962; Egglishaw, 1964; Minshall, 1967; Kaushik and Hynes, 1968, 1971). Woodall and Wallace (1972) found that differences in the standing crop (biomass) of streams were dependent on different inputs from allochthonous detritus. This followed earlier studies (Egglishaw and MacKay, 1967) that streams in areas devoid of deciduous trees had less allochthonous plant material and lower densities in bottom fauna than streams with bordering deciduous trees. Low diversity and reduced biomass in streams draining depauperate deciduous forests have also been reported by Minshall (1968). Woodall and Wallace (1972) considered that watershed vegetation can be a primary factor that determines species abundance and composition in aquatic systems. Considering the known detrital-based food webs in Apalachicola Bay, it is entirely possible that such a generalization could apply to this system also. The importance of allochthonous detritus to estuarine systems has already been established (Darnell, 1961; Teal, 1962). Odum (1971) has shown the importance of mangrove leaves to the productivity of estuaries in south Florida. The complexity of the utilization of organic matter from leaf litter is considerable (Cummings et al., 1972; Lush and Hynes, 1973). It is quite possible that any form of development of critical portions of the flood plain areas that would prevent detrital exchanges could eventually lead to reduced productivity of the river and bay systems.

Fig. 11. Dyked area near Murphy Creek in the Apalachicola Flood Plain.

In addition to an extensive program to maintain maximum depths along the Apalachicola River for navigation, the U. S. Army Corps of Engineers now has under study a plan for damming portions of the river. Certain questions can be raised concerning the impact of such a project on the salinity and nutrient levels of the Apalachicola Bay System in general and the effect of such impact on the oyster industry in particular. It is thought that phosphates could be trapped by the dams (Wilson, 1974, personal communication); in view of the fact that during certain times of the year, phosphate may be limiting in portions of the Apalachicola Bay System, this aspect of the dam project should undergo considerable scrutiny. The question of the effect on dissolved organics also remains unanswered. These questions reflect a general lack of knowledge concerning the exact effects of further dam operations on the Apalachicola Drainage System. Questions also remain concerning local effects on the terrestrial and fresh water fauna and anadromous fishes which almost certainly would be affected by such projects. There is also a possibility that increased standing water would require the need for augmented mosquito control programs involving the use of pesticides.

Some dredging is routinely carried out in Apalachicola Bay. A navigational channel at the mouth of the Apalachicola River is maintained, and dredge spoils are placed in banks along the side of the channel. Since a major portion of the dredged channel runs toward the Sikes Cut (Fig. 12) it is possible that fresh water is being diverted through the cut; this could cause increased salinities in St. Vincent Sound. Such salinity changes could result in increased predation on the oysters of this area by organisms that are normally susceptible to low salinities. This possibility is presently being examined by the Sea Grant researchers; included in this, is the study of the effect of the Sikes Cut on the bottom salinities of Apalachicola Bay.

TABLE 7. Preliminary leaf cage data (November-February 1974).

Leaf Types Found In Bay	
Water oak—*Quercus nigra* (dominant) Laurel oak—*Quercus laurifolia* (dominant) Pop ash—*Fraxinus carolineata* River birch—*Betula nigra* Water hickory—*Carya aquatica*	
January 12, 1974—2 cages lost	
coarse mesh (2 cages)	fine mesh (1 cage)
1 *Gobiosoma bosci* (stomach contents-5amphipods) 2 *Callinectes sapidus* 23 *Palaemonetes pugio* 17 *P. vulgaris* 3 isopods (*Cassidinidea sp.*) Many amphipods	2 *Gobiosoma bosci* (stomach contents-polychaetes and amphipods) 1 *Callinectes sapidus* 2 *Palaemonetes pugio* 6 *Palaemonetes vulgaris* 2 isopods (*Cassidinidea sp.*) Many amphipods Some polychaetes
February 16, 1974—leaves almost all broken up and washed out	
coarse mesh	fine mesh
1 *Callinectes sapidus* 6 *Palaemonetes vulgaris* 5 amphipods	3 *Palaemonetes vulgaris* 3 isopods 5 amphipods 1 decapod larva

Industrial Development—Various types of industrial development such as pulp mills, chemical plants, and various forms of heavy industry often have adverse effects on aquatic communities due to the release of various trace metals. There also can be considerable changes in parameters such as color, turbidity, pH, etc. Polychlorinated biphenyls (PCB's) are often associated with various industrial processes; Arochlor 1254, a fairly common PCB, was found in organisms in Apalachicola Bay in moderate amounts (Table 6). It is possible that such agents are moving down from areas above the Jim Woodruff Dam; this could be associated with municipal waste disposal into the Apalachicola System. Recently, a dredging project was approved that provided for a docking facility under the auspices of the Jackson County Port Authority. This would include an industrial park just below the Jim Woodruff Dam. This is one part of an effort for increased utilization of the Apalachicola River as a major barge facility. The channelization, dam, and dredging projects are therefore associated with an overall effort to increase the industrial facilities in the Apalachicola Drainage System and provide inexpensive transport for established industrial interests in Georgia and Alabama. The effects of dredging and channelization on the river system have already been discussed above (Cox and Auth, 1971, 1972, 1973). The impact of an increase in barge traffic on the system remains unknown, but could lead to increased levels of pollutants such as gasoline, oil, trace metals, and sewage. Any associated industrial expansion should be carefully analyzed for potential impact on the drainage system, especially with respect to the compatibility of such development with existing seafood interests and the nursery function of Apalachicola Bay. Long-term physical, chemical, and biological monitoring programs should be established to determine possible chronic effects of industrialization and associated activities on the Apalachicola System.

Fig. 12. Aerial photograph of Bob Sikes Cut on St. George Island (Spring, 1974).

Discussion—The nature of the sources of stress on estuarine systems are generally known (Odum, 1970) although the long-term effects of such factors on the productivity and ecological relationships of such areas remains in question. Lindall (1973) has pointed out that most of the species taken by commercial and sports fishing interests are dependent on estuaries during at least some portion of their life history. McQuigg (1971, personal communication) considered that sport fishing and associated industries are responsible for expenditures exceeding $2 billion per year in Florida. Alterations of natural drainage patterns, dredging and filling, dyking, and various other forms of activity (described above) have already had significant effects on various estuarine systems in this state. Although it is true that some modifications of estuaries are potentially beneficial to fisheries interests, without realistic guidelines the consequences of such activities often prove to be detrimental in the long run (Livingston et al., 1972). In a broad sense, the problem of human development in sensitive drainage systems is two-fold; there is a general lack of basic knowledge concerning the functional relationships of such systems in their natural state, and relatively little is known concerning the long-term effects of the various forms of man-induced stress. In most instances, the complexity of the multiple-factor impact on estuaries has precluded even an elementary assessment of the ecological ramifications of such actions. Considerably more information is necessary before reasoned decisions can be made concerning the management of natural drainage systems. Such information would provide protection and guidelines for the developer as well as the fisherman in most cases.

Although considerable portions of the Apalachicola Drainage System as yet remain relatively undeveloped, a growing number of projects could affect the sustained productivity of the area. The Apalachicola Bay System is still relatively free from various forms of pollution, and remains an extremely productive area. However, alterations of the nutrient and detrital input to the bay could result in widespread changes in the biota of the system. One of the principal difficulties in the evolution of a comprehensive plan of management is the sheer size of the Apalachicola Drainage Basin. It is true, however, that various sensitive portions of this area have been identified. The continued uncontrolled development of St. George Island as well as the massive alteration of substantial portions of the up-river wetlands (M-K Ranches, pulp mills, local land use) would indicate that, as yet, no comprehensive management plan exists which encompasses the system as a whole. While various forms of development that are compatible with the existing interests should be encouraged, those types of activity that remain questionable should be thoroughly examined before they are permitted to become established. Heavy industry, certain forms agriculture, damming, dyking, dredging, and the concentration of masses of people in the primary drainage areas should be controlled by existing local, state, and federal agencies. Whenever possible, sensitive portions of the wetlands that directly impinge on the river-bay system should be identified and purchased by the State of Florida under the Land Conservation Act of 1972. The Apalachicola Drainage System should be declared an area of critical concern before it suffers the fate of so many of the estuarine systems around the state.

There is, in addition to the obvious economic arguments in favor of conserving the Apalachicola System, another reason for concern. The intrinsic value of this area as a major (relatively) undisturbed drainage system is considerable; it is literally a way of life for thousands of people who use it as a source of income and/or recreation. The scientific, economic, and sociological aspects involved would thus provide a solid framework on which to build an enlightened management program. In spite of serious efforts of various individuals and agencies, it must at this time be recognized that no such basis for a broad management scheme is operable. Unless there is a concerted effort to generate and utilize a broad data base for such an effort, every indication is that the Apalachicola Drainage Basin will be seriously altered by a combination of uncontrolled forms of development that could eventually impair one of the most naturally productive systems in the country.

Summary of Results and Conclusions—1. The Apalachicola Drainage System is viewed as a highly productive area that presently is relatively free from damage due to human activities. Continual dredging of the Apalachicola River is one source of stress although productivity appears to remain high in most areas. Because of a lack of data, the impact of the Jim Woodruff Dam on the Apalachicola Bay System remains unknown. The river controls such factors as salinity, nutrients, detritus, and levels of pollution in the bay system. As such, the Apalachicola Bay System is inextricably linked to the upland drainage system.

2. The Apalachicola Bay System, a shallow barrier estuary of considerable productivity, is characterized by periodic salinity stratification. Various other hydrographic features are strongly influenced by wind and tide conditions. The bay system was quite turbid, and had a relatively high level of phytoplankton productivity during the study period. Seasonal changes in the nutrient levels of the river-bay area were determined, and water temperature, light, turbidity, nutrients, grazing and flushing rates were seen as controlling factors for such productivity. The biota of the bay system was described; dominant organisms included oysters (*Crassostrea virginica*), shrimp (*Penaeus* spp.), blue crabs (*Callinectes sapidus*), and various species of finfishes.

3. The economy of Franklin County, Florida remains, to a considerable degree, dependent on the Apalachicola Bay System. A large proportion of the commercial landings depend on species that spend at least part of their life history in this bay. In addition to being the source of millions of dollars worth of seafood each year, the Apalachicola Bay System is viewed as integral to an entire way of life in the region.

4. Group coliform organisms are a major source of concern to the dominant oyster industry of the bay. MPN values are directly correlated with river discharge rates. Although there is no significant difference between present coliform group MPN values and data taken during the 1940's, it is felt that increased concentrations of people and animals such as cattle in the bay area could eventually cause a problem. As yet, the significance of group MPN values in the differentiation of the source of such contamination remains in question although it is felt that the river is still the most significant factor in the distribution of coliform bacteria in the bay system. If the Apalachicola Sewage Treatment Plant were run efficiently, such local municipal effluents would not be a significant source of concern outside of the present 2 mile radius closed to shellfish harvesting.

5. The bay appears to be in a relatively healthy state with regard to cultural eutrophication; however, considering the relatively restricted circulation of portions of the bay system, this could be a problem in the future. Introductions of additions of nutrients from various sources should be carefully controlled so that the present trophic relationships of the bay are maintained. Since little is known concerning the interrelationships of the nutrient-dependent and detrital food webs, this area should be studied in greater detail to determine the nutrient loading capacity of the bay with respect to river flow, seasonal changes in productivity, and activities associated with various forms of development.

6. St. George Island is considered to be a key to the maintenance of the Apalachicola Bay System, and, if improperly developed, could cause considerable ecological damage to the bay in the future. Such factors as sewage and fertilizer wastes, storm drainage, sheet water runoff, dredging, marina construction, pesticide concentrations, and small boat operations are just a few of the potential problems if the island becomes over-populated. Only carefully controlled development of this barrier island will assure the continued (useful) productivity of Apalachicola Bay.

7. Preliminary figures would indicate that organochlorine insecticide levels in the bay system are relatively low although occasionally moderate levels of PCB's (principally Arochlor 1254) have been found in certain organisms. However, a continuing concern exists about the impact of public health spray programs (dogflies, sand-flies, mosquitoes) that could accompany increases in population pressure. Any such programs should be carefully monitored so that there is minimal damage done to sensitive non-target organisms.

8. Various upriver activities are presently being planned and/or carried out that could have an impact on the Apalachicola Bay System. A 33,000 acre cattle ranch and pulp mill activities involving the dyking, ditching, and draining of thousands of acres of wetlands just above the bay, have established an ominous precedent for the future. If such development is allowed to continue along the river, it could have serious repercussions throughout the system. Again, more knowledge is needed before definitive statements can be made concerning the critical factors involved in the nutrient and detrital exchanges between upland and bay systems. Similar questions can be posed concerning ongoing dredging and damming activities of the U. S. Army Corps of Engineers. Dredging in the bay itself is also under scrutiny. The north channel maintenance south of the Bob Sikes Cut and the development of open water spoil banks in this area is open to question. Any proposed alterations of natural current and drainage flows (channelizations, bridges, sea walls, finger canals, etc.) should be carefully evaluated before any such action is taken. The Sikes Cut itself is presently being studied relative to the salinity patterns in Apalachicola Bay. Much of this kind of activity is related to increased barge traffic and upriver industrialization (Jackson County Port Authority). Once again, the impact of such activities on natural drainage systems is little understood, but side effects on aquatic organisms, due to increased levels of trace metals, PCB's, petro-chemicals, etc., are not uncommon in other systems. Overall, there is considerable pressure from various upriver interests for a variety of developmental activities that could have adverse long-term effects on portions of the Apalachicola Drainage System.

9. Considering the importance of the Apalachicola Drainage System as a natural source of food and recreation for various interests, and in the face of increasing pressure from different groups who wish to use this system for other purposes, it is of the utmost importance that more information is generated that will resolve some of the questions raised above. An overall regulatory and administrative system is needed to gather such information and use it so that judgements can be made concerning future development. Although attempts

have been made by various local, state, and federal agencies, an integrated management program has not yet been implemented. It is suggested that some form of tri-state (Florida, Georgia, Alabama) cooperation be developed that would assure the continued well-being of the Apalachicola Drainage System.

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LITERATURE CITED

BROOKS, H. K. 1973. Geological oceanography. *In* JONES, J. I., R. E. RING, M. O. RINKEL, AND R. E. SMITH (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico. State Univ. Syst. Florida Inst. Oceanography. St. Petersburg.

BUCKLEY, E. N., III. 1973. The fishes of the Apalachicola Bay System with reference to life history, abundance, distribution, and species diversity. Honors Thesis (unpublished). Florida State Univ. Tallahassee.

COLBERG, M. R., AND D. M. WINDHAM. 1965. The oyster-based economy of Franklin County, Florida. Pub. Health Ser. and Florida State Univ. 22 pp.

_________, T. S. DIETRICH, AND D. M. WINDHAM. 1968. The social and economic values of Apalachicola Bay, Florida. Final report to: Fed. Water Poll. Cont. Admin. (Contract No. 14-12-117) 58 pp.

COX, D. T. 1969. Stream investigations. Annual Progress Report, Florida Game and Fresh Water Fish Commission (1968-1969).

_________. 1970. Stream investigations, Annual Progress Report, Florida Game and Fresh Water Fish Commission (1969-1970).

_________, AND D. AUTH. 1971. Stream investigations. Annual Progress Report, Florida Game and Fresh Water Fish Commission (1970-1971).

_________, AND _________. 1972. Stream investigations. Annual Progress Report, Florida Game and Fresh Water Fish Commission (1971-1972).

_________, AND _________. 1973. Stream investigations. Annual Progress Report, Florida Game and Fresh Water Fish Commission (1972-1973).

CUMMINGS, K. W., J. J. KLUG, R. G. WETZEL, R. C. PETERSEN, K. F. SUBERKROPP, B. A. MANNY, J. C. WUYCHECK, AND F. O. HOWARD. 1972. Organic enrichment with leaf leachate in experimental lotic ecosystems. Bioscience 22:719-722.

CURL, H., JR. 1959. The hydrography of the inshore northeastern Gulf of Mexico. Publ. Inst. Mar. Sci. 6:193-205.

DANGLADE, E. 1917. Conditions and extent of the natural oyster beds and barren bottoms in the vicinity of Apalachicola, Florida. Rept. U. S. Comm. Fish. (1916) 42:68 pp.

DARNELL, R. M. 1961. Trophic spectrum of an estuarine community, based on studies of Lake Pontchartrain, Louisiana. Ecology 42:553-568.

DAWSON, C. E. 1955. A contribution to the hydrography of Apalachicola Bay, Florida. Publ. Tex. Inst. Mar. Sci. 4:15-35.

EGGLISHAW, H. J. 1964. The distributional relationship between the bottom fauna and plant detritus in streams. J. Anim. Ecol. 33:463-476.

_________, AND D. W. MACKAY. 1967. A survey of the bottom fauna of the streams in the Scottish highlands. Part III: Seasonal changes in the fauna of three streams. Hydrobiologia 30:305-334.

ESTABROOK, R. H. 1973. Phytoplankton ecology and hydrography of Apalachicola Bay. M. S. Thesis. Florida State Univ. Tallahassee.

GORSLINE, D. S. 1963. Oceanography of Apalachicola Bay. pp. 69-96. *In* CLEMENTS, T. (ed.) Essays in Marine Geology in Honor of K. O. Emery; Univ. S. California Press. Los Angeles.

INGLE, R. M. 1951. Spawning and setting of the American oyster, *Crassostrea virginica* (Gmelin), in Apalachicola Bay, Florida. M. S. Thesis. Univ. of Miami. Coral Gables.

__________, AND C. E. DAWSON. 1950. Variations in salinity and its relation to the Florida oyster. Salinity variations in Apalachicola Bay. Proc. Gulf Caribb. Fish. Inst. 3:35-42.

__________, AND __________. 1952. Growth of the American oyster, *Crassostrea virginica* (Gmelin), in Florida waters. Bull. Mar. Sci. Gulf Caribb. 2:393-404.

__________, AND __________. 1953. A survey of Apalachicola Bay, Florida State Bd. Conserv. Tech. Ser. 10:38 pp.

JORDAN, C. L. 1973. Climate. pp. IIA-1—IIA-22. *In* JONES, J. I. et al. (eds.) A Summary of Knowledge of the Eastern Gulf of Mexico. State Univ. Syst. Florida Inst. Oceanography.

KAUSHIK, N. K., AND H. B. N. HYNES. 1968. Experimental study on the role of autumn-shed leaves in aquatic environments. J. Ecol. 56:229-243.

__________, AND __________. 1971. The fate of the dead leaves that fall into streams. Arch. Hydrobiol. 68:465-515.

LAWRENCE, J. M. 1968. Dynamics of chemical and physical characteristics of water, bottom muds, and aquatic life in a large impoundment on a river. Zoology-Entomology Dept. Ser. Fisheries no. 6. Auburn Agric. Exper. Sta. Auburn Univ.

LINDALL, W. N., JR. 1973. Alterations of estuaries of South Florida: A threat to its fish resources. Mar. Fish. Rev. 25(10):26-33.

LIVINGSTON, R. J., T. S. HOPKINS, J. K. ADAMS, M. D. SCHMITT, AND L. M. WELCH. 1972. The effects of dredging and eutrophication on Mulat-Mulatto Bayou (Escambia Bay; Pensacola, Florida). Rept. for Florida Dept. Transportation.

__________, AND N. P. THOMPSON. 1972-74. Chronic effects of certain chlorinated hydrocarbon insecticides on estuarine animals of the northern Gulf coast of Florida. Florida Sea Grant Project R/EA-1; Annual Reports.

LUSH, D. L., AND H. B. N. HYNES. 1973. The formation of particles in freshwater leachates of dead leaves. Limnol. Oceanogr. 18:968-977.

MENZEL, R. W., AND E. W. CAKE, JR. 1969. Identification and analysis of the biological value of Apalachicola Bay, Florida. Rept. to F. W. P. C. A. (Contract 14-12-191)

__________, N. C. HULINGS, AND R. R. HATHAWAY. 1957. Causes of oyster depletion in St. Vincent Bar, Apalachicola Bay, Florida. Proc. Natl. Shellfish Assoc. 48:66-71.

__________, __________, AND __________. 1966. Oyster abundance in Apalachicola Bay, Florida, in relation to biotic associations influenced by salinity and other factors. Gulf Res. Rept. 2(2):73-96.

MENZEL, D. W., AND J. H. RYTHER. 1961. Nutrients limiting the production of phytoplankton in the Sargasso Sea, with special reference to iron. Deep-Sea Res. 7:276-281.

MINSHALL, G. W. 1967. Role of allochthonous detritus in the trophic structure of a woodland springbrook community. Ecology 48:139-149.

__________. 1968. Community dynamics of the benthic fauna in a woodland springbrook. Hydrobiologia 32:305-339.

MOORE, H. F. 1897. Report of the specimens collected from the oyster beds of St. Vincent Sound, Apalachicola Bay, and St. George Sound, Florida during the winter of 1895-96. Rept. U. S. Comm. Fish. 22:218-221.

NATIONAL ESTUARY STUDY. 1970. Vol. III. U. S. Dept. Int. Fish Wild Serv., Bur. Sport Fish. Wild and Bur. Comm. Fish. Washington, D. C.

NELSON, D. J., AND D. C. SCOTT. 1962. Role of detritus in the productivity of a rock-outcrop community in a piedmont stream. Limnol. Oceanogr. 7:396-413.

ODUM, W. E. 1970. Insidious alteration of the estuarine environment. Trans. Amer. Fish. Soc. 1970:836-847.

__________. 1971. Pathways of energy flow in a south Florida estuary. Sea Grant Tech. Bull. No. 7. Univ. Miami.

PEARSE, A. S., AND G. W. WHARTON. 1938. The oyster "leech," *Stylochus inimicus* Palombi, associated with oysters on the coasts of Florida. Ecol. Monogr. 8:605-655.

RILEY, G. A. 1956. Oceanography of Long Island Sound. 1952-1954. IX. Production and utilization of organic matter. Bull. Bingham Oceanogr. Collect. 15:324-344.

ROCKWOOD, C. E. 1973. A management program for the oyster resource in Apalachicola Bay, Florida. Res. Rept. Florida Dept. Nat. Res. (N-042-44-72)

RYTHER, J. H., AND R. R. L. GUILLARD. 1959. Enrichment experiments as a means of studying nutrients limiting to phytoplankton production. Deep-Sea Res. 6:65-69.

SCHINDLER, D. W. 1966. A liquid scintillation method for measuring carbon-14 uptake in photosynthesis. Nature 211:844-845.

SOLORZANO, L. 1969. Determination of ammonia in natural waters by the phenolhypochlorite method. Limnol. Oceanogr. 14:799-801.

STEEMAN-NIELSEN, E. 1952. The use of radio-active carbon (C-14) for measuring organic production in the sea. J. du Conseil. 18:117-140.

STEVENSON, H. M. 1969. Report on bird observations in vicinity of Apalachicola Bay, Florida. *In* MENZEL AND CAKE; Identification and Analysis of the Biological Value of Apalachicola Bay, Florida. Rept. to F. W. P. C. A. (14-12-191)

STRICKLAND, J. D. H., AND T. R. PARSONS. 1972. A practical handbook of seawater analysis. Fish. Res. Bd. Canada Bull. 167:310 pp.

SUMMARY OF FLORIDA COMMERCIAL MARINE LANDINGS. 1972. Florida Dept. Nat. Res. Div. Mar. Res.

SWIFT, F. 1897. Report of a survey of the oyster regions of St. Vincent Sound, Apalachicola Bay, and St. George Sound, Florida. Rept. U. S. Comm. Fish. 22:187-217.

SYKES, J. E. 1970. Report of the Bureau of Commercial Fisheries Biological Laboratory, St. Petersburg Beach, Florida. U. S. Fish. Wildl. Serv. Circ. 342:1-22.

TEAL, J. M. 1962. Energy flow in the salt marsh ecosystem of Georgia. Ecology 43:614-624.

U. S. GEOLOGICAL SURVEY. 1971. Environmental Atlas of the United States. Washington, D. C.

WARD, F. J., AND M. NAKANISHI. 1971. A comparison of Geiger-Mueller and liquid scintillation counting methods in estimating primary productivity. Limnol. Oceanogr. 16:560-563.

WILSON, D. 1974. District Engineer, U. S. Army Corps of Engineers. Mobile. (Personal communication)

WOLFE, D. A., AND C. L. SCHELSKE. 1967. Liquid scintillation and Geiger counting efficiencies for carbon-14 incorporated by marine phytoplankton in productivity measurements. J. du Conseil. 31:31-37.

WOODALL, W. R., JR., AND J. B. WALLACE. 1972. The benthic fauna in four small southern Appalachian streams. Amer. Midl. Nat. 88:393-407.

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THE FUTURE OF SCIENTIFIC COMMUNICATIONS—ACADEMIES OF SCIENCE[1]

HARVEY A. MILLER

Department of Biological Sciences,
Florida Technological University, Orlando, Florida 32816

PUBLICATION of the Florida Academy of Sciences Symposium comprising this number of the FLORIDA SCIENTIST represents a significant departure from recent journal content. The papers deal not only with ecological characterization but consider additionally human impact and potential application of scientific knowledge to problems in our state. Because they provide carefully documented summaries of a considerable body of knowledge, these reports on Florida estuaries should be of considerable assistance to our legislators and other government officials who must address themselves to resolution of the problems defined by the authors. It seems fitting in these times of great concern for our dwindling natural

[1]Based upon a presentation at the AAAS meeting in New York on January 28, 1975, as a contribution to a symposium entitled *Technology Assessment and Academies of Science: The Future of Scientific Communications.*

resources that our Academy of Sciences should rise to assist in development of policies and legislation to serve the best interests of all citizens.

Presentation of the Academy Symposium has provided valuable information to our membership and the scientific community of the world, and it also has brought into focus a problem in scientific communication which seems destined to have an influence on scientific publication practices in the future. Examination of the bibliographies in each of the papers shows a significant dependence upon sources other than journals and books offered in open trade. What does this phenomenon portend? Does it have future implications for academies of science or is it a harbinger of a total revolution in scientific communication? Some of the answers seem to lay within the structure of science academies and their publications. Therefore we will review our Academy functions in relation to comparable organizations and what steps have been taken within the Academy to enhance scientific communications.

It seems that most state academies of science function in about the same manner as the Florida Academy of Sciences. Their memberships may be somewhat larger per unit of state population but our membership deficiency may relate to Florida's recent expansion of a scientific community which is not yet fully aware of the Academy.

In common with us, most academies offer:

1) An annual meeting with presentations of papers or symposia and events which encourage informal communication.
2) A journal of contributions mostly from the membership; sometimes these consist of expanded abstracts of papers given, but others parallel our official Quarterly Journal very closely.
3) A newsletter which varies from attractively printed bimonthly productions to irregularly distributed mimeographed sheets.

Production in advance of a substantial *Program Issue* is apparently less often practiced by academies and so we differ in that aspect of our publications program. We have been most fortunate that production costs for the program issue have been modest. Because our program issue has been treated of late as an official supplement, copies are distributed to all subscribing libraries as well as to individual members. This means that the abstracts are exposed to a spectrum of readers beyond our immediate participating membership. Because it serves to notify others of like interest who plan to attend the meeting, it would seem to encourage participation in the annual meeting. Thus, in a sense, it represents a refinement of item 1) above which seems to be completely compatible with the goals and aims of the Academy.

We also differ from the other academies somewhat in our encouragement of other state-wide or regional groups to meet with us and share in our program along with their regular meeting. Continuation and expansion of this practice seems to bring new members to the Academy and stresses the breadth of the Academy interests which are sufficient to provide an umbrella for a catholic assortment of special interest groups.

Assembly and manufacture of the program is accomplished against a very close time frame from final submission of author's abstracts to arrangement of section programs by the Section Chairman, and finally to the Program Chairman and (perhaps) the journal editor for final assembly. The abstracts are numbered and coded by room and time, then cut up and cemented in place for the camera. All the special session, coffee break, and business meeting notices are inserted where they belong among the author-prepared abstracts. Thus, camera copy is furnished to the printer with a considerable savings in cost. Our most recent program, including mailing, reached the membership for about 2 cents a page—a very good buy these days, and one achieved only because of the time generously given by the Section Chairmen and especially by the Program Chairman who puts it all together. Rollins College has been especially helpful with on-campus manufacture for the past two years.

Preparation and manufacture of the FLORIDA SCIENTIST, the official *Quarterly Journal of the Florida Academy of Sciences*, requires more expensive and exacting procedures in the face of rapidly expanding costs for paper, labor, and printing. At present, we accept contributions from any author in any field of science without limit so long as the paper is deemed appropriate and worthwhile by reviewers in the field and the editor. How long we will be able to continue without page charges for long papers is not at all certain. Papers by Florida authors or dealing with Florida related phenomena are favored and we not-so-subtly encourage non-member authors to join the Academy. The cost for manufacturing and mailing a 64-page issue is running about $34.00 per page, or about 7.2 cents per word. If the present editor were paid (he is not) at an average State University System salary for time spent as a fraction of 40 hours, the cost would go to over 12 cents per word. There is a clear message in this. The publications of the Academy represent an exceptionally good buy when compared to other scientific reference sources.

Members have probably noticed that volume 36 contained the same number of pages as volume 35 and perhaps some were disappointed that it didn't look bigger. It was bigger—20% so, in fact, because our type block was changed from 25 × 42 picas (printers use this unit of measurement) creating a 1050 sq. pica page to a 28 × 45 pica block for a 1260 sq. pica page. Additional words were added to pages by changing subheadings within a paper so that white space was reduced. Further, utilization of computer composition, a so-called cold–type system, has reduced type setting expenses as well. These changes, and other lesser ones, have made possible a significant increase in the information reaching our membership with little increase in cost despite generally spiraling prices.

We trust that these comments will assist in understanding of the manner in which our scientific publications are prepared, and of the comparative status of the Florida Academy of Sciences among publishing academies. Cost spiraling will apparently continue and so the Academy must review its role as a contributor to preservation of scientific knowledge by means of the journal. There can be little question that pressure for publication in the journal will intensify greatly over the next few years with the growth of the Academy and intensification of scientific effort in the state.

I have pondered scientific communications for the future and their roles in the past. Among other things, some examination of the historical development and of the paradigms in a few fields leads to the conclusion that in science we deal with critical populations of intercommunicating scholars. Whenever the critical population is too large to be effective, splintering inevitably seems to occur and this exfoliation of subdisciplines may be manifested in new societies or in new journals. One need only to examine the awesome proliferation of new periodicals since 1945 to observe the phenomenon first hand.

If we pursue the implications of this fractionation still further, we are forced to conclude that specialists communicate with specialists, often in barely intelligible jargon, and that relevant basic data residing in tangent scientific populations may be completely overlooked. This may be the reason that, as Kuhn and others suggest seems to be the case, the breakthroughs often come when specialists carry their expertise into a tangent but comprehensible discipline. Although this circumstance seems to prevail, we should not all immediately jump into an adjacent discipline expecting to generate a great discovery or revolutionary theory.

How do we reconcile these things with the information explosion and the future of scientific communication? And what roles, if any, do academies of science have to play?

Let's look at it this way. Most day-in, day-out science is data gathering. It requires some innovation to successfully gather these data which are often most elusive. Then some consolidation is accomplished and, in the natural course of things, publication occurs. Publication is an important part of this process—indeed, because the printed word can be reviewed precisely, it may be second in import only to the quality control imposed by the data gatherer. And without publication there is no permanent base for future data gathering from promising leads nor for the ultimate synthesis which leads to scientific advances. The function of the scientific society journal is the stockpiling of information gathered by its members or others who enjoy access to its pages.

We would agree, I think, that publication is great—but is there no interim, less delayed, less costly kind of communication? Yes, sometimes. The Academy can continue to encourage communication by means of annual (or more frequent) meetings which may stimulate some cross-disciplinary dialogue. The "quick and dirty" abstract helps identify work in process but usually communicates little else. Thus, the meeting and the abstract serve as a communicative device but copies of hard data are usually reserved for print in a journal. If we accept that a quick printing is not required in many fields and that many forms of scientific contribution retain validity despite delays in journal production, the Academy journal will continue to be important—and probably increasingly so—for those contributions of local or regional interest. Over the next 5—10 years, I see our Academy role as a publisher changing as competition for journal space increases resulting in a higher rejection rate for papers. Further limitations will accrue because of a greater use of the journal as an educational instrument through publication of closely focused symposia bearing on Florida's special problems.

Symposia and other educational activities under sponsorship of science academies should greatly expand their visibility to the public and elected officials. Effective science academies will achieve great enhancement from involvement, probably first with environmental issues, and subsequently in policy formulation by state governments. This may not be easily accomplished, but it must be if scientists are to bring their expertise to bear in development of political decisions which have far-reaching implications for every citizen. We must learn to effectively communicate scientific concepts to the public, including elected officials, but I am unaware of any localities where a high degree of success can be claimed—including Washington, D.C.

Although we are concerned with academy journals, two recent developments in scientific publication should be noted. The first is the manuscript facsimile print utilized by some journals in fast-breaking highly competitive fields such as biochemistry or biophysics. These publications serve a useful purpose but they are ancillary to, and do not replace, the formally printed journal as presented by academies of science. The second kind of printed creation has generated uncounted nightmares among editors, bibliographers, and librarians. It is the multilithed agency report, impact statement, meeting handout, locally produced college course package, the commercial laboratory report, private foundation special reports, and a host of other items. Authors and others claim that such items constitute publication and that all should be recognized. Librarians and bibliographers note that these are often not available, that they never were on the market, are frequently shabbily produced, and that handling costs are not commensurate with the short useful life of the item. An editor is caught in the middle. This kind of *gray literature* constitutes more than an unpublished manuscript and yet, by its nature, it is not formally published in a closely edited, reviewed, and distilled form which would be required prior to publication in the FLORIDA SCIENTIST, for instance. So far, citation of *gray literature* has been tolerated by editors, but we eventually may have to review a policy which allows citation of unobtainable sources.

It seems clear that *gray literature* is going to proliferate and that these oft ponderous tomes of raw data will stagnate on, e.g., governmental agency shelves, for practical purposes inaccessible and therefore rather illegitimate in function. These compendia may introduce new data worthy of documentation and credit to the original author in review articles similar to those in this issue of the FLORIDA SCIENTIST. An emerging role for academies may become the legitimizing of significant contributions from the cornucopia of ephemeralia including agency reports, grant reports, impact statements and politically produced, totally repetitious hogwash which flows ever more bountifully from indefatigable multilith and mimeograph machines. However, this should never become the primary function of an academy journal and in no case should a membership be expected to subsidize "hard copy" presentation. It is a situation, however, where the academy and state government could develop a mutually beneficial arrangement similar to some which are already operational in a number of states.

Further assistance could be rendered by academies with a permanent headquarters where *gray literature* could be deposited for future reference, perhaps for 10–20 years. The academy might wish to assess a modest fee to cover the handling cost for each such document for a specified time although user charges might also assist. It seems to me that such a function is one especially appropriate for a state academy of science and one worthy of careful consideration. This might be the way to handle the new twilight zone emerging in science communication—the material would be available from a single source but neither widely known nor otherwise easily accessible.

I have suggested expanded roles for academies of science within their traditional roles as media of communication. I see costs escalating greatly, and, in time, it seems likely that the schism between the shirt-pocket academies (and that term is not meant to be demeaning—only a statement of how things are) and the permanently based academies growing wider. Small academies may become limited to publications which are essentially meeting reports or newsletters unless consortia are devised to provide a broader membership and financial base. Permanently based academies can and must assume much greater service roles for the population at large, partly by becoming visible and active institutions within the state.

To summarize, in the area of publications, I see these trends:

1) Small academies will be pushed out of the business of publishing regular journals unless they have a broad base of industrial or governmental support.
2) Medium-sized academies lacking a permanent headquarters will be forced to cut back on publications unless an expanded financial base is created—perhaps by publishing heavily subsidized legitimization of gray literature *without compromise of editorial standards.*
3) Permanently headquartered academies will be under severe pressure to expand their journals and they should take the opportunity to improve the quality of content; further, they should exploit their opportunity to focus scientific effort in the state by becoming centers for holding gray literature and legitimizing appropriate portions as with (2) above.
4) All academies must make their efforts known to the public and their governmental officials via direct contact and by the news media and to utilize these as a means of scientific communication in the name of the academy; it may seem contrary to our "traditional mores", but to do less is to deny our changing role in a technological society which needs our services and talents, and to effectively abandon our cherished academies.

Epilogue—It is impossible, of course, to predict anything with unfailing accuracy but it is possible to recognize and identify trends. The academies of science are at once faced with 1) some of the greatest opportunities for service and influence ever available, and 2) with great trials at a time when science and scientists are needed but not necessarily trusted. We must all support our Academy to the full extent possible and we must seek to make our collective voices heard. If you wish to help, write to your Academy President and tell him what you can and would like to do.

Florida Sci. 37(4):271-276. 1974.

INSTRUCTIONS TO AUTHORS

Rapid, efficient, and economical transmission of knowledge by means of the printed word requires full cooperation between author and editor. Revise copy before submission to insure logical order, conciseness, and clarity.

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FLORIDA ACADEMY OF SCIENCES

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Quarterly Journal
of the
Florida Academy of Sciences

Vol. 36 March 1973 Supplement to No. 1

PROGRAM

of the

THIRTY SEVENTH ANNUAL MEETING OF THE ACADEMY

in conjunction with

THE FLORIDA SECTION OF

THE AMERICAN ASSOCIATION OF PHYSICS TEACHERS

The University of West Florida, Pensacola, Florida

March 22, 23, 24, 1973

Local Industrial Sponsors of Annual Meeting:

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QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

Editor: Pierce Brodkorb

The Quarterly Journal welcomes original articles containing significant new knowledge, or new interpretation of knowledge, in any field of Science. Articles must not duplicate in any substantial way material that is published elsewhere.

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Thirty-Seventh Annual Meeting
of the
Florida Academy of Sciences
at
The University of West Florida Pensacola, Florida
March 22, 23, 24, 1973

GENERAL INFORMATION

All registrants for the Junior and Senior Academy meetings and the meeting of the American Association of Physics Teachers are welcome to attend all sessions of all organizations, including the banquet.

Registration

Registration for the Senior Academy will be at the following times and locations:

Thursday, March 22, 8:00 - 10:00 pm	Hospitality Room, Rodeway Inn, Pensacola
Friday, March 23, 8:00 - 12:00 am	Hallway, Building 51, UWF
1:00 - 4:00 pm	Hallway, Building 51, UWF
Saturday, March 24, 8:00 - 11:00 am	Hallway, Building 51, UWF

Registration for the Junior Academy will be at the following times and locations:

Thursday, March 22, 6:00 - 9:00 pm	Ramada Inn, Pensacola
Friday, March 23, 8:00 - 9:00 am	Hallway, Building 52, UWF

Headquarters Motels

The Rodeway Inn (710 North Palafox, Pensacola, Fla. 32501) will serve as headquarters motel for the Senior Academy. The entire new section of the motel will be held for FAS reservations until March 17. When making reservations, please indicate that you are attending the FAS meeting.

The Ramada Inn Downtown (223 East Garden, Pensacola, Fla. 32501) will serve as the headquarters motel for the Junior Academy.

Hospitality Room

There will be a Hospitality Room on Thursday, March 22, from 8:00 to 10:00 pm at the Rodeway Inn. The Registration Desk will be located there, and those registering there will receive a complimentary cocktail. Soft drinks and coffee will also be available. Above refreshments are courtesy of the local industrial Sponsors.

Transportation

Several automobiles with drivers will be available to provide free transportation Friday and Saturday mornings from the Rodeway Inn to the University; Friday evening from the University to the Country Club or the Rodeway; and Saturday at the close of the meetings from the University to the Rodeway Inn. Since the University is located more than 10 miles from downtown Pensacola, and public transportation will not be available, the transportation needs can best be met if all attendees at the meeting stay at the Rodeway Inn; and by those with cars offering rides to those without. Pickup stations for those needing rides will be marked, and further information will be available at the Registration desks.

Parking

No special parking permits will be required. University classes will not be in session. Parking areas convenient to the meetings are those marked on the UWF Campus maps near Buildings 51, 52, 53, and 58.

Food Services

Lunch will be served in the University Commons (Building 22) on Friday. Those attending the Senior Academy will go through the cafeteria line. Those attending the Junior Academy will have received a luncheon ticket at registration, and will use it in the Junior Academy line for a hamburger plate lunch. There will be no other meals served at the University cafeteria. The Snack Bar in the Commons will be open, 8:00 am until 5:00 pm on Friday, and from 8:00 am until noon on Saturday.

Cocktail Hour

Immediately preceding the Banquet, beginning at 5:30 pm, there will be a complimentary cocktail hour, courtesy Westinghouse and Monsanto, at the Scenic Hills Country Club for FAS Annual Meeting registrants and their spouses. Cocktail tickets will be issued upon registration.

Academy Banquet

The Banquet is scheduled for 6:45 pm on Friday, March 23, at the Scenic Hills Country Club. Reservations should be made at registration, and before 12 noon Friday. Only a few tickets will be available later in the day. The cost will be $4.50 per person for a delicious and satisfying buffet.

Junior Academy Banquet and Dance

The Convention Center of the Ramada Inn will be the setting for the Annual Awards Banquet at 6:30 pm followed by a Dance at 9:00 pm. Tickets must be obtained in advance at $5.00

Plant Visit

Interested members of the Academy are invited to visit the Escambia Plant of the Chemicals Group Manufacturing Division of Air Products and Chemicals, Inc., and observe industrial pollution abatement practices and systems. The plant is about 15 minutes by car from the University. The tour will begin at 10:00 am Saturday, and last 1 1/2 to 2 hours. Transportation to the Plant from the University, and from the plant to the University or Rodeway Inn will be provided as needed. Those wishing to go may register for the tour at the Registration desk.

Ladies Program

Friday, March 23, starts for the ladies with a get-acquainted coffee at the Rodeway Inn; free tours (on request), from 10:00 am to 12:30 pm, of Pensacola's Historical District at Seville Square, including historical and art museums and galleries; or tour of Pensacola Beach and Gulf Islands National Seashore; inexpensive luncheon at 1 pm in quaint Coppersmith Galley Restaurant; afternoon tour of city shops and residential areas, UWF campus, and complimentary tea at private home; and ends with the Cocktail Hour and Academy Banquet at the Scenic Hills Country Club. UWF faculty wives of Academy members will serve as hostesses, chauffeurs, and guides.

Local Arrangements Committee

Chairman: P. L. Edwards
Registration: G. F. Pearce
Visual Aids Equipment: J. R. Baylis
Transportation: R. C. Smith
Refreshments: G. A Moshiri
Junior Academy: W. P. Halpern
AAPT: W. B. Phillips
Ladies Program: Mrs. P. L. Edwards

CHRONOLOGICAL PROGRAM OF EVENTS

Thursday, March 22, 1973

3:00 pm	Executive Council Meeting	Board Rm. Bldg. 10 UWF	
8-10 pm	Social Hour	Rodeway Inn	

Friday March 23, 1973

	Florida Junior Academy of Science	Bldg. Rm.	
9:00 am	Junior High Research Papers	51-158	Pg. 32
9:00 am	Senior High Literary Research Papers	52-152	Pg. 32
11:00 am	Sponsor's meeting	52-146	
	Biological Sciences and Conservation Sections		
8:30-9 am	Joint Business Session	51-152	Pg. 5
9:00 am	Symposium: Planning for the Future - Preserving Florida's Environment	51-152	Pg. 5
8:30 am	Physical Sciences Section	51-164	Pg. 18
8:30 am	Social Sciences Section	52-147	Pg. 24
9:00 am	Science Teaching Section	51-165	Pg. 28
11:30 am	Special Lecture, P.A.M. Dirac	Top Floor Lib.	Pg. 20
11:40-1:30	Luncheon, University Commons Cafeteria	Bldg. 22	
1:20 -1:50	Academy Annual Business Meeting	51-152	
1:00 pm	Junior Academy Welcome by President H.B. Crosby, The University of West Florida	52-152	
1:15 pm	High School Experimental Research Papers	52-152	Pg. 33
3:15 pm	Junior Academy Annual Business Meeting	52-152	
2:00 pm	Biological Sciences Section - Botany	51-147	Pg. 5
2:00 pm	Biological Sciences Section - Zoology	51-158	Pg. 8
2:00 pm	Biological and Medical Sciences Sections-Biochemistry, Physiology and Medicine	51-148	Pg. 10
2:00 pm	Physical Sciences Section	51-164	Pg. 20
2:00 pm	Social Sciences Section	52-147	Pg. 25
2:00 pm	Science Teaching Section	51-165	Pg. 28
4:00 pm	Session on Hypnosis	51-148	Pg. 17
5:30-6:45 pm	Cocktail Hour	Scenic Hills Country Club	
6:45 pm	Annual Banquet Welcome from President H. B. Crosby, The University of West Florida Presentation of Academy Medal, and Medalist's Address Address by R. C. Twombly, General Mgr. Nuclear Equipment Divisions, Westinghouse Electric Corporation on "Nuclear Power and the Environment"		
6:30 pm	Junior Academy Annual Awards Banquet	Ramada Convention Center	
9:00 pm	Junior Academy Dance		
9 -10 pm	Junior Academy Sponsor's Social Hour	Ramada Inn	

Saturday March 24, 1973

8:30 am	Biological Sciences Section - Ecology and Zoology	51-158	Pg. 12
8:30 am	Biological Sciences Section - Environmental Science	51-147	Pg. 16
8:30 am	Physical Sciences Section	51-164	Pg. 23
8:30 am	Social Sciences Section	52-147	Pg. 27
9:00 am	American Association of Physics Teachers-Florida Section	51-165	Pg. 30
10:15 am	Visit to plant of Air Products and Chemicals, Inc. to observe pollution abatement practices	51-147	Pg. 17

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We are indebted to the following Sponsors, who are hosting the Hospitality Room on Thursday night and the Complimentary Cocktail Hour at the Scenic Hills Country Club on Friday, and helping provide financial support for various Meeting expenses such as the printed Program, etc.:

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The Florida Academy of Sciences expresses its gratitude for their support.

GENERAL INTEREST SESSIONS

SYMPOSIUM

Biological Sciences and Conservation Sections
Friday 9:00 am (Preceded by 8:30 am Business Session) Room 51-152
PLANNING FOR THE FUTURE - PRESERVING FLORIDA'S ENVIRONMENT

Fred E. Clark (Stetson University) presiding

Jay Landers - Governmental Assistant, Office of the Governor

Earl Starnes - Director of the Division of Planning, Department of Administration

Robert Carlton - Chief of Bureau of Beaches and Shores, Department of Natural Resources

Peter Baljet - Department of Pollution Control

John DuBose - Director of Land Management Division, Land and Water Management, Trustees of the Internal Improvement Trust Fund

LECTURE

Friday 11:30 am Top Floor of Library
PS-10 Long Range Forces and Broken Symmetries P.A.M. Dirac, Florida State University

SECTION PROGRAMS

BIOLOGICAL SCIENCES SECTION

Friday 8:30 am Room 51-152
BUSINESS SESSION OF THE BIOLOGICAL SCIENCES AND CONSERVATION SECTIONS
Fred E. Clark (Stetson University) Chairman

Friday 2:00 pm Room 51-147

BOTANY

Peggy A. Winter (University of West Florida) presiding

2:05 BS-1 Isolation of Alternaria eichhorniae - A Potential Biological Control for Water Hyacinths. *D.S. McCorquodale, R.D. Martyn, and T.T. Sturrock, Fla. Atlantic University. -- *Alternaria eichhorniae* was isolated from a diseased water hyacinth leaf collected from a drainage canal in South Palm Beach County, Florida. Initial inoculations back onto healthy hyacinth leaves via agar block techniques proved the pathogenicity of this fungus and re-isolation of the same concurred the last of Koch's postulates. The infection is characterized by the development of a general chlorosis approximately 2-3 mm in diameter at the initial site of inoculation which with time increases in size and darkens forming a classical leaf spot. Shotting may occur following a general necrosis of the leaf and death of the leaf and petiole usually results after 2 weeks. The isolation of this fungus from South Florida water lends additional encouragement to the concept of biological control.

* Research supported by grant #R-801036, United States Environmental Protection Agency.

2:20 BS-2 Distribution of Mycopropagules in Sea Foam from Mid-Florida Gulf Beaches. Diane T. Wagner-Merner, Univ. of South Florida. The occurrence and distribution of arenicolous fungi from the south and central gulf coast of Florida are studied by periodic sampling of foam from four gulf beaches. The results indicate that fungal spores do occur and their distribution and diversity appear to be influenced by the location of the beaches. The role of fungi in foam is discussed.

2:35 pm BS-3 Soil Algae from North Central Florida. JIMMIE R. NORTON, Univ. of Florida. -- Surface soil samples from 6 undisturbed (non-farmed and non-grazed) areas in Alachua county representing 5 major soil types and peaty soil were treated to determine the variety of the algae they contained. Although genera from the phyla Cyanophyta, Chlorophyta, Euglenophyla and Chrysophyta occurred in most of the soil samples, the algae of the Cyanophyta and Chlorophyta were the predominant forms. A list of all the algal species encountered is presented, and the relationship of the algae to the various environmental conditions is discussed.

2:50 pm BS-4 Late Pleistocene Fungus Spores from a Florida Peat Bog. Diane T. Wagner-Merner and Linda Bergen, Univ. of South Florida. Samples from a drained peat bog in central Florida were collected and the fungus spores therein are characterized and considered in relation to the two major substrata known from the bog area. The diversity of these mycopropagules is discussed in relation to the occurrence of fungus spores from the pleistocene sediments of a lake[1] in the North Carolina coastal plain.

[1]F. A. Wolf, J. Elisha, Mitchell Sci. Soc. 84, 227-232 (1968).

3:05 pm BS-5 Bryophytes Past and Present. H. A. MILLER, Florida Technological University -- Perhaps no other major plant group has been so poorly understood and mis-represented in texts as the bryophytes. Recently discovered fossils, and re-examination of previously studied forms of ancient vascularized terrestrial plants, provide a basis for substantial revision of many previously held ideas about evolution in mosses and liverworts. Among other things, the long nurtured argument concerning homologous *vs* antithetic origin of the sporophyte seems to be irrelevant when fossils are subjected to modern processing techniques and new insights are provided. Mosses and liverworts evolved independently from early land plants similar to *Cooksonia* with forms of hepatics similar to modern *Pallavicinia* and *Jensenia* being most ancient. Bryophytes apparently neared extinction in the late Paleozoic-early Mesozoic during arid climatic periods and began to flourish again during the Cretaceous angiosperm explosion. A modern classification is presented which takes account of the evolutionary history.

3:20 pm BS-6 Introgressive Hybridization In Ipomoea Section Batatas.* WALLACE E. ABEL, Fla. Atlantic Univ. Pilot studies of the Batatas section of the genus *Ipomoea* (Convolvulaceae) revealed plants with an intermixing of characteristics between *I. trichocarpa* and *I. lacunosa*. The hybrids have characteristics similar to *I. trichocarpa* i.e., corolla, sepals, configuration and size. In addition the paler flower color of the hybrids falls well within the range of color variation occasionally seen in *I. trichocarpa*. Closer examination of hybrids reveals; stamens are deep purple as in *I. lacunosa*; the number of pollen grains per anther is significantly reduced; and the presence of extra stigma lobes, pistils, stamens and sepals is common. These indicators of meiotic abnormalities are classically associated with hybrids. Further introgression studies are in progress to determine genetic affinities within the section.

*Research supported by a grant from the Div. of Sponsored Research, Fla. Atlantic Univ. (Principal investigator D. F. Austin).

3:35 pm COFFEE BREAK

3:50 pm BS-7 The Sweet Potato Allies: A Taxonomic Review.* D. F. AUSTIN, Florida Atlantic University. --Confusion about the taxonomy of the Sweet Potato allies has plagued horticultural researchers and other biologists throughout the World for over 200 years. Some progress has been made in our laboratories in the past two years with breeding programs, morphological and anatomical study, and computer analysis. We recognize *Ipomoea triloba* (2n), *I. trifida* (2n postulated), *I. trichocarpa* (2n), *I. lacunosa* (2n), *I. tiliacea* (4n), *I. gracilis* (4n), and *I. batatas* (6n). Other names used in section Batatas by Jones, Martin, Nishiyama, Yen, and others are synonyms of these species. Our data suggest *I. triloba* allied with *I. batatas*; *I. trifida* distinct from *I. trichocarpa*; and *I. lacunosa* derived from *I. trichocarpa*.

*Research supported by a grant from the Division of Sponsored Research, Florida Atlantic University.

4:05 pm BS-8 The Status of Calonyction.* EDWARD V. CONROY, Florida Atlantic University. --The separation of the genus *Calonyction* (Convolvulaceae) from the genus *Ipomoea* has been based on characters common to many Ipomoeas, e.g., five sepals, stamens exerted from the corolla, corolla infundibuliform. A new set of characters including pollen morphology, cotyledon shape, and anatomical features are used to show the affinities of *C. tuba* (*macrantha*) to the *Ipomoea* group while these same characters demonstrate the distinctness of *C. aculeatum* and *C. muricatum*.

*Research supported by a grant from the Division of Sponsored Research, Florida Atlantic University. (Principal investigator D.F. Austin).

4:20 pm BS-9 New Evidence Concerning the Placement of the Genus Hemigraphis in the Family Acanthaceae. S. D. TODD, Univ. of S. Florida.
Chromatographic data on corolla pigmentation of the genus *Hemigraphis* is offered as a new approach to the proper placement of this genus within the family Acanthaceae. Information obtained in comparing the various subtribes is considered along with other methods employed in classifying this tropical genus. It is tentatively concluded that the placement by Melchior of the genus *Hemigraphis* is incorrect, and that the genus is actually more closely related to subtribe Rueliinae.

4:35 pm BS-10 Field Studies of Two Species of Leucobryum in West Central Florida. George D. Griepenburg and Diane T. Wagner-Merner, University of South Florida. *Leucobryum albidum* (Brid.) Lindb. and *Leucobryum glaucum* (Hedw.) Schimp. are found in hardwood hammocks but occassionally occur in other plant communities. Each of these species typically lives in distinct microhabitats. The preliminary results indicate that gametophyte size variations are correlated with specific substrata. This suggests that the taxonomy of these two species should be reconsidered.

4:50 pm BS-11 Biosystematic Studies of Ruellia geminiflora, Acanthaceae
J. J. Wassmer, University of South Florida

Hybridization experiments with *Ruellia geminiflora* demonstrate that this tropical American species is genetically related to species in both of the temperate North American complexes *R. humilis* and *R. caroliniensis* since fruits were formed from interspecific crosses. Crosses were scored on the basis of (1) sterile, seeds absent or all aborted; (2) partially interfertile, seeds present but empty; and (3) fertile, seeds present with embryo. Chromatographic evidence also indicates relationship between *Ruellia geminiflora* and the *R. caroliniensis* complex. Repeated attempts involving members of the *R. coccinea* complex produced only empty seeds. Total results suggest a definite relationship between *R. geminiflora* and certain temperate American species.

Friday 2:00 pm Room 51-158
ZOOLOGY
Sneed B. Collard, University of West Florida, presiding

2:05 pm BS-12 Observations on a reversed specimen of the fringed flounder, *Etropus crossotus* Jordan and Gilbert, from Escambia Bay, Florida. P. M. McCaffrey and G. Cherr, Florida State University. A single reversed specimen of *Etropus crossotus* was collected from Escambia Bay, Florida, during trawling studies aboard the R/V SUSIO during November, 1972. This appears to be the first report of reversal in this species. Identification of the reversed specimen is confirmed by comparison of its external morphology, meristic characters, and osteology as determined by radiograph analysis, with those of normal specimens from the same and other areas of the Gulf coast.

2:20 pm BS-13 Biotope Diversity in Relation to the Ichthyofauna of the Indian River Region of Florida. ROBERT H. GORE, Smithsonian Institution, Ft. Pierce, Florida. -- The Indian River on the central east coast of Florida is an elongate, shallow, eurythermal and euryhaline lagoon, separated along its eastern margin from the Atlantic Ocean by several long, interrupted barrier islands. Freshwater inflow from the marshes and tributaries of the St. John's River plus marine inflow from the Atlantic Ocean give the river a decidedly estuarine character. Resultant ecological conditions throughout the river are quite varied with seasonal temperature fluctuations from 13° C in the winter to about 36° C in the summer; salinity varies from 5°/o near freshwater canals to 36°/o near the inlets from the ocean. Evidence obtained during a one year survey of the ichthyofauna indicated that the over 260 species collected occured in nine major habitats. These habitats are briefly described and discussed in relation to the ichthyofauna of the Indian River.

2:35 pm BS-14 Ecological and Zoogeographical Aspects of the Fishes of the Indian River Region of Florida. R. GRANT GILMORE, JR., University of West Florida. -- Throughout 1972 an ichthyological survey of the Indian River was made. Over 260 species were recorded representing 169 genera in 74 families. The majority of these fishes had affinities with the Antillean fauna. A smaller number represented the continental and Carolinian faunas or had a disjunct distribution through the Caribbean. At least five species were range extensions previously unknown from north of South Florida and the Keys. Complete records of the environment at each sampling site enables prediction of preferred fish habitats and seasonal movements.

2:50 pm BS-15 Biological Observations on Some Sharks of the Indian River Region of Florida. L.D. WILLIAMS , Florida Technological University. -- Aspects of the distribution, feeding habits, behavior, reproduction and morphology of sharks collected from the inshore waters of the Atlantic in the Indian River Region are discussed. Collecting was carried out over the past two years with both longline and conventional fishing techniques. Five families encompassing seven genera and 15 species of sharks have been presently collected in the survey.

3:05 pm BS-16 Occurence and distribution of *Bembrops anatirostris*, a little-known percophidid fish, on the continental shelf in the northeastern Gulf of Mexico. P. M. McCaffrey, Florida State University. On the basis of collections made during the Gulf Shelf Project, *Bembrops anatirostris* is shown to be an important component of the demersal ichthyofauna of the outer shelf zone in the northeastern Gulf of Mexico. Its occurence and distribution in the area are related to temporal and spatial variations in bottom temperatures and substrate types, respectively.

3:20 pm BS-17 Structure and Hypothetical Feeding Function of the Batfish Esca. C.L. COMBS, Florida State Univ. -- Small gastropods were found to comprise about 80% of the diet in 19 specimens of the batfish, Ogcocephalus cubifrons. The glandular nature[1] of the esca, or "lure", of this batfish species was studied histologically. Anatomical and morphological studies of the esca and related musculature as well as preliminary behavioral observations suggest that secretions may be forcibly ejected from the esca. Most species of gastropods identified in intestinal analyses of batfishes are known to be highly chemoreceptive carnivores[2]. The esca may function as a unique chemical "lure" useful in attracting secretive, chemoreceptive gastropods to within range of visual capture by the batfish.

[1]Bradbury, M.G. 1967. The genera of batfishes (Family Ogcocephalidae). Copeia 1967 (2):399-422.
[2]Kohn, Alan J. 1961. Chemoreception in gastropod molluscs. Am. Zoologist 1:291-308.

3:50 pm BS-18 Growth Rate of Juvenile Pomacentrus variabilis (Pisces: Pomacentridae) in the Northeastern Gulf of Mexico. Hal A. Beecher, The University of West Florida. Juvenile P. variabilis (9-10mm SL) first appear at Panama City jetties in late May and continue to appear through early September. Young damselfish gain about 20mm during June, about 12mm during July, about 5mm during August, and about 2mm a month in September and October. This growth produces a 200-fold weight increase from 0.04gm at metamorphosis to 8gm in early November. Fish metamorphosing later in the summer will not attain this growth in the first year.

4:05 pm BS-19 Biomass, diversity and yield of the ichthyofauna of a small estuarine bayou, Anclote River, Florida. *W. A. Fable, J. K. Rolfes, R. C. Baird, University of South Florida.--Ecological studies of shallow water marine and estuarine fishes which attempt to measure biomass, diversity or productivity are inherently difficult due primarily to problems of quantitative sampling.

A small bayou which drained almost completely at extreme low tides was blocked using a Fyke net arrangement at high tide. Fishes were then collected in or behind the Fyke at the succeeding low tide. The low selectivity of the collecting methodology allowed reliable estimates of biomass, diversity and seasonality in this restricted habitat.

*Research supported by Florida Power Corporation, St. Petersburg, Florida.

4:20 pm BS-20 Preliminary results of an ecological study of the ichthyofauna of Anclote Anchorage. *A. Feinstein, J. K. Rolfes, D. M. Milliken, R. A. Dietz, R. C. Baird, University of South Florida.--An environmental study of the Anclote Anchorage has been in progress since September 1970. To date approximately 110 species and 50 families of fish have been taken. Description of the program and the results of preliminary data analysis are presented.

*Research supported by Florida Power Corporation, St. Petersburg, Florida.

4:35 pm BS-21 The 1972 field study of the pygmy chimpanzee, Pan paniscus in central Africa.*M.J.HANSINGER, Univ. of Florida. This paper will describe the background and results to date of a behavioral, physical, and ecological study by a Yale Peabody Museum team which included a Univ. of Florida member. The distinctive size of the pygmy chimpanzee qualifies it as the best living analogue for the earliest hominids, Ramapithecus and Australopithecus. Heretofore it has been studied only superficially in the wild. The field team set up a base in equatorial rainforest in Zaire (Congo) and started observations on nesting and feeding behavior, obtained basic data on updating distribution maps, and has a

preliminary report on the ecology of the study area. The prinicipal investigators will analyze the osteology and dental morphology in the museum collections in Europe and the US, while Zaire studies continue. Data are sought to permit building models of evolutionary behavior.
* Research supported by NSF grant GS-32741.

4:50 pm BS-22 Intestinal Parasites of Squirrels C.J. CHEW, University of West Florida. A random sample of 40 individuals of the Easter Gray Squirrel (Sciurus carolinensis) were collected in northwest Florida from an area extending from Liberty County westward to and including Escambia County. The specimens were sexed and sized (i.e. dry weight of the liver, kidneys, and adrenal glands). The gastro-intestinal tract was examined to determine if parasites discriminate as to sex or size of the host. The stomach content was also examined for food type and possible arthropod intermediate hosts. The following types of parasites were collected: nematodes, acanthocephalans, and cestodes. No discrimination by these parasites was observed.

5:05 pm BS-23 Comparative Studies of Grooming Behavior in Three Subspecies of Peromyscus polionotus.* L. M. Ehrhart, Florida Technological Univ. -- The grooming behavior of old-field mice from populations in central Alabama (P. p. colemani); Santa Rosa Island, Fla. (P. p. leucocephalus); and Marion Co., Fla. (P. p. subgriseus) is compared through analysis of the number of grooming bouts and the duration of grooming in two separate tests in an open field arena. Comparisons of grooming performance between sexes and between laboratory-raised and field-captured subjects are also discussed. A brief description of the motor patterns involved in grooming in P. polionotus is also included. Intersubspecific comparisons of grooming behavior revealed two distinct trends: 1) a definite gradient in grooming activity from leucocephalus (the highest) through colemani to subgriseus (the lowest) insofar as field-captured animals are concerned and 2) similar grooming performances by all lab-raised animals. The possible adaptive significance of these trends is discussed.
*Research supported by N.S.F. grant 3072 to J. N. Layne.

5:15pm BS-23A The Moonfishes and Lookdowns of the Carangid Genus of Selene, FRED H. BERRY, National Marine Fisheries Service, Miami, Florida -- The toxonomy and zoography of the seven species of the genus selena are described and discussed.

Friday 2:00 pm Room 51-148

BIOCHEMISTRY, PHYSIOLOGY AND MEDICINE
John P. Riehm (University of West Florida) presiding

2:05 pm BS-24 Seasonal Temperature Characteristics of Cytoplasmic Malic Dehydrogenase from the Gut of the Sand Dollar, Mellita quinquiesperforata. W. ROSS ELLINGTON Department of Biology, University of South Florida. Tissue extracts were prepared from the guts of juvenile and adult sand dollars, Mellita quinquiesperforata (Leske), collected seasonally at ambient water temperatures between 18 and 31°C. Arrhenius plots (log specific activity vs. 1 T°K) show a departure from linearity which is most pronounced at higher temperatures. Calculated value for the Arrhenius activation energy (Ea) decrease as temperature increases. Slight, noncompensatory translations right and left occur. Apparent Km vs. temperature plots are U-shaped curves regardless of season or state of maturity of the enzyme source. The apparent Km increases greatly above 25°C. The increase in Km at higher temperatures results in a moderation of the reaction rate. This homeostatic feature of the enzyme would be of adaptive value to the organism. Seasonal data indicate that there is no acclimatization of malic dehydrogenase activity in M. quinquiesperforata.

2:20 pm BS-25 Potential Antitumor Agents of Dacryodes excelsa Vahl. *C.W.J. Chang, M. Moorer, and R.B. Brownlee, University of West Florida. One of the more important trees in the lower Cordillera forest of Puerto Rico is the species D. excelsa which belongs to the family Burseraceae. The resinous exudate of the wounded tree has been reported to be used by the natives in alleviating pain due to arthritis. It has also been used as an antipyretic. This paper discusses work related to the isolation of the chemical constituents of D. excelsa and partial results of biological testings for antitumor activity.
Sponsored in part by National Science Foundation and National Cancer Institute.

2:35 pm BS-26 Utilization of Marine Polysaccharides by Bacteria of the Gut of the Sea Urchin, Lytechinus variegatus. P. PRIM, Department of Biology, University of South Florida. Six bacterial isolates from the gut of Lytechinus variegatus (Lamarack) were examined to determine their ability to metabolize natural polysaccharides (alginic acid, laminarin, carrageenin, agar, starch, cellulose and chitin). Mixed gut fauna were examined for their ability to metabolize the same natural polysaccharides and marine plants (Eucheuma nudum J. Agardh, Caulerpa prolifera (Forsskal) Lameureux, Thalassia testudinum Konig and Sims, Diplanthera wrightii (Aschers) Aschers, and Ulva lactuca Linnaeus).

The six isolates were found to have the ability to metabolize alginic acid, agar, starch and carrageenin. Mixed gut fauna were found to have limited ability to metabolize all the natural polysaccharides investigated. All the marine plants except Caulerpa prolifera were physically degraded after extended periods of time by the mixed gut fauna.

2:50 pm BS-27 Preliminary Characterization of a Prolactin-like Hormone from the Pituitary of the Grey Mullet, Mugil cephalus. JOHN T. WOOSLEY, Univ. of South Florida. -- Pituitary extracts were fractionated by G-75 Sephadex gel chromatography. The prolactin-like hormone peak was determined by radioimmunoassay and by the Gillichthys xanthophore pigment dispersion bioassay of Sage[1]. The molecular weight was estimated from its eleution behavior.

[1] Martin Sage, J. Exp. Zool., 180:169-174 (1971)

3:05 pm BS-28 Prolactin Production in Organ Cultures of Anterior Pituitaries from the Gray Mullet, Mugil cephalus. M.E. McNulty, Univ. of South Florida.--Pituitaries removed from M. cephalus were used to establish both organ and tissue culture systems. The organ cultures, consisting of the anterior pituitaries, maintained their histological integrity and their ability to produce prolactin for at least three days. Tissue cultures derived from whole pituitaries continued to proliferate for at least thirty days. However, prolactin activity could not be detected in medium in which the monolayer cultures were grown. These data suggest that the histological architecture of the endocrine gland may be required for production of prolactin in vitro.

3:20 pm BS-29 A Capillary Micro-Method for Screening Hyperlipoproteinemic Subjects. H.H. DASH, M.S., D. YARMOSH, B.S., E. VICENTE, B.S., E. BOYLE, JR., M.D., Research Division, Miami Heart Institute.-- A rapid, economical and reliable capillary method is described for characterizing subjects with possible elevated levels of beta- and prebeta lipoproteins. Such elevated levels are presumptive for Type II and IV hyperlipoproteinemia as classified by the World Health Organization. In summary the method employs 50 lambda of plasma separated from blood obtained by finger puncture and collected in a microhematocrit tube. The lipoproteins are precipitated by K-Agar solution. The precipitate is quantitatively estimated under specified conditions. Evaluation of the results are processed statistically.

Boyle, E. and Moore, R.V., J. Lab. and Clin. Med. 53:272 (1959)
Boyle, E., Dash, H., Owen, D., Yarmosh D., Ann. Clin. Lab. Sc. 2 Num 5:393 (Sept-Oct. 1972)

3:35 pm BS-30 Subunit Structure of a Flavoprotein External Hydroxylase. *L. G. HOWELL, J. O. TSOKOS, Univ. of South Florida.-- p-Hydroxybenzoate hydroxylase is a catabolic aromatic hydroxylase which has been isolated from several pseudomonads. The enzyme, as isolated from P. fluorescens is representative of flavoprotein external hydroxylases; it possesses one active site per molecule and exhibits the unique control property all external hydroxylases have been found to possess in which the substrate acts as an effector or activator in addition to its role as substrate. The physical characteristics related to this control mechanism will be discussed.

*Research supported by -- U. S. P. H. S. grant number GM-19304-01.

3:50 BS-30a The Neural Mechanism of Resistance to Botulinal Toxin.* G. M. COHEN and A. L. PATES. Florida Inst. of Technology and Florida State University. - Botulinal toxin acts specifically at presynaptic nerve endings where it blocks the release of acetylcholine. Though there are variations in resistance among different species of animals, no animal remotely approaches the resistance exhibited by the vulture. The latter, however, posses - ses no detoxifying mechanisms nor natural antibodies as a defense against the toxin. Instead it seems that the vulture's resistance is attributable to the properties of the presynaptic nerve endings. A model suggesting differences in presynaptic receptor sites accounts for the neural mechanism of resistance and susceptibility. The rooster, a susceptible animal, was tested in a series of experiments in conjunction with the highly resistant vulture.

*Supported in part by U.S. Army Research and Development Command Contract DADA 17-68-C8165

Saturday 8:30 pm Room 51-158
ECOLOGY - ZOOLOGY
G.A. Moshiri (University of West Florida) presiding

8:30 am BS-31 Floral and Sedimentological Succession in Taylor Slough, Everglades National Park, Florida. Patrick J. Gleason, Central and Southern Florida Flood Control District. -- Thirty cores of peat and calcitic mud sediment were taken from Taylor Slough in Everglades National Park. The peat was embedded in paraffin and examined in thin section. Water-lily rootlet peat is found at the bottom of the deep bedrock trough in the slough suggesting that deeper levels of fresh-water prevailed in the slough in the past. Shallow water peats such as sawgrass peats are found on top of water-lily peats. Red mangrove peat is found north of the present inland boundary of mangrove growth. The stratigraphy of the fresh water calcitic mud indicates that it may undergo many cyclical interbeddings with peat, particularly mangrove peat. The arrangement of mangrove peat over fresh-water calcitic mud in the southern-most part of the slough indicates that a transgression of the sea has occurred on this section of the Florida coast.

8:45 am BS-32 Certain Nutrient Primary Productivity relationships in a bayou estuary. *G.A. Moshiri, D. S. Brown, R. S. Engert, Jr., and P. H. Crittenden, University of West Florida. Results of the first of a two-year study of nutrient-primary productivity relationships in Bayou Texar, Pensacola, Florida suggest that strong spatial and temporal correlations exist between surface and sub-surface carbon fixation rates, BOD, community respiration, dissolved oxygen and the extent of nutrient input from Carpenter's Creek. Results of concurrent studies also suggest correlation between the above-mentioned factors, fluctuations in algal genera and cell numbers, and periods of community instability as demonstrated by frequent fish kills.

*Research supported by office of Water Resources Research, U. S. Department of the Interior

9:00 am BS-33 Certain aspects of spatial and temporal periodicities in phytoplankton populations in a bayou estuary. *G. A. Moshiri, P. J. Conklin, K. K. Bennert, Univ. of West Florida. Results of the first year of a two-year study indicate certain trends in the appearance of phytoplankton organisms. In general during the warmer months the dinoflagellates were the dominant species. These were replaced by diatoms during the cooler months. Dinoflagellate blooms also followed periods of high raw sewerage inflow into the bayou and preceeded fish kills. Spatially, the highest concentration and greatest fluctuation in cell numbers were observed in areas of highest nutrient concentration caused by input from Carpenter's Creek at the northernmost point in the bayou. Concentrations and fluctuation decreased with a decrease in nutrient concentration in the lower stations.

* Research supported by Office of Water Resources Research, U.S. Department of the Interior.

9:15 am BS-34 Observations on parasites of mid-water fish. Sneed Collard, Norm Rubenstein and Pete Blizzard, University of West Florida.

Observations were made of parasitic copepods found on two families of mid-water fishes (Myctophidae and Gonostomatidae). Discussion will be concerned with host-parasite relationships. A preliminary description of the copepods will be presented.

9:30 am BS-35 A New Monogenetic Trematode Related to the Genera Kuhnia and Mazocraes (Family Maxocraeidae). An undescribed monogenetic trematode was collected from the butterfish, Stromateus stellatus. The fish were caught off the coast of Chile in 1967. The parasite was provisionally placed in the family Mazocraeidae because of its U-shaped Mazocraes-like clamps and its armed genital atrium. It appears to be superficially related to the genera Mazocraes and Kuhnia, especially the latter. The worm's asymmetrical opisthaptor and newly reported host are unusual.

Submitted by Arthur J. Butt, University of West Florida

9:45 am BS-36 Observations on a parasitic copepod of a mid-water fish. SNEED COLLARD, NORM RUBENSTEIN AND PETE BLIZZARD, University of West Florida. Observations were made of a parasitic copepod on a mid-water fish of the family Gonostomatidae from the Western Sargasso Sea. A ten foot Issacs Kidd Mid-water Trawl was utilized and specimens were fixed in formaldehyde and preserved in 70% ethanol. A preliminary description of the copepod will be presented and discussion will be concerned with the host-parasite relationship.

10:00 am BS-37 The Culture of the Lugworm, Arenicola cristata, as a source of Bait. C. N. D'Asaro, The University of West Florida, Pensacola, Florida.

Lugworm culture holds great promise as a source of bait for sportfishermen. Due to direct development and unsophisticated feeding habits, the various ontogenetic stages are much easier to rear than bloodworms or clamworms. Solutions to several problems will facilitate mass culture. The best culture vessel must be determined for worms less than 5mm in length. Small worms living in sand or mud are difficult to handle or observe. Swimming at all stages should be prevented or a large percentage of the animals will escape from the culture vessel. Readily available supplementary foods must be developed so that the worms can be crowded at concentration above 100/m. When these problems have been solved lugworm culture will be possible on a commercial scale.

10:15 am BS-38 The Distribution of Fiddler Crabs, Genus Uca, Along the Northwestern Gulf of Mexico. C. L. Thurman, Univ. West Florida. In recent years; the status of Uca along the Gulf Coast of the United States has undergone reevaluation. The original distributions of various species as proposed by Rathbun (1918) in several cases are no longer valid. U. pugilator is found in the northern Gulf of Mexico. West of Pensacola, Florida it is succeeded by an undescribed species. U. pugnax in this region has been reclassified as U. longisignalis. U. spinicarpa has been collected in Escambia Bay thus slightly extending its distribution eastward from Mississippi. The species boundary of U. minax appears to be in the Mississippi River Delta area. Westward into Texas, its ecological position is succeeded by U. longisignalis. U. rapax and U. subcylindrica appear to maintain their originally described distributions.

10:30 am COFFEE BREAK

10:45 am BS-39 Observations on Chaetognaths from Selected Areas of the Caribbean Sea and Yucatan Straits. R. H. Mattlin, Univ. of West Florida. Opening/closing half-meter plankton net tows taken during March 1972 from the USNS Mizar at two stations off the northern Venezuelan coast and one station in the Yucatan Straits have been examined for chaetognaths. Species diversity, vertical and spatial distribution correlate with watermass characteristics. The species encountered are: Krohnitta subtilis, K. pacifica, Pterosagitta draco, Sagitta bipunctata, S. lyra, S. enflata, S. hexaptera, S. decipiens, S. serratodentata, S. hispida, S. helenae, and S. friderici. The appearance of S. friderici at Station I (10°38 N; 65°45W) is unusual.

11:00 am BS40 Occurance of a Digenetic Trematode in the Coelom of a Chaetognath. A. J. Butt, R. H. Mattlin, Univ. of West Florida. A hemiurid trematode (metacercaria) was found in the coelom of Sagitta serratodentata collected from the USNS Mizar in March, 1972, while in the Yucatan Straits. Since the chaetognath is decapitated, identification was determined by the shape and location of the paired fins. The chaetognath is 7.20 mm long (minus head) and 0.36 mm wide at the location of the trematode. The trematode is 0.64 mm long, and 0.30 mm wide. It is located 2.49 mm from the chaetognaths caudal end, 0.42 mm. from the caudal septum, and is facing posteriorly. The chaetognaths intestine is displaced against the left ovary, which in turn is pressed against the body wall. Pressure is also against the right ovary. There is no other apparent damage to the chaetognath.

11:15 am BS-41 The Renopericardial Complex In Several Marine Prosobranchs.,HAROLD J. McDONALD JR.,University of West Florida. The marine prosobranchs have been largely ignored in studies of molluscan excretory structure and function. Only Duerr(1967,1968) has dealt with the marine prosobranchs at length.However,his work was only concerned with analyses of the final urine. With the use of vital stains and latex,the gross anatomies of the selected renopericardial complexes will be determined. Histological sections will be made at several points along the system. The marine prosobranch excretory system is composed of the heart and kidney connected via a ciliated renopericardial canal. Dissections and histological sections will be interpreted and related to the literature.

Duerr F.G.,Comp.Biochem.Physiol. 22:333-340(1967).
Duerr F.G.,Comp.Biochem.Physiol. 26:1051-1059(1968).

11:30 am BS-42 Mesopelagic Fishes from the Gulf Stream. S. B. Collard, A. W. Blizzard and N. J. Rubenstein, Univ. of West Florida.

Midwater fishes from 27 three meter Isaacs-Kidd Midwater trawl collections made in the Gulf stream and western Sargasso Sea from the R/V Eastward are discussed. Few collections have been made in this area, and the catch composition is unusual. Emphasis is placed on fishes of the families Myctophidae and Gonostomatidae.

*Research supported by Duke University Oceanographic Programs

11:45 am BS-43 A description of a mesopelagic fish and its parasite Pete Blizzard, Norm Rubinstein, University of West Florida.

A specimen of Gonostoma elongatum (Pieces: Gonostomatidae) was collected in September, 1972, in the western Sargasso Sea. Examination revealed the presence of a lernaeocerid copepod of the genus Cardiodectes attached to the fish between the third and fourth VAV photophores. The host was dissected to determine the specific location of parasite attachment. Non-parasitized specimens collected from the same area were compared to the parasitized individual as a possible means of determining parasite influence. A review of the literature disclosed no information concerning parasitism of this particular mesopelagic fish. A description of the copepod is presented and discussion includes aspects of the host-parasite relationship.

12:00 BS-44 Capture and Recovery of Common Snipe on Paynes Prairie. Michael J. Fogarty, Florida Game and Fresh Water Fish Commission, Gainesville, Florida. About 2,100 common snipe (Capella gallinago) have been captured with mist-nets, banded, and released on Paynes Prairie since 1967. Details on the habitat, capture techniques, and various physical measurements of the snipe wintering on Paynes Prairie are presented. Direct and indirect recoveries resulting from this banding effort are discussed.

12:15 pm BS-45 A Preliminary Survey of DDT and Mirex Residues in Turtles (Reptilia: Testudines). C. G. JACKSON, JR., C. M. HOLCOMB, M. M. JACKSON, Mississippi State College for Women. -- An investigation of the chlorinated pesticide residues in the tissues of turtles was undertaken, using gas chromatography. Animals were collected in 1970 and 1972. DDT residues (*p,p*-DDT, *p,p*-DDD, *o,p*-DDT, and DDE) and Mirex were assayed in liver tissue and shelled eggs (contents only). Mean DDT residue value for liver in the 1970 sample of turtles was 1.47 mg/kg dry weight tissue. In 1972 samples the value dropped to 0.38, a 74% decrease. Mirex in liver tissue in 1970 samples was 2.39 mg/kg dry weight tissue. In 1972 the value increased to 3.64, a 54% increase. Mean DDT residue value for egg contents in the 1970 sample was 1.89 mg/kg dry weight. In 1972 samples the value dropped to 0.79, a decrease of 58%. Mirex in egg contents in 1970 samples was 1.54 mg/kg dry weight. In 1972 the value increased to 1.88, an increase of 22%.

12:30 pm BS-46 Field Studies of Alligators Nesting in the Everglades. Michael J. Fogarty and James L. Schortemeyer, Florida Game and Fresh Water Fish Commission. -- Alligators (Alligator mississippiensis) nesting in the Everglades Wildlife Management Area, Broward Co., have been studied since 1968. Basic nesting biology data are presented on nest size and construction, clutch size, incubation periods, response to varying water depths, hatching percentages, and agnostic behavior of the adult females.

12:45 pm BS-47 Herbicide Related Changes in Phenolic Acid Content of Hydrilla verticillata.* R. E. WOODWARD, R. L. MANSELL, W. S. SILVER, Univ. of South Florida. Two local lakes, infested with Hydrilla verticillata, were treated with diquat via the bivert system. Five major phenolic acids were identified in samples of four tissue types; apical meristems, leaves, stems and turions. Phenolic content was quantitatively assayed prior to herbicide treatment and monitored for a period of five months thereafter. Vanillic, protocatechuic, p-hydroxybenzoic and ferulic acids were present at ug/g (D.W.) levels while caffeic acid, occuring as at least six isomers, was present at mg/g (D.W.). The latter exhibited the greatest magnitude of variation in all tissue types while the other compounds remained relatively constant in amount. The possible relationship of this to biological control of the plant will be discussed.

* Research supported by the Dept. of Nat. Res. and SWFWMD.

Saturday 8:30 am Room 51-147
ENVIRONMENTAL SCIENCE
J. A. Edmisten (University of West Florida) presiding

8:30 am BS-48 A Regional Educational Environmental Feasibility Study* WILLIAM TRANTHAM, Florida Keys Community College. — This paper will describe the project now in progress at Florida Keys Community College to train Ecological Technicians for government and industry utilizing the natural living reef and island environment adjacent to the College. The three-year project has been Federally funded in the amount of $50,000.00 for the 1972-73 school year.

*Research supported by Title III

8:45 am BS-49 The Florida State Collection of Arthropods and the Research Associate Program which supports its development. Howard V. Weems, Jr., Curator, FSCA, Doyle Conner Building, University of Florida campus, Gainesville. -- The Florida State Collection of Arthropods is the official state reference and research collection. It is the largest and most complete arthropod collection in the southeastern U. S. Support for the program is provided primarily by the Division of Plant Industry, Florida Department of Agriculture and Consumer Services, but support in various forms is provided also by the Florida State Museum, Department of Entomology and Nematology, Division of Biological Sciences, and Graduate School of the University of Florida. Also close working relationships are maintained with the Laboratory of Aquatic Entomology at Florida A & M University and with Tall Timbers Research Station located near Tallahassee. An arthropod identification service is provided to the people of Florida, and the collections and library are available to research workers, including graduate students. Primary area of interest covers the southeastern U. S., Greater and Lesser Antilles, and lands in or near the Gulf of Mexico and the Caribbean Sea.

9:00 am BS-50 Florida's Coastal Vegetation -- Current and Future Research. J. M. CARLTON, Florida Dept. of Natural Resources, Mar. Res. Lab. -- The Department of Natural Resources has undertaken a Florida coastal vegetation survey, including mangrove, salt marsh, and sand dune areas. This effort will result in an inventory of plants from selected sites around the state and notes on the vegetation between sites. Plans also include transplant experiments of both mangrove and sand dune species.

9:15 am BS-51 Artificial Sea Grass Beds. V. Foster, Pensacola Junior College. This paper describes the effectiveness and durability of artificial marine grass beds formed from strands of polypropylene strands anchored to the floor of Escambia Bay, Florida.

9:30 am BS-52 Progress Report: Mangrove Planting for Stabilization of Developed Shorelines. A. S . AUTRY, Tampa Electric Company; & V. N. STEWART, MAUREEN FOX, WILLIAM HAMILTON, Conservation Consultants, Inc. In October 1972, over 900 mangrove seedlings (Rhizophora mangle, Avicennia germinans, and Laguncularia racemosa) were planted on a breakwater at the Tampa Electric Company Big Bend Power Plant on Tampa Bay. Various planting techniques were employed. Each month the site is surveyed and survival and development recorded. Red Mangrove radicles were also planted and their stability and growth is noted. To date, Red Mangroves have been most successful. The sandy northeast beach has been the most favorable habitat.

9:45 am BS-53 Agricultural use of Sewerage Sludge. Joe A. Edmisten, University of West Florida. Liquid sludge (2-3% solid) was applied to green house populations of tomatoes and corn. The maximum rate of safe application was found to be about 1 acre inch per week. Elemental analysis of sludge and plant tissues were performed. The results are being applied to field experiments. Color slides and details will be presented.

10:00 am BS-54 Removal of Nitrogen and Phosphorus in Industrial Waste Water by Oxidation Ponds. JAMES B. LACKEY, Air Productes and Chemicals, Inc. (A trip to see the oxidation ponds in action will be made at this time).

SESSION ON HYPNOSIS

Friday 4 pm Room 51-148

4:00 pm Mind Over Platter WILLIAM TRANTHAM, Florida Keys Community College. This paper will discuss the use of hypnosis rather than diet pills for weight loss. This will include a discussion of multiple reinforcement of suggestion by means of varied sense modalities as well as ego involvement to combat obesity. Techniques of both heterohypnosis and self hypnosis will be incorporated in the discussion.

4:10 pm The Use of Hypnosis to Reduce or Eliminate Post-Operative Pain WILLIAM TRANTHAM, Florida Keys Community College. — This paper will describe hypnotherapy conducted by the author at Florida Keys Memorial Hospital and The Medical Arts Building in Key West to alleviate post-operative pain. This will include a discussion of the use of hypnosis to decrease discomfort and improve performance in physical therapy following surgery.

4:20 Hypnosis in Self Improvement, WILLIAM TRANTHAM, Florida Keys Community College. A lecture and demonstration of the use of hypnosis in self-improvement areas. This will include audience participation in suggestibility exercises. The phenomenon of hypnosis will be explained and misconceptions clarified.

PHYSICAL SCIENCES SECTION

Friday 8:30 am Room 51-164
Sylvan C. Block (University of South Florida) presiding

8:30 am PS-1 Physical Aspects of Biological Effects of Microwave Radiation.* S. C. BLOCH, J. G. CORY, AND D. S. WILKINSON, University of South Florida.-- The physical basis of microwave radiation effects on biological systems are briefly reviewed. Specific experiments are described concerning quasi-plane wave 2450 MHz irradiation of live mice with Ehrlich tumors, and subsequent radioisotope analysis of effects on DNA, RNA, and protein synthesis as functions of the incident power density. Irradiation of tumor cells *in vitro* in the TM_{010} mode of an L-band resonant cavity is also discussed.

* Research supported by NIH and The Florida Chapter of the American Cancer Society.

8:45 am PS-2 Thermal Expansion Measurements on Optical Materials. S. S. BALLARD, J. S. BROWDER*, J. F. EBERSOLE, and G. W. CHRISTOPH, Univ. of Florida. -- This program has been underway for several years. An interference-type dilatometer was first used to measure the thermal expansion of small samples, usually cylinders 1/2-inch in length, in the range 0-100°C. A sensitive capacitance-type dilatometer was then designed and constructed with which measurements can be made from room temperature down to 4.2 K. A somewhat similar instrument covers the range from room temperature up to 250°C. Thus, measurements can now be made over a 500° temperature interval. Samples studied have included chiefly newer materials of interest in the infrared spectral region. Most are cubic in structure, but some anisotropic crystals have also been studied.

*Now at Jacksonville University.

9:00 am PS-3 High-Resolution Seismic Reflection Studies of the West Florida Continental Shelf 1: Equipment and Techniques. T. E. Pyle, J. C. McCarthy, L. Kershaw, D. Wallace, Univ. of South Florida.--Environmental and marine geologic studies in progress at the Dept. of Marine Science have led to a need for information on the structural configuration of sub-bottom sedimentary layers, particularly the upper strata. To provide such data a high-resolution seismic reflection profiling system has been developed which includes a 300 joule EG&G "Uniboom" sound source and Aquadyne Mesh-8 hydrophone streamer interfaced to an EPC Labs dry-paper PGR. Peak power output (and penetration) is achieved in the frequency range of 0.5 to 1.5 kHz although adequate power at higher frequencies (2.0-3.0 kHz) is available if higher resolution is more desirable than penetration capability. Performance ranges from ≤20' penetration in shallow water, "hard bottom" conditions - such as portions of the inner shelf and Tampa Bay to >100' in other portions of Tampa Bay and >500' in the deeper water of the middle and outer shelf. In application the quality of data is dependent on a number of environmental, design and operational limitations.

9:15 am PS-4 High-Resolution Seismic Reflection Studies of the West Florida Continental Shelf 2: Initial Results, 27°N to 29°N. *J. C. McCarthy, T. E. Pyle, Univ. of South Florida.--Reconnaissance seismic reflection surveys conducted on the west Florida shelf during the fall and winter of 1972-73, with a 300 joule boomer system, have provided new structural data relevant to the genesis of the Pleistocene-Holocene relict shoreline features and reefs observed in earlier studies of this region. Initial efforts have been concentrated between the 50 and 200 m isobaths and the most prominent morphologic features described have been found to consistently reoccur at 60, 80-100, and 150 m depths. In addition, traverses have been made over the Florida Middle Grounds province which appears to be composed of constructional features modified by regional current patterns. There is little evidence to support the presence of a "river delta" proposed on the basis of an early bathymetric survey.

*Ship time provided by State University System Institute of Oceanography.

9:30 am PS-5 Another Attempt To Get Around The Uncertainty Principle. J. S. Marsh, Univ. of West Florida.--An experiment is described to record the double slit electron diffraction pattern and to allow the determination of the slit through which each electron has passed, thus violating the Uncertainty Principle. The experiment uses a floating plate holder and does not tamper with the electronic wave function, in contrast to the gedanken experiments of Bohr-Einstein. The failure of the experiment is traced to position-momentum uncertainties of the plate holder itself, showing that even "classical" measuring objects contribute, if necessary, to the quantum conspiracy.

9:45 am PS-6 BCH Formulas in Superfluid Physics. R. Gilmore, Univ. of South Florida. -- Assume $\underset{\sim}{m}$ is an $n \times n$ matrix Lie algebra with a direct sum matrix decomposition $\underset{\sim}{m} = \underset{\sim}{a} + \underset{\sim}{b}$, where $\underset{\sim}{a}$ and $\underset{\sim}{b}$ are subspaces of $n \times n$ matrices that are not necessarily subalgebras. Then for $M \in \underset{\sim}{m}$, it is possible by simple matrix multiplication to find $A(M) \in \underset{\sim}{a}$ and $B(M) \in \underset{\sim}{b}$ with the property $EXP\ M = EXP\ (A)\ EXP\ (B)$. If b is an $n \times 1$ matrix of boson operators obeying $[b_i, b_j^\dagger] = -\delta_{ij}$ then the following operator identity is valid: $EXP\ b^\dagger Mb = EXP(b^\dagger Ab)\ EXP(b^\dagger Bb)$. Such a BCH formula is derived and applied to a superfluid model.

Friday 10:00 am Room 51-164
BUSINESS SESSION
Sylvan C. Block (University of South Florida) Chairman

Friday 10:20 am COFFEE BREAK

10:35 am PS-7 The Formation of Main Sequence Contact Binary Systems. E.F. MULLEN, University of Florida. -- This paper deals with aspects of the formation of contact systems due to rotational braking resulting from a stellar wind. The theory predicts mass transfer between two main sequence stars which are initially in hydrostatic and thermal equilibrium and which may still be in the early stages of the hydrogen burning phase of their evolution. The implications of such mass transfer for the W Ursae Majoris systems will be discussed.

10:50 am PS-8 The 1971 Eclipse of 32 Cyg. Raymond H. Bloomer, Jr., and Frank Bradshaw Wood, Univ. of Florida. -- 32 Cyg is a member of a class of close double stars in which one component is a hot star of spectral type B4V and the other a much cooler extremely large supergiant of Type 5Iab. Very few such systems are known. Our observations were made photoelectrically using the 30-inch reflector of the Rosemary Hill Observatory and special narrow-band interference filters centered at 3530, 4250, and 5000 Å plus red observations at 6560 Å. Twelve sets of identical filters, supplied by the Danish Research Corporation, were distributed to observatories around the world to permit realistic combination of results. Our observations show that the phenomenon of light loss is a gradual extinction of the light of the hotter star as it passes behind the extensive outer atmosphere of the cooler; details of this light loss will be of interest in analyzing the nature of this atmosphere. We also observed on some nights relatively rapid (time scale of an hour) variations in the ultraviolet which were not present in the red observations made simultaneously or in the other colors made nearly simultaneously.

11:05 am PS-9 The Advanced Evolution of a 15 Solar Mass Star. A. S. ENDAL, Univ. of Florida. Using an evolutionary computer code described by Paczyński[1] and the latest available input physics, a study is currently in progress of the post-core helium burning stages of a 15 solar mass star. The results, to date, will be reviewed and future plans outlined.

[1]B. Paczyński, Acta Astronomica, 20, 59 (1970)
Acta Astronomica, 20, 287 (1970)

Invited Paper Top Floor of Library

11:30 am PS-10 Long Range Forces and Broken Symmetries. P. A. M. DIRAC, Florida State University. -- It is proposed to use Weyl's geometry to combine the gravitational and electromagnetic fields. The usual objections to Weyl's theory can be countered. With Weyl's geometry one has a breaking of the C and T symmetries, with no breaking of P or of CT.

Friday 2:00 pm Room 51-164
H. S. Plendl (Florida State University) presiding
Friday 2:00 pm Room 51-164

Invited Paper:
2:00 pm PS-11 Novel Aspects of Heavy Ion Reactions. R. H. DAVIS, Florida State University.-- While the most novel theoretical work in recent years is the prediction of stability for super heavy nuclei in the vicinity of mass 300, the novel experimental results to date are new effects of the high angular momentum and the large Coulomb force involved in heavy ion collisions. Anomalously large increases in the moment of inertia are found for large values of nuclear spin. A striking cancellation of nuclear and Coulomb forces is observed in the inelastic scattering of heavy ions. In the search for super-heavy nuclei, additional new phenomena are excpected.

2:30 pm PS-12 Diffusion Study in a Steady-State Helium Plasma. J. T. PYTLINSKI, N. L. OLESON, University of South Florida. In the previous experiment*, we studied the diffusion losses in a collisionless argon plasma and we showed that diffusion varie with the plasma radius. Using a similar diagnostic technique as previously, we will show here some results of the diffusion study in a collision-dominated steady-state, helium plasma. By applying the classical diffusion theory, we have determined the variation of diffusion losses with the plasma radius. The meaning of the ionization frequency in the case of variation of diffusion losses will also be discussed.

*FAS Meeting, April 6,7 and 8, 1972, Orlando, Florida

2:45 pm PS-13 Stationary Nonlinear Longitudinal Waves in a Cold Magnetoplasma.* R. W. FLYNN, University of South Florida.-- The nonlinear fluid equations describing a magnetized zero temperature plasma give rise to two energy-like conserved quantities, one corresponding to each linear mode. We can exploit these invariants to demonstrate that the nonlinear waves oscillate at the frequency given by linear theory, regardless of amplitude, but as the wave amplitude increases the wave steepens and finally breaks.

* Research supported by Air Force Cambridge Research Laboratory.

3:00 pm PS-14 Electromagnetic Pulse Propagation Perpendicular to the Magnetic Field in a Collisional Magnetoplasma. C. E. SEYLER, JR., R. W. FLYNN, and S. C. BLOCH, University of South Florida.-- We have extended our previous work[1,2] to treat the problem of pulse propagation perpendicular to the magnetic field, with the incident wave linearly polarized perpendicular to $\vec{B}$. Computer solutions of pulse shapes are presented for selected values of ω_p/ω_o , ω_b/ω_o , ν/ω_o, and propagation distance in the plasma.

[1]C. E. Seyler, Jr., R. W. Flynn, and S. C. Bloch, Quart. J. Fla. Acad. Sci. 35, 17 (1972), Suppl. to No. 1.
[2]C. E. Seyler, Jr., S. C. Bloch, and R. W. Flynn, J. Geophys. Res. 77. 4237 (1972).

3:15 PS-15 Time Irreversibility - A Minority Report. P. J. Nawrocki, Federal Electric Corporation. First we examine the properties of space and time inversion in the macrodomain and find that space inversion covariance is a general 'law' but that time-inversion covariance is not. Second we discuss the inter-relation of macrophysics with the existing microphysics in which the CPT theorem and time inversion covariance are alleged to hold. Third we show that the common notion that motion is reversed under time inversion is totally incompatible with the very existence of the CPT theorem , and further that neither the CPT theorem nor the time inversion covariance is a general law of the microdomain. Fourth we show that all the existing inconsistencies are removed if we assume that the object systems of the microdomain are finite distributions of charge. Lastly we discuss biological clocks and cosmic clocks in terms of the adopted entropy clock.

3:30 COFFEE BREAK

3:45 pm PS-16 The Use of Nuclear Explosions for Gas Well Stimulation.* J.A. WETHINGTON, JR., Univ. of Florida. -- A shortage of natural gas now exists in the United States; however, in the West, there are large amounts which cannot be recovered economically because of the low permeability. Detonation of nuclear explosives in such formations offers a means for recovery. Experimental data from two such experiments, Projects Gasbuggy and Rulison, will be reviewed. Project Rio Blanco, involving the simultaneous firing of three explosives, will also be discussed.

*Research supported by University of Florida, United States Atomic Energy Commission, Associated Western Universities, and Lawrence Livermore Laboratory.

4:00 pm PS-17 Radioactivity of Construction Materials.* R. J. de MEIJER,† Florida State Univ. -- To solve the problems of shielding against background γ-radioactivity, a search for low-intrinsic radioactive concrete components has been made.[1] Several materials have been found highly radioactive. The origin and intensity of the radiation from one of them has been investigated in more detail using a 60 cm^3 Ge(Li) counter. From the measurements, conclusions are drawn concerning the suitability as construction material.

*Research carried out at the University of Utrecht, The Netherlands.
†Exchange visitor under the Senior Fulbright-Hays Program.
[1]R. J. de Meijer and A. A. Sieders, Ingenieur G51 (1969); R. J. de Meijer, Proc. Conf. Radiation and Isotope Techniques in Civil Engineering, Euratom, Brussels, October 1970

4:15 pm PS-18 Outlining Sanitary Landfills by Resistivity Surveying. Daniel P. Spangler, Univ. of South Florida.-- The resistivity survey method detects and measures variations in the resistance (inverse of conductance) of materials beneath the surface of the earth. Two field techniques aid in interpreting these variations The first, profiling, measures lateral variations and the second, sounding, measures vertical variations.

The locations and volume determinations of old landfill sites has become important from a constructional and groundwater viewpoint. Most landfill materials, due to the nature of the material, has a higher ionic concentration (and therefore more conductance or less resistance) than the surrounding natural geologic material.

To test the method three profiles with several soundings along each profile were made across a known sanitary landfill on the University of South Florida Campus, Tampa, Florida. Topographic profiles constructed from the resistivity data are in close agreement with actual topographic profiles made prior to the fill.

4:30 pm PS-19 A Petrologic Study of Some Suwannee and Post-Suwannee Limestones. J. E. Goetz, Univ. of South Florida.-- A detailed petrologic investigation of Suwannee and post-Suwannee limestone samples collected from two quarries in Hernando County, Florida disclosed many similarities common to each section. Both apparently represent a similar environment of deposition. Petrographic analysis and insoluble residue studies comprise the major portion of this investigation.

Petrographic analysis of the thin sections showed that the rocks are now sparites and biosparites. However, the extremely fine size of the spar may indicate recrystallization of an original micrite sediment.

Quartz is the most abundant mineral in the $>62\mu$ size fraction of the insoluble materials with microcline feldspar the next most prevalent. Smectite is the most abundant mineral in the $<62\mu$ size fraction with minor amounts of other minerals present. Proper interpretation of the environment of deposition may depend upon solving the problem of the origin of the insoluble material.

4:45 pm PS-20 Calorimetry of Binding in the Fe(III)-transferrin Complex. *J. S. BINFORD, JR., J. C. FOSTER, Univ. of South Florida, Lund Univ.--Reaction of Fe(III) with apotransferrin (APT), a blood plasma protein, in the presence of nitrilotriacetate (NTA) and HCO_3^- is a two site-two phase reaction but only one phase in the absence of HCO_3^-. Enthalpies of reaction have been determined in 0.05 M Tris at pH 7.96, as follows:

(1) $APT + 2\ Fe\ NTA + 2\ HCO_3^- \rightarrow APT\ (Fe\ HCO_3)_2^{2-} + 2\ NTA \qquad \Delta H = -22.5\ \frac{kcal}{mole}$

(2) $APT + 2\ Fe\ NTA \rightarrow APT\ (Fe\ NTA)_2 \qquad \Delta H = -10.4\ \frac{kcal}{mole}$

The enthalpy change for the addition of the first mole of Fe(III) is the same as for the second in (1) and (2).

*Research supported in part by the Swedish Research Council.

Saturday 8:30 am Room 51-164
R.N. Rigby (University of West Florida) presiding

INVITED PAPERS

8:30 am PS-21 An Undergraduate Laboratory in Ion-Atom Scattering. W. F. Block, Eckerd College. The study of low-energy interactions of ions with atoms and molecules yields information concerning the mechanism of charge transfer in reactions such as $N_2^+ + H_2 \rightarrow N_2 + H_2^+$[1]. Analysis of the cross sections of such interactions might well lead to useful potential functions. This research is adaptable to undergraduate physics instruction. The design, construction, and use of ion-atom scattering apparatus forms the nucleus of research-oriented undergraduate physics at Eckerd College. Preliminary results of this research are discussed.

[1]D. W. Vance and T. L. Bailey, J. Chem. Phys., 44, 486(1966)

9:00 am PS-22 Meson Interactions in Liquid Deuterium.* J. E. Lannutti, Florida State University High Energy Physics Laboratory.--The technique of using liquid deuterium in a bubble chamber to study particle interactions at high energies will be discussed. Deuterium is the most convenient target to use to study the meson-neutron interaction, but interpretations of data must be done carefully due to complications caused by the residual proton. Some results will be presented on a isotopic spin one hyperon production experiment. K^-meson-neutron reactions are analyzed for resonance production.

*Research sponsored by AEC Contract Number AT-(40-1)-3509.

9:30 am PS-23 Boson Production in π^+D at 15 GeV/c.* N. D. Pewitt, Florida State University High Energy Physics Laboratory.--Using techniques discussed in the previous talk, the reaction of π^+ mesons with deuterium is under study. Multipion final states from interactions of pions with nucleons have proved to be of great value for investigation of the basic symmetries in elementary particle structure. The data processing flow and tentative results from a 400,000 picture bubble chamber experiment presently underway at the Florida State University High Energy Physics Laboratory will be discussed. Emphasis will be placed on low multiplicity, non-strange final states.

*Research sponsored by AEC Contract Number AT-(40-1)-3509.

10:00 COFFEE BREAK

10:15 PS-24 Actinides--A New Frontier in Magnetism.* J. M. Robinson and Paul Erdos, The Florida State University.--The actinides form the least explored group of magnetic elements. Recent experiments concerning the intriguing magnetic and electronic properties of actinides and their compounds are reviewed. The multiple phase transitions, involving jumps of the magnetic moment as a function of temperature in UP, UAs, NpC, and other metallic actinide compounds are explained by a new theory. The theory takes into account the effects of the Coulomb and magnetic exchange interactions between bound and free electrons,

and good agreement with magnetization, susceptibility, heat capacity, and electrical resistivity data is obtained. New directions for experimental and theoretical research in the rich field of actinide magnetism are suggested.
*Research sponsored by the Air Force Office of Scientific Research, U.S. Air Force, under grant number AFOSR-70-1940.

10:45 am PS-25 Applications of Thin Film Scintillator Detectors to Heavy Ion Studies.* M. L. Muga, The University of Florida, Gainesville The invention and development of the thin film detector (TFD) for the detection and identification of energetic heavy ions is reviewed. The manner in which the elementary parameters, nuclear charge Z and velocity V, of the heavy ion affect the TFD pulse-height response is described. Applications to heavy-ion reaction studies and fission decay investigations are discussed.

CONTRIBUTED PAPER

11:00 am PS-26 The Enigma of the Ballast Point Geodes. F. M. Dudley, The Univ. of South Florida. Corals in the area of Ballast Point in Tampa Bay have undergone silica replacement. The conditions conducive to the dissolution of the silicate ion, the replacement of the calcium ion, the life of corals and the chemical and geological environment involved; simply are not found* and evidence for such an environment to have existed in the past is very difficult to validate. Data describing the factors involved is presented.

*Comparative processes of replacement are selected from the work of W. D. Keller, Chem. In Intro. to Geol. (1969), 4th Ed.

SOCIAL SCIENCES SECTION

Friday 8:30 am Room 52-147
HISTORY OF SOCIAL SCIENCES
John Evans (Florida Technological University) presiding

SS-1 Science as Fiction: The Concept History as a Science in the USSR, 1917-1930. L. E. HOLMES, University of South Alabama. The Soviet concept of history as a science is an example of historiography firmly wedded to an ideology and a political party. Soviet historians arrogantly assumed that Marxism and Bolshevism provided a scientific method for the arrival at the absolute truth both historical and contemporary. Despite some efforts to avoid complete politization of historical scholarship, by early 1930 party historians sanctified mimicry of party-dictated interpretations as an exact science.

SS-2 Historical Methods and Afro-American Studies. ROBERT L. HALL, Florida State Univ. - The resurgence of popular and scholarly interest in Afro-American studies raises serious questions about the documentation, writing and interpretation of the past. The author suggests that since the spoken word has held a particular magic for Black Americans, their history should be documented from such sources as sound recordings, phonograph records and verbal folklore. To understand Black Americans historians must be concerned with the cultural findings of other disciplines and must understand something of the methods and materials of anthropology, folklore and ethnomusicology.

SS-3 History; or, when is a Science not a Science? ROBERT J. RUBANOWICE, Florida State University -- First, historicism, or the historical viewpoint, is an indispensable ingredient of the modern worldview. Answers to all questions of any perennial significance--what is man, is there a God, what is truth, etc.--can be adequately understood best when seen in their historical milieux. The question, "Is History a Social Science?", is no exception. Second, intellectual history is the essence of history. That is to say, the discipline of intellectual history has a central place in the academic profession of history, principally because the subject matter of intellectual history is the main stuff of history as existential process. Third, comparative intellectual history is needed as a necessary corrective to what otherwise would be parochial, biased, limited viewpoints. The discipline of comparative intellectual history is the best means of clarifying and perhaps even definitively answering the question, "Is History a Social Science?"

Discussant: Edward Kallina, Florida Technological University

Friday 10:15 am Room 52-147
BUSINESS SESSION OF THE SOCIAL SCIENCE SECTION
John Evans (Florida Technological University) chairman

Friday 10:30 am Room 52-147
COLLEGE CURRICULA
George F. Pearce (University of West Florida) presiding

SS-4 Population Geography: A Suggested Undergraduate Course. L. N. DAMBAUGH, University of West Florida. -- Believing that a larger number of undergraduate students could derive benefit from a course in Population Geography and being aware of the time required to develop a rational course in this discipline are basic considerations for detailing said course as presented at the University of Miami. It is the intent of this paper to detail: (1) the methodology of organization, presentation, and evaluation; as well as (2) the objectives, outcomes, and limitations of the course.

SS-5 Introduction of General Education in Florida. GEORGE OSBORN, Univ. of Florida. -- This paper will deal with the establishment of the General College at the University of Florida in 1935 and its subsequent development. It reveals the reasons for this innovation in higher education, the problems encountered, and the successes of this type of education at Florida's only state university at that time. It shows the impact of President John J. Tigert's General College, later University College, on higher education throughout the nation.

Friday 2:00 pm Room 52-147
TEACHING AND SOCIAL STUDIES
Luella N. Dambaugh (University of West Florida) presiding

SS-6 Are Florida Teachers Rewarded for Obtaining Higher Degrees? M. REDMAN Florida Atlantic Univ. -- This paper sets forth a method for calculating lifetime earnings net of investment costs of public school teachers in Florida by rank and by school district. These data are used to generate private rates of return on each additional degree. Conclusions suggest that over one-third of the districts reward teachers who obtain the M.A. Perhaps one-third of the districts provide a minimum reward for obtaining a M.A. plus. None appear to encourage the Ph.D.

SS-7 Teaching Social Studies Through Inquiry. G. F. Pearce, Univ. of W. Fla.-- This paper will develop the thesis that inquiry teaching should be the essence of social studies programs at all levels of the educational hierarchy. The knowledge explosion and the discontinuity which exists between this generation and preceeding ones dictate that we prepare students to live satisfying lives in a rapidly changing world. This challenge cannot be successfully met with expository teaching which largely concentrates on learning a myriad of irrelevant data as an end in itself. Unlike expository teaching, inquiry teaching stresses learner interaction with data for the purpose of developing broader, more meaningful knowledge, while at the same time coping with change. In short, inquiry teaching is a strategy of instruction that requires a student to use the same intellectual operations as a social scientist engaged in independent problem solving.

Friday 3:30 pm Room 52-147

ECONOMICS AND NATIONALISM

J. M. Scheidell (Florida Atlantic University) presiding

SS-8 The Brain Drain of Scientists, Engineers, and Physicians from Under-Developed Countries to the United States, MICHAEL TRUSCOTT, B. G. HARTZOG, Univ. of Tampa. -- The migration of highly educated manpower (here defined to include scientists, engineers and physicians) from underdeveloped countries to the United States has resulted in considerable controversy in the post-World War II period. The charge has been made that the United States, while offering massive amounts of foreign aid to underdeveloped countries with one hand, has been taking away their most precious labor resources with the other hand, thus neutralizing the effects of United States aid. The seemingly paradoxical actions arise due to the United States' commitment to aid the developing countries and the need to fill domestic manpower requirements. An attempt is made in this paper (via a regression analysis) to isolate the main causes of the brain drain.

SS-9 Subnationalism and Supranationalism. *J. R. ROSNER, Univ. of South Florida. Subnationalism includes those internal tendencies opposed to the existing structure of a nation-state, such as separatism, autonomism, federalism, and regionalism. Supranationalism includes those external tendencies opposed to the existing degree of sovereignty of a nation-state, tendencies toward the transfer of that sovereignty to an international organization. This paper will examine the relationship between the supranationalism of the European Common Market and subnationalism among six European groups: the Scots and Welsh in the United Kingdom, the Flemings and Walloons in Belgium, the Bretons in France, and the Basques in France and Spain. The paper will demonstrate that, despite the different orientations of subnationalism and supranationalism, they are not necessarily opposed to each other.Rather,they may share the same goals and reinforce each other's effects.
*Research supported by Univ.of South Florida Research Council Released Time Award.

SS-10 APPROACHES TO AN ECONOMETRIC MODEL OF FLORIDA W.B. STRONGE, FLORIDA ATLANTIC UNIVERSITY. This paper discusses the trend towards building econometric models of states in the tradition of the national models built by L.R. Klein and his associates.[1] The problems encountered in this approach are surveyed. It is concluded that detailed research on the various parts of Florida's economy should be done prior to building an overall model.

[1]M. Nerlove International Economic Review 7:127-175 1966

Saturday 8:30 am Room 52-147

ECONOMICS AND BANKING
Milton Redman (Florida Atlantic University) presiding

SS-11 Crime and Economic Growth: An Empirical Analysis. D. HEMLEY, L. R. MCPHETERS, Florida Atlantic Univ. -- This paper develops and tests two competing hypotheses concerning crime and economic growth. The technocratic hypothesis that higher levels of output, employment, and income will reduce crime is compared to the environmental hypothesis which postulates that advanced stages of economic development and higher levels of output, employment, and income may actually foster crime. The theoretical foundations of the two positions are analyzed, and the competing hypotheses are tested through application of least squares regression techniques to United States data for the period 1933-1969.

SS-12 Commercial Bank Portfolio Structure: A Predictive Model, B. G. HARTZOG, MICHAEL TRUSCOTT, Univ. of Tampa. -- The composition of commercial bank portfolios is a function of many forces in the financial markets. The composition of bank liabilities, conditions in the economy and profit-maximizing, risk-averting behavior, as well as the philosophy and conduct of monetary policy, impinge upon the portfolio decision making process. This paper analyzes the efficacy and timing of these explanatory forces with an empirical model of commercial bank behavior.

Saturdav 10:00 am Room 52-147

FLORIDA: GEOGRAPHY, LAW AND BICYCLING

George Osborn (University of Florida) presiding

SS-13 An Operational Approach to Economics.* J. M. Scheidell, L. Wonnacott, Florida Atlantic Univ. -- This paper describes the mathematical base and forecasting decision applications of a computer augmented model that is used by the Department of Economics for instruction and student research. Although the computer program is designed to analyze any economic system that can be specified through a system of n^{th} order difference equations, a thirteen equation macroeconometric model of the U.S. for the period 1951-71 is used to illustrate the applications of the program to macroeconomics. This emphasis was chosen because of the value of such a model in analyzing the cost - benefit tradeoff among the economic, environmental and social ingredients of economic policy.

*Research supported by Division of Graduate Science Education, NSF.

SS-14 Karst Topography as an Influence on Land Use in West Central Florida. E.F. ABBOTT, Univ. of Florida. -- A limestone terrane is a distinctive landscape with a particular set of contingencies to which man must adapt. The most important adaptation is in man's use of the land. Limestone outcrops cover several million square miles of the earth's surface, and they can vary extraordinarily from place to place. Rock solubility is the dominant factor in the formation of karst landscapes.

Karst is found extensively in North America, and most of Florida is underlain by limestone sediments deposited during the Cenozoic Era. Eight counties of west central Florida have limestone outcrops of Eocene age; these lands were studied to evaluate the influence of karst on the use of the land.

Sporadic subsidence of land is commonplace throughout, and there are numerous springs of varying size. Land use has always shown some shifting, although overall percentages of land in crops, pastures and forests remain fairly stable.

SS-15 The Small Claims Court: A Political Analysis. **C. JEDDY LEVAR**, Univ. of Florida. This paper is a case study of small claims courts in two Florida counties. It will demonstrate that the business interests are the principal benefactors of these courts in spite of their potential for utilization by consumers. Furthermore, it will be shown that the demand for the credit collection services of the small claims courts come mainly from a limited segment of the business community. Hypotheses will be advanced regarding why they are used principally by certain types of businesses.

SS-16 The Economic Efficiency of Human Powered Technologies: The Case of Bicycle Transportation in Florida. M. D. EVERETT, Florida State University. -- This paper will analyze the economic factors associated with the recent increased popularity of a capital and energy saving transportation technology in Florida -- bicycling. It has been shown that cardiovascular disease, the leading killer in the U.S., is associated with lack of vigorous exercise.[1] It has also been shown that as economic development takes place time becomes more valuable. Hence, a technology which provides transportation and exercise as joint products may be more efficient than mechanically powered transportation modes at least for trips under five miles.

[1] J. C. Cassel, "Evans County Cardiovascular and Cerebrovascular Epidemiological Study," Archives of Internal Medicine, 128 (December 1971).

SCIENCE TEACHING SECTION

Friday 9:00 am Room 51-165
L. B. Sanders (University of Florida) presiding

9:00 ST-1 Drug Information Survey by G. Marian Young, Associate Professor of Education, University of Florida, Gainesville, Florida.

Through the cooperative efforts of the Education Committee of the Bridge Council and the Administration of the Alachua County Public Schools, a Drug Information Survey has been administered through questionnaires to students in grades five through twelve in all public schools. The questionnaire was developed by members of the Education committee of the Bridge Council which is a private, non-profit corporation on Alcoholism and Drug Addiction in Alachua County.

Approval, support and cooperation of the Administration made the survey possible. Student responses to the nine sets of questions in the questionnaire will be data programmed to try to determine the extent of use and abuse of drugs including alcohol and tobacco.

9:20 ST-2 Basic Science Research in Elementary and High Schools in Florida L.A. ARNOLD, University of Florida, Executive Director FFFS. This paper will review the science research project program in Florida for the past fifteen years. It will show the philosophical changes that have taken place and will demonstrate the evolution of present basic scientific research projects from earlier "Science Fair" projects. It will show why Florida participants have consistently received more than their share of International honors.

9:50 Business Meeting of Science Teaching Section
L.B. Sanders (University of Florida) Chairman

10:05 Coffee Break

10:20 ST-3 The Development of Student Motivation in Science by Means of a Science Club WILLIAM TRANTHAM, Florida Keys Community College. -- This paper will describe the successful science club which offers the student excitement, adventure and mystery as well as a means to gain knowledge in science. It is entertaining and informative. Science is adventure, excitement and mystery as well as an avenue of learning, and the school science club is one means of demonstrating this to the student. It is not limited to the confines of the classroom or the background of a single instructor, but can call on the resources of scientifically trained personnel of both private enterprise and governmental agencies. For this reason the school science club becomes part of the larger world in which the student lives and as such a relevant instrument for motivation in science.

10:40 ST-4 Laboratory Method For Skin Transplantation. PAUL HUANG Chipola Junior College.

11:00 ST-5 Radiation Short Holes Designed For Community Participation. NEAL ADAMS, Chipola Junior College.

Friday 2:00 pm Rm 51-165
Paul C.S. Huang (Chipola Junior College) presiding

2:00 ST-6 Physical Science With A New Direction. F. M. Dudley, Univ. of South Florida. This presentation will explain some innovations used in the Physical Science CBS 209 relevant to the course content. A major emphasis change has been effected from the conventional Chemistry and Geology orientation to a Geo-Chemistry-Environmental-Ecology Study. The concepts ánd principles involve the big ideas relevant to the geo-chemical processes that have occurred in Florida, with particular localized analyses of the Bay Area geo-chemical ecology. A unique feature of the course is the substitution of a student syllabus-notebook for a text.

2:30 ST-7 Concept Formation: Generalizability to Environmental and Population Education. John J. Koran, Jr. and Dennis Baker, University of Florida. -- Following a brief review of the literature focusing on concept learning and teaching, this paper will present information in the following areas regarding concepts: (a) analysis, (b) formation, (c) testing, and (d) generalizability. In addition, the paper will explore the application of concept formation and strategies to social and human situations.

3:00 ST-8 A MULTI-MEDIA APPROACH TO CHEMISTRY *J. P. Rimsa, M. L. Ivey, St. Petersburg Junior College

The current emphasis on accountability and independent study has prompted the chemistry department to initiate a program of independent study for students enrolled in its introductory chemistry courses. The student is able to progress at the individual's own rate of achievement and the student is awarded a course grade upon completion of a prescribed number of laboratories and qualifying tests. Cassette tapes, film loops, programmed texts, and video tapes are among the media developed for the program. Color slides, program statistics and sample materials will be presented.

3:30 ST-9
Some Basic Experiments for an Introductory Course in Plasma Physics. J.T.Pytlinski[+], I.Alexeff[+], W.D.Jones[++] and N.L.Oleson[+,++] ++Univ. of South Florida, +Univ. of Tennessee. Using commercially available tubes we have set up several basic experiments suitable for an introductory course in plasma physics. The measurement of an electron temperature and density by a single Langmuir probe built in the tube; the measurement of ionization potential of argon and mercury as well as the ratio of $\frac{e}{m}$ in the case of argon and the measurement of the decay time of a mercury plasma will be described and discussed. Also an alternative technique for measuring electron plasma density will be considered. Information will be given concerning the total cost of the equipment for each experiment.

AMERICAN ASSOCIATION OF PHYSICS TEACHERS

FLORIDA SECTION

Saturday 9 am Room 51-165
W. B. Phillips (University of West Florida) presiding

9:00 am PT-1 The Objectives of an Elementary Physics Course, I. G. FOSTER, Eckerd College. Leo Nedelsky[1] some years ago discussed the teaching objectives of natural science courses, a topic which reappears from time to time in the journals. Despite this, the stated objectives of elementary physics courses are often so general that the student emerges from such courses convinced that the only skill physics requires is the memorization of equations. Content is stressed to the practical exclusion of the cognitive or analytic skills which are equally important. This paper discusses content and skills in elementary physics courses and outlines a set of behavioural objectives approriate to the beginning student of physics.

[1] Leo Nedelsky, Am. J. Phys. 17, 345(1949)

9:30 am PT-2 Undergraduate Research at Stetson University. T. A. LICK and F. D. SRYGLEY, Stetson Univ. For several years selected physics majors have had the opportunity to work on special research projects. During this time several of the faculty have used electron spin resonance techniques to investigate radiation damage to single crystals of several phosphates. Some of the students have been involved in helping the faculty with this continuing project. Others have worked on various independent projects. It was never planned that research on this level would compete in volume or pace with that at graduate institutions. Nevertheless, to be of value, the character of the research must be closely equivalent to that at graduate institutions. An attempt has been made to evaluate the effect of student research on faculty, school, and most importantly, the students themselves.

9:45 Reports

10:00 COFFEE BREAK

10:20 Business Session W.B. Phillips (University of West Florida) chairman

10:50 Report: The Keller Method Physics Project at the University of West Florida - R.C. Smith and W.B. Phillips

11:00 PT-3 Grade Distributions in a Self-Paced Physics Course. JOHN S. ROSS, Rollins College.--During the past three terms we have offered our introductory principles of physics and chemistry course on a self-paced basis, with laboratory experiments. The final grade distribution from the initial offering resembled the typical U-shaped pattern for a Keller-type course. However, succeeding offerings have resulted in grade distributions which are more like the conventional bell-shaped results from lecture courses. This anomaly will be discussed and analyzed in terms of the course structure that we have been using.

11:15 PT-4 Open Laboratories for the General Physics Courses. M. H. TELLER and S. S. BALLARD, Univ. of Florida. -- We have gone to the "open lab" format for our lower-division general physics courses, both the three-quarter sequence for liberal arts students and the sequence for engineering and physical science majors. A trial in the fall quarter of 1972 for just the final course in each sequence was successful; it involved about 125 students. A questionnaire comparing the old and new formats showed the students overwhelmingly favoring the latter. Beginning in January 1973 all six laboratory courses were shifted to the open format, with over 1200 students participating. Student and faculty opinions on the new arrangement will be reported; its advantages and disadvantages will be discussed.

11:30 am PT-5 A Self-Paced Competency-Based General Physics Sequence with Integrated Labs. J. L. AUBEL, University of South Florida. One section of our introductory non-calculus general physics sequence is being taught by a technique which, although developed independantly, is quite similar to that recently reported by Anderson and Artman[1]. Some unique grading features and non-procrastination incentives will be discussed, along with student evaluations and study time data.

[1] O. T. Anderson and R. A. Artman, Am. J. Phy. 40,1737 (1972)

11:45 General Discussion

FLORIDA JUNIOR ACADEMY OF SCIENCE
Thirty fourth annual meeting
Friday, March 22, 1973

9:00 am Presentation of Junior High Literary and Experimental Papers
Gil Duffee (Marianna High) presiding 51-158

1. A Comparison of Two Genetic Diseases: Sickle Cell Anemia and Hemophilia

   Johanna Drickman, McNicol Middle School

2. The Flurochromasia of Penicillin Sensitive and Resitant Leptospira Serotype Patoc

   Annette O. Wells, John F. Kennedy Junior High School

3. The Formation of Aldehydes, Hydrocarbons and Carbohydrates in the Martian Atmosphere by Ultraviolet Radiation

   Mark Minie, Madeira Beach Junior High School (Science Center)

4. Auxin Developments, Tropisms, and Translocation Utilizing Carbon-14 in the *Phaseolus vulgaris*

   Jeanette Norton, John F. Kennedy Junior High School

5. The Oxidation of Promethium to the Positive Four Oxidation State

   Vincent J. Lipsio, Azalea Junior High School (Science Center)

6. Mycorhizal Fungi Infestation of Plants

   Dave Baker, Cocoa High School - 9th Grade

7. An Assessment of the Irreversibility of Sterility produced by Vitamin E Deficiency

   Kurt Denninghoff, Edgewood Junior High School

8. The Effects of Cythion, 50% Malathion on the *Gallus gallus* as related to Pesticide Poisoning.

   Margaret A. West, Rockledge High School,- 9th Grade

9:00 am Presentation of Senior High Literary Research Papers
Jimmy Brendemuehl (Marianna High) presiding 52-152

1. The Correlation Between the Circadian Rhythms of Extractable Luciferase Activity and Scintillons to the Bioluminescent Rhythm of the *Bonyaulax polyedra*

   Vicki Doler, Cocoa High School

2. Etiological Relations of Schizophrenia

   Bill Coughlin, Naples High School

3. Epigenetic Changes Underlying Cecidogenesis in Crown-Gall

   Lorraine Pillus, Cocoa High School

4. Inteferon: Function and Application

   Martin Gordon, Forest Hill High School

5. The Physical Correlation Between Solar Magnetic Field Structures and Coronal Activity

   George Ellis, Largo High School (Science Center)

6. The Effects of Urea on Sickle Cell Hemoglobin

   Lynda Cowan, Cocoa High School

7. The Piezoelectric Phenomenon: Stress Produced Electric Polarization Found in Electric Structures

   Christopher S. Willson, Merritt Island High School

8. The n-Alkane Distribution in _Polystichum acrostichoides_, Native to Florida and North Carolina

   John P. Denninghoff, Merritt Island High School

1:00 pm General Session 52-152
Jimmy Brendemuehl presiding
Welcome by President H. B. Crosby, The University of West Florida

1:15 pm _Presentation of High School Experimental Research Papers_

1. Liesegang Banding: A Colloidal Phenomenon of Periodic Precipatation.

   Ri McGlamery, Chipley High School

2. The Refined Period and the Placement of the Secondary Ecli pse of Eclipsing Binary Star, _Er Scuti_

   Clare Yu, Gainesville High School

3. Relative Seed Performance Characteristics in a MHD Generator.

   James McEachron, Rockledge High School

4. Rabbit Anti-Mouse C3M4 Anti-body: Its Effects on the Immunologically Enhanced Growth of Methylcholanthrene Induced Tumors Employing in Vitro Studies.

   Denise A. Miller, Cocoa High School

5. Induced Metabolic Depression, Mitotic Inhibition, and Histological Destruction of Malignant Tissue by TMCA Methyl Ether d-Tartrate and Vinblastine.

   Joseph G. Nolan, Merritt Island High School

6. Fetal Hemoglobin Dependency as Evidenced by Erythrocyte Sickling in Sickle Cell Anemia.

   Amy Floyd, Merritt Island High School

7. Changes in Lactic Dehydrogenase and its Electrophoretically Slow-Moving Isoenzymes in C3H Mice with Mammary Adenocarcinoma

   Heidi E. Denninghoff, Merritt Island High School

8. A Study of the Sizes and Weights of Fish Caught by the Prehistoric (Archaic) People of the Big Island Shell Ring, an Archaeological Site in South Carolina

   Laureen Miller, William M. Raines Sr. High School

3:15 pm Business meeting

OFFICERS OF JUNIOR ACADEMY

PRESIDENT:	MARIANNA HIGH SCHOOL
CONVENTION CHAIRMAN	DAVID SHEFFIELD
VICE PRESIDENT:	COCOA HIGH SCHOOL
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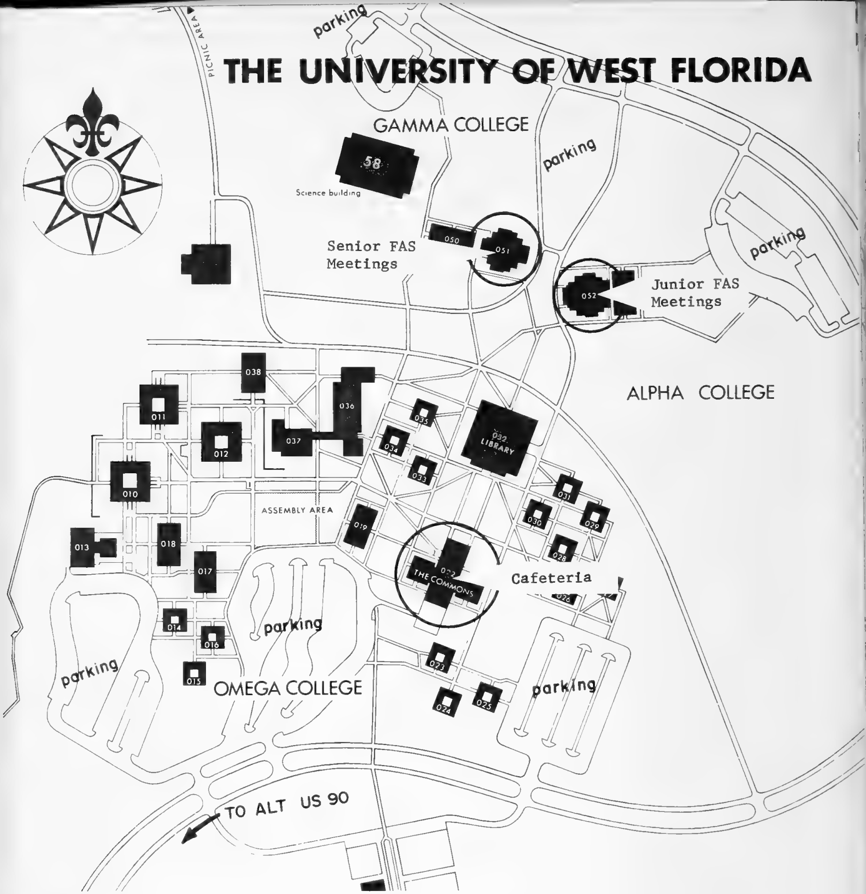
NOTES



DR. PIERCE BRODKORB, Editor
Department of Zoology, University of Florida
Gainesville, Florida 32601

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Quarterly Journal of the Florida Academy of Sciences

P R O G R A M

of the

THIRTY EIGHTH ANNUAL MEETING OF THE ACADEMY

in conjunction with

THE FLORIDA SECTION OF
THE AMERICAN ASSOCIATION OF PHYSICS TEACHERS

and the

SOUTH FLORIDA BRANCH
AMERICAN SOCIETY FOR MICROBIOLOGY

Florida Technological University
Orlando, Florida

March 21, 22, 23, 1974

TABLE OF CONTENTS

Thirty-Eighth Annaul Meeting
of the
Florida Academy of Sciences
at
Florida Technological University
Orlando, Florida
March 21, 22, 23, 1974
GENERAL INFORMATION

All registrants for the meetings of the Junior and Senior Academy, the American Association of Physics Teachers, the Southern Florida Section of the American Society of Microbiologists and the Society of Physics Students are invited to attend all sessions of all organizations, including the banquet.

Registration

Registration for the meetings will be at the following times and locations:

Senior Academy			
	Thursday	7:00 - 9:00 pm	Ramada Inn East
	Friday	8:00 - 12:00 noon	Engineering Building, FTU
		1:00 - 4:00 pm	Engineering Building, FTU
	Saturday	8:15 - 10:00 am	Engineering Building, FTU
Junior Academy			
	Thursday	9:00 - 12:30 pm	Sheraton Colonial Plaza Motor Inn
		12:00 - 4:00 pm	Engineering Building, FTU
American Society of Microbiologist			
	Friday	8:00 - 12:00 noon	Engineering Building, FTU
		1:00 - 4:00 pm	Engineering Building, FTU
Society of Physics Students			
	Friday	8:30 - 12:00 noon	Engineering Building, FTU,Room 333

Lodging

Rooms are being held for those attending the meetings until March 8, 1974 at the following facilities.

	Single	Double
Ramada Inn East 11731 East Colonial Drive (Hwy. 50) Orlando, Florida 32807 Telephone: (305)273-1500	\$12.50	\$17.50
Langford Resort Hotel E. New England Avenue Winter Park, Florida 32789 Telephone: (305)644-3400	\$16.50	\$16.50

Headquarters for the Junior Academy will be at the Sheraton Colonial Plaza Motor Inn, 2801 E. Colonial Drive, Orlando, Florida.

Transportation

Transportation is available from the Ramada Inn to the campus. Those staying at the Langford should provide for there own travel arrangements to and from the meetings.

Parking See map for campus parking areas.

Food Services

Lunches can be obtained at the cafeteria located in the Village Center on campus. See map.

Academy Banquet

The cocktail hour (6:00 pm - 7:15 pm) and the banquet (7:15 pm) will be held at the Ramada Inn East. It will be necessary to make reservations for the banquet prior to MARCH 22, 1974 . The price will be \$5.50 for a delmonico steak dinner. Following the dinner will be the awarding of the Academy Medal. There may be a short address by the Medalist. State Senator George Firestone, co-chairman of the legislative Energy Committee, will speak on matters with which his committee is concerned.

Junior Academy Awards Banquet

The Junior Academy Awards Banquet will be at the Sweden House, Friday evening at 7:00 pm.

Ladies Program

There will be no official ladies program. However, there are a number of outstanding resort attractions in the Orlando area including Walt Disney World and Sea World, for which public transportation is available from the Ramada Inn and the Langford Hotel.

Local Arrangements Committee

Harold I. Klee
Harvey A. Miller
Rudy J. Wodzinski
William C. Oelfke
John L. Evans
Edmund F. Kallina
Kenneth E. Paschall
Leslie L. Ellis

PROGRAM OF EVENTS
Florida Academy of Sciences

	Thursday, March 21, 1974			
3:00 pm	Executive Council Meeting	Board Rm. 3rd fl.Ad.Bldg.		
6:30 pm	Council Dinner	Ramada Inn East		
7:30 - 10:00 pm	Social Hour	Ramada Inn East		
	Friday, morning, March 22, 1974	Bldg.	Rm.	
8:30 - 10:50 am	Botany-Biological Sciences Section	En	109	Pg. 4
11:00 - 12:00 am	Zoology-Biological Sciences Section	En	109	Pg. 5
8:20 - 12:00 am	Earth & Planetary Sciences Section	En	108	Pg.10
8:30 - 12:00 am	Physical Sciences Section	En	305	Pg.17
8:30 - 12:00 am	Medical Sciences Section	En	306	Pg.23
8:30 - 12:00 am	Science Teaching Section	En	331	Pg.25
8:30 - 12:00 am	Social Sciences Section	En	318	Pg.27
	Friday afternoon, March 22, 1974			
1:00 pm	Annual Business Meeting of the Academy	En	Aud.	
1:30 - 3:30 pm	Symposium-Florida's Estuaries Management or Mismanagement	En	Aud.	
3:45 - 5:15 pm	Biological Sciences Section	En	109	Pg. 7
3:45 - 5:15 pm	Earth & Planetary Sciences Section	En	108	Pg.13
3:40 - 5:15 pm	Session A, Physical Sciences Section	En	305	Pg.19
3:40 - 5:15 pm	Session B, Physical Sciences Section	En	306	Pg.20
3:30 - 5:00 pm	Social Sciences Section	En	318	Pg.28
	Friday Evening, March 22, 1974			
6:00 - 7:15	Cocktail Hour	Ramada Inn East		
7:15 pm	Annual Academy Banquet	Ramada Inn East		
	Saturday morning, March 23, 1974			
9:00 - 12:00 am	Biological Sciences Section	En	109	Pg. 8
8:20 - 12:00 am	Earth & Planetary Sciences Section	En	108	Pg.15
8:30 - 11:15 am	Physical Sciences Section	En	305	Pg.21
11:15 - 12:15 am	Special Lecture, J.C. Slater	En	Aud.	Pg.22
8:30 - 12:00 am	Social Sciences Section	En	318	Pg.28

Saturday afternoon, March 23, 1974

1:30 - 2:30 pm	Biological Sciences	En	109	Pg. 10
2:00 - 5:00 pm	Earth & Planetary Sciences Section	En	108	Pg. 15

American Association of Physics Teachers

Saturday morning, March 23, 1974

9:00 - 11:15 am	Presentation of papers	En	306	Pg. 29
11:15 - 12:15 pm	Special Lecture - J.C. Slater	En	Aud	Pg. 30

American Society for Microbiology
South Florida Branch

Saturday morning, March 23, 1974

9:00 - 12:00 am	Presentation of papers	En	110	Pg. 30

Society of Physics Students

Friday, March 22, 1974

8:30 - 12:00 am	Open to attend FAS sessions			
1:30 - 3:30 pm	FAS Symposium	En	Aud	Pg. 6
3:30 - 5:15 pm	Open to attend FAS sessions			
7:00 pm	Dinner Campus Cafeteria	Village Center		
8:00 pm	Film "The Violent Universe"	En	333	
10:00 pm	Party (informal) Location to be announced.			

Saturday, March 23, 1974

8:30 - 11:15 am	SDS Papers	En	333	Pg. 31
11:15 - 12:15 am	Attend Lecture - J.C. Slater	En	Aud.	Pg. 30
1:00 pm	Picnic			

Junior Academy of Science

Thursday afternoon, March 21, 1974

1:00 - 4:30 pm	Senior High Expermental Papers	En	Aud	Pg. 32
1:00 - 4:30 pm	Junior High Experimental Papers	En	360	Pg. 32
4:30 - 5:00 pm	Planning Session Jr. & Sr. High	En	Aud	
8:00 - pm	Planetarian visit	Orlando		

Friday morning, March 22, 1974

9:00 - 12:00 am	Senior High Literary Papers	En	Aud	Pg. 34
9:00 - 12:00 am	Junior High Literary Papers	En	360	Pg. 33

Friday afternoon, March 22, 1974

12:00 noon	Luncheon Cafeteria	Village Center		
1:30 - 3:30 pm	Symposium of Senior Academy	En	Aud.	Pg. 6
3:30 pm	Sponsors Meeting	En	331	
3:30 - 4:15 pm	Open to attend Sr. Academy Sessions			
4:15 pm	Business Meeting of the Jr. Academy	En	Aud.	
7:00 pm	Jr. Academy Annual Awards Banquet	Sweden House		

BIOLOGICAL SCIENCES SECTION

Friday 8:30 am Room En 109

BOTANY

Presiding TBA

8:30 am BS-1 Development Of A New Acrasid Cellular Slime Mold* M.G. Nesom. Univ. of Florida. This paper will describe the development of a new acrasid, Copromyxa arborescens, as observed by light and electron microscopy. From these observations we have placed Copromyxa in the subclass Acrasia of the Mycetozoa (Phylum Protozoa). Copromyxa is apparently one of the simplest forms of either the dictyostelid or acrasid cellular slime molds. The purpose of the study is to further clarify the taxonomic position of these aggregating social amoebae in the Mycetozoa.
*Research supported by grant GB-23821 from NSF to Dr. L.S. Olive.

8:45 am BS-2 Noteworthy Fungi from Beach Sands in the Tampa Bay Area. LINDA BERGEN and DIANE T. WAGNER-MERNER. University of South Florida. Fungi from Tampa Municipal Beach and Clearwater Beach are isolated from intertidal sands. The occurrence, distribution and nutrition of these organisms are discussed in relation to these two areas.

9:00 am BS-3 Caladesi Island - A Floristic Study A.L. Fowler, Univ. of So. Fla. This report is a preliminary study of the floristic composition of Caladesi Island State Park, a barrier island located two miles west of Dunedin, Florida. On this island which is about 0.5 x 3 miles have been found 67 families, 147 genera and 180 species of vascular plants of which 56% are non-tropical and 44% are tropical in origin with 4% considered introduced and naturalized species. Mangrove, coastal strand, saltflat, sabal palm flat, pineland and hammock plant communities have been identified. Coreopsis leavenworthii and Eupatorium mikanioides are Florida endemics. Iresine rhizomatosa and Hedyotis uniflora var. fasciculata are two species from the north not previously included within the Tampa Bay area checklist.

9:15 am BS-4 Mullet Key: A Floristic Study Richard A. Hilsenbeck, Paula C. Hilsenbeck, University of South Florida. This paper is a preliminary study of the vegetation of Mullet Key and adjacent keys (Fort DeSoto County Park). The island complex, comprised of 900 acres, is located at the mouth of Tampa Bay. Specimens of 80 families, 211 genera, and 280 species have been identified. Of the natural vegetation, 56% are tropical and 44% non-tropical; 7% of the total number are considered to be introduced. Several range extensions of tropical plants have been established, including Piscidia piscipula, Bursera simarouba, and Cissus trifoliata. Five major communities have been shown to be present on the island: Mangrove, Coastal Strand, Sabal-Juniper shore hammock, Oak-Persea hammock, and Pineland. There are also significant areas over which the natural vegetation has been destroyed.

9:30 am BS-5 Effects Of Density On The Pattern Of Resource Allocation Of Chamaesyce hirta (Euphorbiaceae) T.W. Snell, Univ. of South Florida.--The pattern of resource allocation in Chamaesyce hirta was significantly affected by both density and nutrient availability. Increased intraspecific competition and decreased nutrient levels both produced decreases in the proportion of total plant energy allocated to reproductive tissues in all units tested. A 32-fold increase in density diminished reproductive effort by one-third and an 8-fold decrease in nutrient levels diminished reproductive effort by one-half. These results are in agreement with theoretical predictions that for a resource limited population, reproductive effort should decrease with decreasing resource availability. Increased root growth seemed to be inversely related to reproductive effort. When the pattern of resource allocation was determined for both biomass and calories, similar results were obtained.

9:45 am BS-6 Plant Growth Hormones And Stamen Filament Development. J. L. KOEVENIG, Florida Technological University.--Experiments show that various floral organs and hormones control stamen filament elongation in the spider flower, *Cleome hassleriana*, but the effect varies with the stage of stamen development. Prior experiments have shown that the movement of IAA in stamen filament sections is polar, whereas the movement of kinetin is not. Evidence suggests that the polar IAA movement is not controlled by the anther or an apical source of IAA. Endogenous GA and IAA have been identified in extracts from *Cleome* floral organs at different stages of development, however the amounts have not been determined. It is proposed that the various floral organs affect stamen filament development by supplying various growth hormones and that the changing influence of these hormones is controlled in part by their production, movement, immobilization and breakdown.

10:00 am BS-7 An Analysis of the Vegetation at Turtle Mound*. E.M. Norman, Stetson University. An ecological study was conducted at Turtle Mound Historic Memorial, 9 miles south of New Smyrna Beach. Soil samples were analyzed and compared with adjacent areas. There are approximately one hundred species of vascular plants growing on the Mound; 25% of which are characteristic of tropical hammock communities. Line transect studies showed the dominant species and their distributional pattern.

*Research supported by American Philosophical Society.

10:15 am BS-8 Vegetational Change in Southern Florida Since 1940* T. R. Alexander, University of Miami. The changes that could be detected by examination of 1940 aerial photography and recent photography will be summarized. Ground truth observations supplemented the recent photograph study. The area covered extended from a line near the southern shore of Lake Okeechobee to Cape Sable. A sample of 100 quadrats, each a square mile, constituted the project.

*Research supported by U. S. Department of Interior.

10:30 am BS-9 The Role of Mangroves As Land Builders and Shoreline Stabilizers in Florida. A. E. Rehm, Biology Department, University of South Florida. No Abstract received.

10:50 am COFFEE BREAK En Third Floor Lobby.

Friday 11:00 am Room En 109

ZOOLOGY

M.A. Roessler, Tropical BioIndustries Development Company, Presiding

11:00 am BS-10 Analysis of the egg of the laughing gull, *Larus attricilla*. J.LAWRENCE, R.SCHREIBER. Univ. So. Fla. -- Six 3-egg clutches were analyzed. Eggs, aged on the basis of degree of embryonic development, decreased in wet weight in the order laid. This sequential trend did not occur in percent yolk or white; or in levels of total lipid, carbohydrate, or protein in the yolk or white. The mean wet weight of the yolk and white of eggs from the three clutches with undeveloped embryos was 35g. The organic material in the yolk and white of these eggs represented 56.9 kcal. The ratio of yolk/white in these eggs was 40/60 in terms of g wet weight; 56/44 in terms of g dry weight; 66/34 in terms of g organic material; and 74/26 in terms of kcal.

11:15 am BS-11 Recent Decline of Chlorinated Hydrocarbon Pesticide Residues in Migratory Birds.* D. W. JOHNSTON, Univ. of Florida.-- Well publicized have been cases of population declines in raptorial and piscivorous birds since the widespread use of DDT about 1946-47, but almost no attention has been given to birds in lower trophic levels. Small insectivorous birds have been picked up at Fla. TV towers since before 1964. In 10 species, a progressive and consistent decline of DDE burdens is reported here, this decline presumably correlated with the recent decreased agricultural use of DDT.

* Research supported by NSF grant GB-25872.

11:30 am BS-12 Population Dynamics Of Voles *(Microtus)* In Contrasting Ecosystems In Southeastern Washington, 1968-70* I. JACK STOUT, Florida Technological University.-- This report provides data on numerical and structural changes in fluctuating populations of the long-tailed vole, *Microtus longicaudus* and montane vole, *Microtus montanus*. Areas selected for study were climax remnants of the original vegetative mosaic (Palouse Prairie). Vole populations in these undisturbed ecosystems fluctuated on an annual basis, and neither species reached unusual levels of abundance. However, local extinction of a population of *M. longicaudus* was documented. Populations tended to reach maximum densities in fall and winter. Survival was heterogeneous among the sexes and weight classes on all study areas. Common factors did not appear to be associated with either all increasing populations or all decreasing populations. *Research supported by PHS Grant 5T01 ES000 89 to Vincent Schultz.

11:45 am BS- 13 A Study Of The Loggerhead Turtles *(Caretta caretta)* of Merritt Island, Florida.* L.M. EHRHART, Florida Technological Univ.--Studies of female loggerhead turtles *(Caretta caretta)* coming ashore to deposit eggs on the beaches within the Merritt Island National Wildlife Refuge (at the Kennedy Space Center), Brevard Co., Florida, were carried out in the summer of 1973. Carapace length, carapace width, plastron length, weight, exact location and other data were recorded for each of 51 loggerheads. Each turtle was tagged before release. The range in weights was from 202 to 385 lbs.; the mean weight was 265.5 lbs. There is a very good correlation between linear measurements and weight (r=0.88 and 0.90 for carapace and plastron lengths, respectively). The regression equations of weight on carapace and plastron lengths are: $\log W = -3.69 + 2.52 \log CL$ and $\log W = -1.52 + 2.12 \log PL$, respectively. Research supported by NASA grant NGR 10-019-004 and U.S. Fish and Wildlife Service.

Friday 1:00 pm Room Engineering Auditorium

Annual Business Meeting of the Florida Academy of Sciences

James G. Potter, Florida Institute of Technology, Chairman

Friday 1:30 pm Room Engineering Auditorium

SYMPOSIUM

William H. Taft, University of South Florida, Presiding

1:30 pm FLORIDA'S ESTUARIES- MANAGEMENT OR MISMANAGEMENT? — Five major estuaries in Florida, Biscayne, Tampa, Charlotte, Apalachicola and Pensacola will be described in terms of physical, biological, and chemical characteristics and their economic value. An attempt will be made to define present problem areas and to project what will happen to the estuary given certain development alternatives.
Speakers: Dr. Martin Roessler, Dr. Joseph Simon, Dr. Jack Taylor, Dr. Robert Livingston, and Dr. Thomas Hopkins

3:30 pm COFFEE BREAK En Third Floor Lobby.

3:45 pm Room En 109

Business Meeting of the Biological Sciences Section

Sneed B. Collard, University of West Florida, Chairman-elect

4:00 pm BS-14 Anclote Fish - the Characteristics of an Estuarine Fish Fauna
J.K. ROLFES, R.A. DIETZ, AND R.C. BAIRD, Univ. of South Florida.--The Dept. of Marine Science has been studying the fish fauna of the Anclote River area since 1970. The study is part of the Anclote Environmental Project* which is intended to develop the information necessary to assess the environmental impact of a power plant construction and operation.

Estuarine fish fauna in general are complex and highly variable. An examination and description of the patterns of variation found in the baseline phase of our study are presented and discussed.

* Research supported by Florida Power Corporation, St. Petersburg, Florida.

4:15 pm BS-15 Zooplankton Species Diversity in Lake Apopka, Florida. John A. Osborne, Florida Technological Univ. -- Seasonal and spatial distribution of species comprising the cladocera, copepoda, and rotifera components of the zooplankton community were studied in eutrophic Lake Apopka during 1973. A total of 21 taxa were collected from net samples. Rotifers accounted for 48% of the taxa, copepoda 19%, and cladocera 33%. Enumeration data were used to determine population density and to calculate an index of diversity ($\bar{d}$). Although changes in population size of individual species ocurred, it did not contribute to large variations in the value of $\bar{d}$.

4:30 pm BS-16 Spoil Islands and Natural Islands of the Tampa Bay Estuary, Florida--Preliminary Report.* R.R. Lewis III, F.M. Dunstan, Hillsborough Community College and The National Audubon Society. This paper will describe preliminary results of a study of the stability, succession, and wildlife habitat values of spoil islands and natural islands in Tampa Bay. Methods of enhancing wildlife habitat values and stabilizing existing and proposed new spoil islands will also be discussed.
*Research supported by the Tampa Port Authority.

4:45 pm BS-17 A preliminary study of a Florida dead-end canal D. H. Mook, Harbor Branch Foundation Laboratory, Fort Pierce, Florida. -- A study was initiated to monitor ecological conditions in the Linkport canal before extensive commercial development takes place. Dissolved oxygen and chlorophyll a values were highest on the surface and lowest along the bottom of the canal. Zooplankton density was highest at the mouth of the canal. Benthic diversity was highest along the banks at the mouth of the canal. Deeper sediments were largely anaerobic.

5:00 pm BS-18 High-Frequency Electrodynamics of Living Systems WILLIAM TRANTHAM, Florida Keys Community College.--This presentation will involve the description and demonstration of a Kirlian high-frequency field autoelectron and autoion emission system which converts the non-electrical properties of living systems into electrical ones which can be photographed.

7:15 pm Ramada Inn East

Annual Academy Banquet

Saturday 9:00 am Room En 109

ZOOLOGY

John Lawrence, University of South Florida, Presiding

9:00 pm BS-19 Significance of Egg-Size in Echinoderm Development. R. TURNER, Univ. So. Fla. -- Pattern of larval development in poorly-known marine invertebrates is frequently inferred from data on egg-size. Large eggs supposedly indicate divergence from classical indirect development of invertebrate taxa. This relationship does not hold for ophiuroids[1], asteroids, and holothuroids with certain types of broodcare or with rapid development. Re-examination of the literature suggests that the significance of egg-size lies in the nutrition and duration, rather than pattern, of embryonic and/or larval development.

[1]G. Hendler, Amer. Soc. Zool. Symposium, Houston (1973).

9:15 am BS-20 Absorptive efficiencies of Lytechinus variegatus (Echinoidea). E. LOWE Univ. So. Fla. - Digestibility was estimated as the efficiency of absorption by the method of Conover[1]. Absorptive efficiencies of total organic material of Halimeda incrassata, Thalassia testudinum, Ulva lactuca, Sargassum sp. and Eucheuma issiforme, respectively were 43, 19, 13, 6, and -35%. Absorptive efficiences of total protein, lipid, and carbohydrate respectively were 47, 67, and 13% for Thalassia and 65, 71 and 35% for Halimeda. Negative absorptive efficiency of total organic material for Eucheuma could result from addition of organic material to gut contents or absorption of inorganic material in the gut. Field observations of feeding and the low absorptive efficiencies observed for fresh plant foods suggest that Lytechinus feeds primarily on decaying blades of grasses or algae.

[1]Conover, R. J., Limnol. Oceanogr. 11:338-345 (1966).

9:30 am BS-21 Temperature tolerances of tropical shallow-water echinoids (Echinodermata) at Elat (Red Sea).* J.LAWRENCE. Univ. So. Fla. -- Temperature tolerances of Echinometra mathaei, Diadema setosum, Tripneustes gratilla, and Echinothrix calamaris were ascertained by measuring the time required for inverted individuals to right themselves after exposure to a range of temperatures (12-35°C) for varying periods of time. Ability to recover from an experimental temperature by a return to the ambient temperature (27°C) was also measured. Echinometra mathaei and D. setosum are functionally more eurythermal than T. gratilla or Echinothrix calamaris. Echinometra mathaei was most tolerant to high temperatures. In all cases, the sea urchins were more tolerant of temperatures below than above the ambient temperature.

*Research supported by the Hebrew University of Jerusalem and the Smithsonian Institution.

9:45 am BS-22 Stomach contents of Luidia clathrata (Asteroidea). J. LAWRENCE, K. ERWIN, R. TURNER. Univ. So. Fla. -- Forty-eight adults were collected on April 28, 1973, in Tampa Bay. Cumaceans and newly settled bivalves (Tellina spp.) were the dominant food constituents on the basis of the number of stomachs containing them, and the number and weight of prey individuals contained in the stomachs. Low numbers of amphipods and ostracods occurred frequently, and gastropods occurred occasionally in the stomachs. Few foraminiferans and no echinoderms were found in the stomachs. Luidia clathrata appears to be an opportunistic feeder on inhabitants of the upper few cm of the substratum, engulfing the substratum and retaining the prey by straining the soft bottom material through the spines of the mouth-angle plates.

10:00 am BS-23 Reaction of Two Ophiuroids to *Luidia clathrata* (Echinodermata) S.E. Stancyk, Univ of Florida.--The ophiuroids *Ophiolepis elegans* Lütken and *Ophioderma brevispinum* (Say) have a dramatic escape response to the asteroid *Luidia clathrata* (Say) or filtered solutions made from ground *Luidia*. In the laboratory, *L. clathrata* fed on both species at rates up to 5 individuals/day; however, records of stomach contents of *L. clathrata* from collections and the literature showed almost no ophiuroid component. Experiments showed that escaping ophiuroids were almost twice as fast (133-158 cm/min) as the fastest *L. clathrata* (77 cm/min). It is concluded that these ophiuroids can escape *L. clathrata* in nature. The possibility that a rarer congenor, *L. alternata* (Say), is an echinoderm predator merits further investigation, since a single specimen was found to contain an amphiurid ophiuroid and a young *L. clathrata*.

10:15 am BS-24 Spacial Distribution and Numerical Abundance Of The Sand Dollar, Encope michelini And Mellita quinquiesperforata. J. R. Wilcox, Harbor Branch Foundation Laboratory, Ft. Pierce, FL. Preliminary observations have shown that the sand dollar, Encope michelini and Mellita quinquiesperforata, have discrete and depth dependent patterns of distribution. Mellita is the inshore species, while Encope is found offshore. Population densities of Encope range from 2.50 to 8.50 individuals/ m^2; densities of Mellita range from 4.00 to 11.75 individuals/ m^2. The distributional pattern of both species in a 4 m^2 area is random.

10:30 am COFFEE BREAK En Third Floor Lobby

10:45 am BS-25 An Ecological Survey of Sponges From The Eastern Gulf Of Mexico* R.H. Yockey, Jr., Univ. of Florida.--Approximately 147 specimens of Porifera were recovered from 18 of 21 stations sampled at three sites: estuarine waters near Cedar Key, along a transect from Cedar Key to the shelf margin west of the Florida Middle Grounds, and along a transect from Sanibel Island to Key West, Florida. Of the 116 species found, only 7.2% were recovered at more than one site, while only 9.9% were recovered at more than one station. Sponges taken at more than one station were found to have a mean depth range of 20.0 meters, while the total depth range sampled was 180 meters. It was concluded that depth has a significant effect on the species composition of the sponge community.

*Ship time donated by SUSIO and the University of Florida, Marine Laboratory.

11:00 am BS-26 Observations on the Life History and Ecology of the Nudibranch, *Hypselodoris edenticulata*, White* J.A. Paige, Univ. of Florida.--A study of the life history and ecology of the chromodorid nudibranch, *Hypselodoris edenticulata*, was made in the Cedar Key, Florida, area. Studies revealed that predation on healthy individual is practically non-existent despite the lack of acidic, mucous secretions seen in other dorid nudibranchs. The bright orange egg ribbon is spawned in the characteristic counterclockwise spiral with an average length of 145mm containing 52,000 eggs. The planktotrophic larva is released six days after oviposition (25.5°C) and all indications point toward a fourteen larval life before metamorphosis. The adults feed exclusively on one species of Demospongiae, *Dysidea* cf. *fragilis* (Montagu).

*Research supported by---Estuarine Ecology Grant and Univ. of Florida.

11:15 am BS-27 Systematics and Ecology of *Sphaeroma* Latreille in Florida. E. ESTEVEZ, Univ. of South Florida. The isopod genus *Sphaeroma* is represented in Florida by *S. walkeri* Stebbing, *S. quadridentatum* Say, and *S. terebrans* Bate (= *S. destructor* Richardson). Sexual dimorphism and chromatic phenotypes of *S. quadridentatum* are described, and some previous reports of the wood-boring *S. terebrans* around Florida are shown to be misidentifications of *S. quadridentatum* males. Geographic and specific distributions of each species living in the mangrove habitat of west Florida are also described.

11:30 am BS-28 The Scientist-In-The-Sea Program - Christopher L. Combs, State University System of Florida Institute of Oceanography. -- The "SITS" Program provides unique training for selected marine science and engineering graduate students in state-of-the-art in situ studies of the marine environment. The U.S. Navy, the State University System of Florida, and distinguished visiting lecturers provide academic and technical expertise in numerous areas of specialization including hard-hat diving, semi-closed and closed mixed-gas systems, field operations organization and supervision, underwater communications systems, manned submersibles, and open water saturation diving using a habitat. This paper will present a very brief overview of the SITS Program in order to stimulate interest and provide information to potential future SITS candidates.

11:45 am BS-29 The Florida Continental Shelf Oceanographic Research Platform, "Marsha Lynn" - Christopher L. Bombs, State University System of Florida Institute of Oceanography. -- This paper will introduce to investigators of the marine environment in the Gulf of Mexico information on present and potential uses of a 338 foot long, 50 foot wide anchored, floating marine research platform, the "Marsha Lynn". Facilities will be described and illustrated, and current and future plans will be discussed.

1:30 pm BS-30 Life Beyond Earth WILLIAM TRANTHAM, Florida Keys Community College.--This presentation will include orbital photos of the planet Mars, original half-frame material from the "Star Trek" television series, "2001: A Space Odyssey," and color slides of Unidentified Flying Objects from national and international sources by the former director of the U.F.O. Investigator.

EARTH AND PLANETARY SCIENCES SECTION

Friday 8:20 am Room En 108

Patrick J. Gleason, Florida Flood Control District, Presiding

8:20 am EPS-1 Water Consumption Trends Within Central and Southern Florida Abe Kreitman, R.H. Walker and Jim Beck. Central and Southern Florida Flood Control District, West Palm Beach, Florida 33402. This study was initiated with the objective of determining the per capita water consumption, in an effort to manage efficiently the water resources of Central and Southern Florida. It is estimated from this study that the mean water consumption is 197 gallons per capita per day with a standard deviation of 87 gpcd. The water consumption figures ranged from 75 gpcd to 406 gpcd. The estimated figure compares fairly well with the per capita consumption estimated by U.S.G.S. The per capita figure for Central and Southern Florida is compared against South Atlantic Gulf region and the national figures.

8:40 am EPS-2 Peat Stratigraphy of Two Tree-Islands in the Northeastern Everglades Patrick J. Gleason and Peter Stone, Central and Southern Florida Flood Control District West Palm Beach, Fla. 33402. Peat stratigraphy of two tree-islands in Conservation Areas 1 and 2, Palm Beach County, Florida, suggests that these hammock-covered islands are recent biomorphic features in the northeastern Everglades. The islands are underlain by 1.5-2 meters of sawgrass and water-lily peat. Freshwater sponge spicules are locally abundant in lower levels of the cores. Fusinite or charcoal fragments, indicative of fires, are present at all levels. Basal peat from one hammock core located 3 miles south of S-6 pumping station in Conservation Area 2A was radiocarbon dated. Peat from a depth of 224 cm gave a C-14 age of 4860 ± 170 yr BP (referenced to AD1950), which was an average depositional rate of 4.6 cm/100 years.

9:00am EPS-3 Evolution of the Sedimentary Regime Surrounding Sebastian Inlet M. S. KNAPP, Test Lab, 5006 N. Grady Ave., Tampa, Fla., 33614.--Sebastian Inlet, located 15 miles north of Vero Beach is part of a barrier island bounded by the Atlantic on the east and the Indian River on the west. The inlet was artificially opened in 1947 by blasting and dredging before which, existed as a tidal delta that had become clogged by sediment. By 1972 there was pronounced deposition on the north side of the inlet and slight erosion directly south. Post 1972 deposition and erosion depend mainly on littoral and longshore drift, and the recent extension of the north jetty. The area South of the inlet has undergone severe erosion whereas deposition prevails north of the inlet.

9:20 am EPS-4 Escambia Bay - A Study of the Circulation and Stratification During the Period of Low Freshwater Inflow* N.C. Edwards, Jr., Lt. USCG, Florida State University. During the period of July through October, Escambia Bay is in a state of high stratification. This characteristic has enhanced some environmental problems. Within the past decade, there have been several studies of the sedimentology, hydrology and biology of the Bay without an intensive investigation of the physical characteristics. This study considers the circulation pattern and the salinity and temperature distribution under various wind, tidal and river flow conditions. The salinity, temperature and current velocity data were collected using a Beckman induction salinometer and a Marine Advisors current meter at various states of spring and neap tidal cycles. In conjunction, the wind speed was measured by a hand-held hot wire anemometer, and the river discharge was monitored. Salinity and temperature profiles taken along the central axis and across the mouth of the Bay are used to show the pronounced effects of the three varying parameters. During the late summer and early fall months, the mean river discharge is half of the annual mean of $170m^3$ sec^{-1}, diurnal tide has a mean range of 0.45 meters and the winds are variable. A very pronounced halocline appears. Although Escambia Bay averages 2 to 3 meters depth, a vertical salinity gradient of 14°/oo per meter is not uncommon. A two layer circulation is evident with tidal oscillations dominating. Reversals in the vertical velocity profile are portrayed by the velocity vector diagrams. A reversal from 0.33m sec^{-1} near the surface outflow to 0.33m sec^{-1} inflow at about 3 meters depth has been observed in the river. The circulation is generally counter clockwise in the lower Bay and clockwise in the upper Bay greatly to geomorphology. Consequently, the saltwater intrudes along the eastern shore and the bottom while the river water is directed along the surface on the western side. Opposing fresh and salt water flows increase stratification. Increased surface wind stress weakens and lowers the stratified layer. A correlation between the circulation and stratification is evident, with the maximum inflowing current located within or below the halocline. The maximum outflowing current is above the holocline but not necessarily at the surface.
*Research conducted for Masters Thesis and Sponsored by State of Florida and U.S. Coast Guard.

9:40 am EPS-5 Simulation of Water Quality in a South Florida Canal* Thomas N. Russo, U.S. Geological Survey, 901 S. Miami Ave., Miami, Fl. 33130--QUAL-I** is a mathematical model system that was used to calculate spatial and temporal distribution of DO (dissolved oxygen) and BOD (biochemical oxygen demand) in Plantation Canal, Broward County. Calibration of seasonal flow and no flow models showed that photosynthesis, rather than atmospheric reaeration, is the primary means by which the water replaces its oxygen. Verification of the model provided a good fit of the model predictions to observed field of 4.0 milligrams per liter in the canal increases as the quality of the head water decreases, and that any flow augmentation program should be designed to allow the photosynthetic communities to produce as much oxygen as possible.
*Research support by CSFFCD-BCPC USGS **Developed by the Texas Water Dept. Board

10:00 am COFFEE BREAK En Third Floor Lobby

10:20 am EPS-6 Morphology and Sedimentary Processes In and Around Tortugas and Agassiz Sea Valleys, Southern Straits of Florida* Larry L. Minter, George Hl. Keller, NOAA, 15 Rickenbacker Causeway, Miami, Florida 33149, Thomas E. Pyle, Dept. of Marine Science, USF, St. Petersburg, Florida. Continuous sesmic reflection profiling and new bathymetry in addition to observations from the submersible DR/V ALVIN indicate that the Tortugas and Agassiz sea valleys are being filled shoreward of 600m.' The morphology of the two valley systems reflect probable differences of origin. Current meter readings and photographs indicate the currents are relatively sluggish and not very active in sediment transport within the valleys. Additional items of morphological interest include step-like topographical features on the lower continental slope, numerous escarpments, terracing in the valley channels, possible local slumping, and shallow undulations which appear to be remnant valleys.
*Research supported by NOAA.

10:40 am EPS-7 Shoreline Changes on Honeymoon Island, Pinellas Co., Fla., 1967-1971, in response to man induced modifications of the island, Mrs. A.P. Wright, Fla. Bur. Geol., Tallahassee, FL 32302, and E. O'Donnell, U. of S. Fla., Tampa, FL. 33620. The SW shoreline of Honeymoon Island was extended seaward by a dredge-fill operation in 1969. During the project 1.5 million yards of material composed predominantly of boulder sized limestone was dredged from 1500 feet offshore to bring the SW beach to an elevation of five feet above mean sea level. Aerial photographs, current measurements, and sedimentological analyses of the island from 1967-71 indicate cyclic patterns of erosion and deposition. Significant alterations evident are: (1) pronounced erosion of the SW shore of the island, and (2) the deposition of a series of hooks along the NW shoreline. The dredge-fill operation has enhanced erosion of the SW shoreline and continued erosion in that area can be anticipated.

11:00 am EPS-8 Boron Concentrations in Natural Waters of Florida* N.E. Carriker** and P.L. Brezonik, University of Florida. A modification of the curcumin method for determination of boron is described and results of surveys of boron concentrations in rainfall, river basins, municipal water supplies, and several lakes and springs throughout the state are presented. Findings are compared with available data on boron concentrations in natural waters in Florida and other parts of the world, and possible cultural sources and environmental significance are discussed.
*Research supported by Florida Water Resources Research Center
**Environmental Engineering Sciences, Univ. of Florida, Gainesville, Fla.32611

11:20 am EPS-9 Variation in Cultures of a Rosalinid Foraminifer from Florida*, D.C. Steinker, Bowling Green State University, Bowling Green, Ohio 43403. An understanding of the biology, ecology, and variation of living foraminifers is essential in making paleoecological inferences. Laboratory investigations of controlled cultures yield information that can be checked against natural oppulations and applied to fossil assemblages. A study of clonal lineages of Rosalina floridana (Cushman) from the nearshore marine environment in Florida reveals variations in certain aspects of reproductive behavior and test morphology that may be correlative with environmental factors.

11:40 am EPS-10 The Impact of Urbanization on Lake Jackson: Hydrology, Water Chemistry and Sediments* Ralph R. Turner, Marine Laboratory, Florida State University, Tallahassee, Florida 32306. Recent urban encroachment in the southern watershed of Lake Jackson has greatly increased runoff of stormwater into the lake and seriously degraded water quality in the lake. Research is in progress on several hydrologically gauged subwatersheds which have been selected to help isolate the hydrologic and land use factors most responsible for the degraded stormwater runoff. Other studies are elucidating the recent sedimentary history of selected sub-basins of the lake with the goal of determining past fluxes of pollutants into the lake.
*Research supported in part by Florida G.F.F.C. and Florida D.O.T.

Friday 1:00 pm Room Engineering Auditorium

Annual Business Meeting of the Florida Academy of Sciences

James G. Potter, Florida Institute of Technology, Chairman

Friday 1:30 pm Room Engineering Auditorium

SYMPOSIUM

William H. Taft, University of South Florida, Presiding

1:30 pm FLORIDA'S ESTUARIES-MANAGEMENT OR MISMANAGEMENT? -- Five major estuaries in Florida, Biscayne, Tampa, Charlotte, Apalachicola and Pensacola will be described in terms of physical, biological and chemical characteristics and their economic value. An attempt will be made to define present problem areas and to project what will happen to the estuary given certain development alternatives.
Speakers: Dr. Martin Roessler, Dr. Joseph Simon, Dr. Jack Taylor, Dr. Robert Livingston and Dr. Thomas Hopkins

3:30 pm COFFEE BREAK En Third Floor Lobby.

3:45 pm Room En 108
Presiding TBA

3:45 pm EPS-11 The Chemical Quality of Water in Florida Flood Control District Conservation Area 2A and Associated Canals. Patrick J. Gleason, Central and Southern Florida Flood Control District, P.O. Box V, West Palm Beach, Fla. 33402. 300 water samples and over 2700 analyses were performed on water collected from Conservation Area 2A from Oct. 1972-Aug. 1973. During July and Aug. 1973, canal water emanating from the agricultural areas exhibited nutrient levels equivalent to urban-runoff nutrient concentrations. Canal and marsh water exceeded Florida Pollution Standards for specific conductance and several times canal water exceeded water quality standards for ammonia. Vegetation in the Everglades marsh absorbed the relatively high nutrient inputs from canal inflows. Dissolved organic nitrogen and dissolved organic phosphate phosphorus concentrations did not vary significantly between canal and marsh suggesting that they are refractory and not available as a nutrient source for organisms.

4:05 pm EPS-12 The Water Quality of the Hillsborough River: 1966-August 1973 DAN F. THOMPSON, JR., Geology Dept., Univ. of South Florida, Tampa, Florida 33620. The City of Tampa draws its drinking water from the Hillsborough River and weekly determines its color, alkalinity, hardness, pH, and non-carbonate hardness at five sites within the city. Color shows the greatest variance and is directly proportional to rainfall. Humus material appears to be the dominate factor in color values. Alkalinity and hardness show an inverse relationship to precipitation as does pH whose low values are attributed to organic acids added upstream. Non-carbonate hardness is also directly proportional to rainfall and exhibits abnormally high values in 1967, 68, 71, and 72, apparently as a direct result of urban runoff.

4:25 pm EPS-13 Tampa Bay Estuarine Hydrology Study* C.R. Goodwin, Hydrologist, U.S. Geological Survey, Tampa, Florida 33602. A 30 minute 16 mm film will be projected.
*In cooperation with Tampa Port Authority.

5:00 pm Room En 108

Business Meeting of the Earth and Planetary Sciences Section

Patrick J. Gleason, Florida Flood Control District, Chairman

7:15 pm Annual Academy Banquet, Ramada Inn East

Saturday 8:20 am Room En 108

Patrick J. Gleason, Florida Flood Control District, Presiding

8:20 am EPS-14 Hydrologic Significance of a Geothermal Submarine Spring Off Florida West Coast. F.A. Kohout, U.S. Geological Survey, National Center (411), Reston, Virginia, 22092. A submarine spring located 12 miles (19 Km) off the southwest shore of Florida represents field evidence of a geothermally activated convective flow cell in saline ground water underlying the Floridan Plateau. The ground water discharges from a sink-like depression with a maximum depth of about 65 feet (20 m) below sea level in average water depths of about 43 feet (13 m). The temperature of the discharging water is 96.6°F. (36.0°C.). This high-temperature anomaly indicates contribution from the underlying Floridan aquifer at depths of 1000 to 3000 feet (305-915 m). Concentrations of the major ions are about the same as those in sea water, but trace-element concentrations are exceptionally high. Seismic data presented by Pyle and Wallace (in this meeting) show the existence of other sediment-filled sinkholes off the Florida west coast and this prompts the question whether trace elements in submarine ground-water discharge might in some way be involved in triggering the Red Tide plankton blooms that occur in this area. The spring also has regional implications in regard to deep-well waste injection into the Boulder Zone segment of the Floridan aquifer at depths of 2000 to 3000 feet (610-915 m). Wherever fissures or sinkholes provide vertical connection across the confining beds that overlie the Floridan aquifer, waste entrained in thermal convection cells could migrate in unanticipated directions.

8:40 am EPS-15 A Hypothesis Relating Submarine Springs to Red Tide* T.E.Pyle and D.W. Wallace, Dept. Marine Sci., USF, St. Petersburg. Previous investigations have focused on land run-off and upwelling as triggering mechanisms for red tides. Limited recent evidence, including seismic and salinity data and the work of Kohout (this meeting), suggests that seafloor discharge from springs and seeps is more extensive than previously thought and tends to link this process with Florida red tide outbreaks in both space and time. Our comparison of worldwide occurrences of submarine springs and red tides also shows a remarkable level of geographic coincidence. It may ultimately be possible to use red tides as an indicator of offshore springs or, perhaps, to use geophysical data to pinpoint the source of certain plankton blooms.
*Ship time provided by SUSIO.

9:00 am EPS-16 The Littoral Power Gradient as Related to Present and Past Nearshore Depositional Patterns on Sanibel Island, Florida. T.M. Missimer, Dept. of Geology, Florida State University, Tallahassee, Florida.* The littoral power gradient, calculated utilizing the WAVE ENERGY computer program developed by May (1973), has been determined for a section of the southwest Florida coast extending from Lacosta Island south to Estero Island. Four wave approach directions have been combined in a set ratio to simulate approximate average natural coastal conditions. The calculated littoral power gradient accurately predicts true measured deposition and erosion areas along the present coast. Beach ridge patterns on Sanibel Island show considerable variation during the depositional evolution of the island. This variation necessitates past changes of the littoral power gradient probably caused by changes in the wave approach direction ratio.
*Present address: USGS(WRD), Rm. 109 Smith Bldg., 2070 Main St., Ft. Myers, Fla. 33901

9:20 am EPS-17 Skeletal Characteristics and Sedimentary Implications of Calcareous Algae.* D.S. Marszalek, School of Marine and Atmospheric Science, University of Miami, 10 Rickenbacker Causeway, Miami, Fla. 33149. Codiacean algae are the most important group of sediment producing green algae in south Florida coastal waters. Dasycladacean algae are important locally and seasonally. Skeletal aragonite is usually secreted as acicular crystals in the less than 15 microns size range. Particle size distribution after breakdown is species characteristic and directly related to skeletal architecture. Growth rates and dry weight percentages of $CaCO_3$ are species dependent and seasonally variable. From these data and standing crop values production rates can be calculated.
*Research supported by NSF Grant GA-35077.

INVITED PAPERS

9:40am EPS-18 Hydraulic Characteristics of the Boulder Zone, F.W. Meyer, U.S. Geological Survey, 901 S. Miami Ave., Miami, Fla. 33130.--Knowledge of the hydraulic characteristics of deep saline aquifers is fundamental to defining the vertical and horizontal controls on fluid movement, information which is needed for assessing the environmental impact of subsurface waste storage. To meet this objective, natural water-level fluctuations in the 2,947-foot deep Peninsula Utilities deep disposal well near Miami, Fla. were analyzed to obtain estimates of the hydraulic diffusivity, hydraulic conductivity, specific storage, transmissivity, and the storage coefficient of the Boulder Zone. The fluctuations are caused chiefly by oceanic and earth tides, and by changes in atmospheric pressure. The oceanic tidal fluctuations probably result from loading due to tides in Biscayne Bay.

10:10 am COFFEE BREAK En Third Floor Lobby

10:15am EPS-19 Sediment Transport in the Near-Shore Zone. W.F. TANNER, Florida State Near-shore sediment transport is being studied by computer simulation, differential bathymetry, serial aerial photography, grain size analysis, sorting studies and SEM studies. The procedure depends on the behavior of near-shore sand, which matches the "a-b-c..." model, and can be predicted by computer techniques.

Analysis is under way for Florida's Gulf Coast. Results (including littoral breaker power at short intervals) can be used to forecase erosion and deposition rates. This work permits one (1) to partition wave energy among major sinks (bottom friction, sand transport, and breaking); (2) to evaluate efficiency of the sand-transport system: and (3) to predict separate effects of changes in water level, waves and bathymetry.

10:45am EPS-20 Geology of the Pourtales Terrace David N. Gomberg, Comparative Sedimentology Laboratory, U. of Miami, Fisher Island Station, Miami, Fl. 33139

Middle to Late Tertiary, phosphatized, shallow-water limestones crop out on the Pourtales Terrace, seaward of the Florida Reef Tract. The terrace surface, now at 200-400 meters depth, was subaerially exposed at least twice in the Tertiary, during which time the limestones were diagenetically altered. Karst terrains that formed during the exposure periods give the terrace its peculiar surface morphology.

Subsidence with little sediment deposition characterizes the Quaternary history of the terrace. Presently, on the shallower (200-250 m.) parts, deep-water skeletal limestones are slowly forming. On the outer (>250 m.) terrace, Quaternary deposition is recorded only within the drowned Tertiary limestone, as sediment infill in cavities caused by boring organisms and physico-chemical processes.

11:15am EPS-21 Significant Problems in Florida Geology. S.R.WINDHAM, Florida Bureau of Geology, Tallahassee. Ever increasing demands for mineral resources in concert with environmental concerns provide Geologists with a unique opportunity to play an important part in the scientific community's contribution to man's ability to live on earth. Applied research is vitally needed to respond to geologic problems including mineral resource development, waste disposal, and land subsidence.

11:45am EPS-22 Turbidity and Coral Reef Health in Waters of Pennekamp Park, Upper Keys, GEORGE M. GRIFFIN and A. ANTONIOUS, Harbor Branch Foundation, Rt. 1, Box 196, Ft. Pierce, Fl. 33450.--Turbidity from dredge-fill and other sources was measured for 18 months and effects on water clarity and Pennekamp State Park coral reefs assessed. A typical dredge project, monitored for 12 months, yielded 2 x 10^9 mg suspended sediment per working day, usually into a 0.3 x 0.3 inshore area. This is 5% of the total natural load of the entire 21 mile inshore Park area, a significant local addition. Unless coastal mangroves and seagrasses, the natural sediment traps/water clarifiers, are preserved, clarity will continue to decline. Our survey indicates that all coral reefs in the Park remain healthy and, so far, have not been adversely affected by increased sedimentation. However, continued monitoring is needed as development progresses because of damage noted on some reefs outside the Park.

Saturday 2:00 pm Room En 108

Presiding TBA

2:00 pm EPS-23 Geophysics and Florida Water Resources. Daniel P. Spangler, Univ. of South Florida, Tampa 33620. The present increase in the demand for groundwater in Florida is responsible for a growing number of groundwater exploration and development projects. In addition, a number of undesirable effects have been associated with the demand and use of land and ground water resources. It seems highly probable that a major increase in the need, use and effectiveness of geophysical techniques to Florida's water resources will increase as the volume of fresh water needs increase. Geophysics can be employed in coordination with geological studies and drilling to establish models of the subsurface structure, determine the physical characteristics of aquifers, and aid special hydrological problems, such as groundwater salinity distribution, and localization of sanitary landfills and their effects. Some techniques with a few field results are outlined.

2:30 pm ESP-24 Evidence of Climatic Change in Florida During the Late Pleistocene and Holocene H. K. BROOKS, University of Florida. -- In historic time peninsular Florida has experienced an interval of relatively high precipitation. Swamp, lake, spring and sinkhole deposits bear evidence that severe aridity existed through central and southern Florida during periods, that in continental temperate regions, represented colder intervals. There is no evidence of significant overall temperature change in peninsular Florida during the past 28,000 years. The changes have been in seasonality and in the pattern and frequency of precipitation from hurricanes, thunderstorms and frontal systems. Sea level has responded eustatically to world changes in climate, even within historic time. Thus, in peninsular Florida, sea level and ground water level becomes an important consideration in evaluation of climatic effects. In the limestone terraine, where the principal drainage is underground through an open aquifer system with high transmissibility, the water table has fluctuated with its base-level -- the sea. Perched water systems are more presistent but have been climate dependent in relation to changing patterns of precipitation and evapotranspiration. A summary of climatic, hydrologic and archaeological events is given.

3:00pm EPS-25 New Oil Field in Florida - C.W.HENDRY,JR., Fla. Bureau of Geology, 903 West Tenn. St., Tallahassee, FL 32304. --Oil Exploration in Florida began about 1900 but not until 1943 was oil discovered in commercial quantities in Lower Cretaceous carbonate sediments in Collier County. In 1970, oil was discovered in Jurassic age sands and carbonates in northwest Florida (Jay Field) and in quantities great enough to enable Florida to be considered an important oil producer. The Jay Field, located in Escambia and Santa Rosa counties, Florida, and its continuation into Alabama, known as the Little Escambia Creek Field, have been combined into a single field-wide unit which covers over 14,000 acres and contains 89 wells on 160 acre spacing. Unitization of the wells in this reservoir allows for pressure maintenance and secondary recovery of additional hydrocarbons. Calculated total production from the unit will be in excess of 300 million barrels of oil and 300 billion cubic feet of gas.

3:30 pm COFFEE BREAK En Third Floor Lobby

3:45 pm EPS-26 Offshore Drilling and Production Environmental Protection. Art Joens Exxon Company, U.SA., P.O. Box 60626, New Orleans, Louisiana, 70160. Key elements in offshore petroleum operations include exploratory drilling, field development, and production operations. Much progress has been made to insure that each of these elements is environmentally sound. This paper highlights the environmental technology now being employed. Current activity reflects high quality operations which are meeting stringent OCS regulations and standards.

4:15 pm EPS-27 Water and Water-Management Problems in Southwest Florida Water Management District. Garald G. Parker, CPG., Chief Hydrologist and Senior Scientist, Southwest Florida Water Management District, Brooksville, Florida 33512. The Southwest Florida Water Management District, covering about 10,000 square miles and including 15 counties, centers around the Tampa Bay area. Its 1970 population was approximately 1.75 million persons but by the year 2,000 the population is expected to double. Water-budget analyses indicate that, on a long-term average, the potential (but not achievable) fresh-water crop is about 7.15 bgd (billion gallons a day). Water use, for once-only usage by industry, agriculture, commerce and municipalities, is now about 1,000 gpcd (gallons per capita per day). This is higher than the 1970 statewide value of 800 gpcd because of the tremendously large quantities of water required by the phosphate and citrus industries centered in the upper Peace and Alafia River Basins, but is lower than the 1,800 gpcd national use because our industries are much smaller than those of the industrial eastern states and our agriculture is much small than that of the irrigated western states. We cannot capture and use all of the potential water crops for consumptive use. Perhaps one-third maybe so used without too great harm to the environment. If this proves to be so, our available water crop is about 2.38 bgd and the water-demand curve will cross the water-crop curve about 1984. Unless steps are taken to increase the availability of fresh water for consumptive use within the District, we will begin mining water at that time, that is, using consumptively more water every year than nature gives us. Obviously, this is an intolerable situation. Some remedies, all costing a great deal more than if we were to live within our water budget, include the following, not necessarily in order of greatest suitability: (1) reuse sewage effluents; (2) desalinate brackish groundwater; (3) engage in artificial aquifer recharge; (4) institute strict economics in all water uses, that is, avoid wasteful water practices; (5) plug the hundreds of existing wild-flowing artesian wells; (6) utilize salt-water control structures in coastal, tidal canals to prevent salt-water encroachment and store larger quantities of fresh-water inland from these structures; (7) by scientifically designed well fields located far enough inland from the salt-water encroachment zone, develop to its maximum the fresh-water potential of the coastal region (where the majority of the population development will be) as the basis for a unitized regional water supply system; (8) by coordination with appropriate county and state governmental agencies, prevent the draining and despoliation of our inland fresh-water sources, particularly the Green Swamp, and lay the foundations for an interior regional water supply system; (9) investigate the feasibility of importing water from the northern and western rivers of the state, some of which discharge immense quantities of fresh-water into the Gulf of Mexico; and (10) increase normal precipitation by rain-making techniques when these become praticable.

4:45 pm EPS-28 Geology As a Resource R.O. Vernon, Director of Division of Interior Resources, Department of Natural Resources, 501 Larson Bldg., Tallahassee, Florida. Carbonate rock can cause environmental problems, provide a means of solution, and give unique qualities to the amenities and necessities for an abundant life. Florida is a case history. Large areas of the coast have zero energy and no clastic beaches, reflecting a low ramp slope that results from a drowned limestone karst plain. In the interior, three zones of karst are present: (1) carbonates at the surface, (2) carbonates covered by overburden, and (3) carbonates saturated with artesian water. The withdrawal of large quantities of artesian water results in the stopping of overburden into small limestone caverns with the resulting collapse of the ground surface. Large cavernous areas in the subsurface at several levels permit both the storage of fresh potable water and the discharge of well treated effluent into the subsurface. These caverns are separated by zones of low vertical permeability and permit the separation of potable waters from well treated effluent. Sewage injection wells have removed nutrients from the canals and streams along high urban-stressed areas. Nitrates, phosphates, and pathogenes are removed. The nitrates form methane gases; the phosphates react with the carbonates to stabilize as calcium phosphates, and the pathogenes are killed with resident time in the formation and reaction with salt water. The removal of nutrients and pathogenes will permit the recovery of water for further use.

PHYSICAL SCIENCES SECTION

Friday 8:30 am Room En 305

ASTRONOMY AND ASTROPHYSICS

James H. Hunter, University of South Florida, Presiding

8:30 am PS-1 The Initial Collapse of Interstellar Gas Clouds. James H. Hunter, Jr., Department of Astronomy, University of South Florida, Tampa, Florida. The mechanisms that can initiate the collapse of interstellar gas clouds are discussed in some detail. In addition, numerical results of the thermal-gravitational collapse of model interstellar clouds are presented. It is shown that clouds having a wide range of initial masses could become unstable, resulting ultimately in the formation of a wide variety of stellar systems.

8:55 am PS-2 The Fragmentation of Interstellar Clouds. Christopher Hunter, Florida State University.* The first stage in the formation of stars from the interstellar medium is the development of an unstable gas cloud. This instability is then believed to lead to the fragmentation of the cloud into many parts. The mechanics of this process of fragmentation will be reviewed.

*Research supported in part by NSF grant GP-34279X.

9:20 am PS-3 Observations of Star Formation in Low Mass Clouds. Anthony F. Aveni, Department of Physics and Astronomy, Colgate University, Hamilton, New York and Départment of Astronomy, University of South Florida, Tampa, Florida and Stephen L. Nightingale, Department of Astronomy, University of South Florida, Tampa, Florida. The T Tauri-like star BM And is embedded in the southern end of an isolated tongue of nebulosity situated $\sim$ 80 pc. above the galactic plane. Photometry and spectroscopy of stars in the vicinity of the nebula indicates the presence of ten probable member stars in the group, as well as several possible outlying members. The age of the complex is estimated to be $\sim 10^7$ yrs., since stars later than A0 have not yet contracted onto the main sequence. The total mass of the group (including interstellar material) appears to be about 60 $M_{\odot}$. In view of its isolation from other early type clusters and associations, it is suggested that the BM And complex is an example of one of the smaller mass primary condensations in which star formation is taking place currently in the solar neighborhood. Two additional small, isolated groups, NGC 7129 and vB80 are also discussed.

9:45 am PS-4 Radiative Transfer in Circumstellar Dust Shells, C. A. HARVEL, University of Florida.--The radiation fields within spherically symetric circumstellar dust shells have been calculated by an iterative procedure. The model characterizes each dust shell by a number of parameters related to the mass, density-distribution and size of the shell and the size and albedo of the dust particles. The dust particles are assumed to be grey bodies and isotropic scatterers. Using the radiation field calculated for a shell, the flux emitted by that shell as a function of wavelength is determined. An application of the model to the T Tauri star R Monocerotis will be described, and the results of the model calculations will be presented and discussed.

10:10 am PS-5 Nucleosynthesis During Carbon Burning in a 15 Solar Mass Star. A.S. Endal, University of Florida. Calculations of nucleosynthesis during carbon burning are currently under way. A Newton-Raphson predictor-corrector network program is used to calculate abundance of nuclei. Temperature and density are set by output from Henyey-type stellar evolution code calculations on a 15 solar mass star. The results of both the model calculations and the nucleosynthesis calculations will be presented and discussed.

10:35 am COFFEE BREAK En Third Floor Lobby

10:45 am PS-6 Origin of Supernova Explosions. Stephen W. Bruenn, Florida Atlantic University. The current state of the theory concerning the origins of supernova explosions is reviewed here. The proposed mechanisms generally divide into two categories. One category involves the explosive ignition of stellar material (^{4}MH, ^{12}C, or ^{16}O) under highly electron degenerate conditions. Much recent work in this area has been concerned with the possibility of forming pulsars by rapid electron capture on the products of the detonation, and to account for type I supernovae by an appropriate sequence of mass transfers in a close binary system. The other category of proposed mechanisms involves the dynamic collapse of the stellar core followed by the violent ejection of the envelope. A number of mechanisms have been proposed for ejecting the envelope (neutrino transport, thermonuclear, pulsar driven radiation pressure), but none of these is free yet of serious objections. The current state of supernova theory is clearly far from satisfactory.

11:10 am PS-7 Emission Line Variations in Gamma-Two Velorum* W.H. SCHNEIDER, F.B. WOOD, Univ. of Florida, R.R.D. AUSTIN, Mt. John Observatory.-- Observations of the southern hemisphere object Gamma-Two Velorum, a spectroscopic binary composed of an O7 star and a Wolf-Rayet star, are discussed. Photoelectric measurements were made with the 24-inch reflector of the Mt. John Observatory in New Zealand and six 10Å bandwidth interference filters, three centered on emission lines and three centered on nearby continuum regions. Changes of up to 0.1 magnitude, on a time scale of minutes to a few hours, were found for the HeII 4686Å and the CIII 5696Å emission lines.

*Research supported in part by the National Science Foundation

11:35 am PS-8 Radio Recombination Line Observations of the Interstellar Medium, S.T. GOTTESMAN, A.W. SEACORD, II, University of Florida --Recent radio recombination line observations[1] have indicated the presence of a diffuse emitting medium in the galactic plane. The radio spectrum of the supernova remnant 3C 391 indicates absorption due to this medium.[2] We will discuss our hydrogen recombination line spectra observed in the direction of 3C 391 and in the electron density, temperature, and general structure of this medium seen in this direction of the galaxy.

[1] M. A. Gordon and S. T. Gottesman, Astrophys. J. 168, 361, 1971.
[2] G. A. Dulk and O. B. Slee, Australian J. Phys., 25, 429, 1972.

Friday 1:00 pm Room Engineering Auditorium

Annual Business Meeting of the Florida Academy of Sciences

James G. Potter, Florida Institute of Technology, Chairman

Friday 1:30 pm Room Engineering Auditorium

SYMPOSIUM

William H. Taft, University of South Florida, Presiding

1:30 pm FLORIDA'S ESTUARIES-MANAGEMENT OR MISMANAGEMENT? -- Five major estuaries in Florida, Biscayne, Tampa, Charlotte, Apalachicola and Pensacola will be described in terms of physical, biological and chemical characteristics and their economic value. An attempt will be made to define present problem areas and to project what will happen to the estuary given certain development alternatives.
Speakers: Dr. Martin Roessler, Dr. Joseph Simon, Dr. Jack Taylor, Dr. Robert Livingston and Dr. Thomas Hopkins

3:30 pm COFFEE BREAK En Third Floor Lobby

Friday 3:40 pm Room En 305

Session A Astronomy

Thomas D. Carr, University of Florida, Presiding

3:40 pm PS-9 Observation of Algol with the Copernicus Satellite* K-Y. CHEN and F. B. WOOD, Univ. of Florida. -- Spectrophometric observation of β Persei using the Princeton University Observatory spectrometer on the Copernicus satellite was made during the period from September 7 to September 10, 1973. Spectral scans from 1050 Å through 1450 Å and from 2100 Å through 2900 Å were taken. This paper will give brief descriptions of the observation, and of data reduction.

*Research supported by the National Aeronautics and Space Administration.

4:00 pm PS-10 Optical Linear Polarization in the Extragalactic Sources BL Lacertae and 3C 120. B.Q. McGimsey, A.G. Smith, R.L. Scott, R.J. Leacock, P.L. Edwards, Rosemary Hill Observatory, University of Florida. During the past year linear polarization observations have been conducted photographically of the Lacertid BL Lac and the Seyfert Galaxy 3C 120 with the Rosemary Hill 30-inch reflector. BL Lac is known to have a linearly polarized optical continuum.[1] The present observations show a variable polarized flux during a period when the object is varying optically. The galaxy 3C 120 is known to have a linearly polarized radio component,[2] and the present observations show a constant polarized component in the blue region of the spectrum with the object at a minimum in brightness.
[1]N. Visvanathan, Ap. J. 179, 1 (1973).
[2]R.W. Hobbs and J.A. Waak, A.J., 77, 342 (1972)

4:15 pm PS-11 Recent Observations of the Lacertids BL Lac and OJ287, and a Possible Lacertid, PKS 0735+17. Roger L. SCOTT, Alex G. SMITH, R.J. LEACOCK, B.Q. MCGIMSEY, P.L. EDWARDS, Rosemary Hill Obs., Univ. of Fla., and Karen R. HACKNEY, Western Kentucky Univ.--OJ287, as well as the Lacertid prototype BL Lac, belong to a class of objects apparently related to quasars but having featureless optical spectra. The optical variability and spectrum[1] of PKS 0735+17 resemble those of a Lacertid. Photographic observations at the f/4 Newtonian focus of the Rosemary Hill 30-inch reflector show large variations for all three objects over a period of days. In addition, high time resolution studies of BL Lac and OJ 287 show considerable intraday activity over a period of hours or even minutes.

[1]Burbidge, E. M. and Strittmatter, P. A., 1972, Ap. J. (Letters), 174, L57.

4:30 pm PS-12 LOW INTENSITY OBSERVATIONS OF JUPITER EMPLOYING A 26.3 MHz VLA M. DESCH, T.D. CARR, Univ. of Florida.--The completion of a 640 element phase steerable dipole array has permitted high sensitivity monitoring of the planet Jupiter during the 1973/74 apparition. A highly directional multi-beam technique has enabled positive discrimination between Jupiter bursts and terrestrial interference even during daylight hours. Six southern declination radio sources have been used to establish a sensitivity limit of about 100 flux units. Two dimensional maps of Jupiter rotation phase versus Io orbital phase will be presented showing the emergence at low intensities of significant non-Io related source B regions.

4:45 pm PS-13 Digital Computer Laboratory For Computer Science W. J. RHEIN, Florida Technological University.--A Varian 73 computer has been installed as a teaching and research tool for computer science students. The system's hardware consists of a central processing unit with 24k words of memory, 256 words of writeable control store, 2 cassette tapes, 2 teletypes with automatic send/receive features and a CRT keyboard display. Experiments with operating systems, computer organization using micro-programming, interfacing with large computing systems, memory management, real time operations and multiprocessing may be carried out on this system. Six software packages are available to the students of the laboratory.

5:00 pm PS-14 PERTURBATION THEORY ANALYSIS OF THE MAGNETIC RESONANCE HYPERFINE SPECTRUM OF $3d^5$ DIVALENT METALLIC IONS. E. F. Strother, Florida Inst. of Technology. Electron Spin Resonance spectra of divalent manganese ions over the region of low concentration and high mobility exhibit 2I + 1 = 6 nearly equally spaced hyperfine spectral lines. Deviations from equal spacing arise from second order effects. The matrix elements $\langle M_S, M_I | \mathcal{H} | M'_S M'_I \rangle$ were calculated for the Spin Hamiltonian

$$\mathcal{H} = g\mu_\beta H S_z + A_0 [S_x I_x + S_y I_y + S_z I_z]$$

It was found that the off-diagonal elements of the resulting 36 x 36 matrix provided the corrections in second-order perturbation theory. The average second-order shifts were of the order $A_0^2/g\mu_\beta H \approx 3.1$ Gauss at X-band frequencies where $A_0 = 101.3 \pm 0.5$ Gauss is the average hyperfine coupling constant.

Friday 3:40 pm Room En 306

Session B General Topics

S.B. Haley, Florida Technological University, Presiding

3:40 pm PS-15 Faraday Rotation in a Collisional Magnetoplasma S. C. BLOCH and P. W. LYONS, University of South Florida.-- For a linearly polarized electromagnetic pulse train incident on a collisional magnetoplasma, computer solutions are obtained for the X and Y components and the magnitude of the transmitted electric field as functions of time, for propagation parallel to the static magnetic field. The crosscorrelations of the transmitted waves with the incident wave train are also computed. It is found that while the Y-component grows and the X-component decreases, the crosscorrelations along both axes decrease. Collisional losses introduce interesting modifications to the usual dispersion and absorption, and the information content, in the vicinity of electron cyclotron resonance.

3:55 pm PS-16 Nonlinear Waves in a Cold Magnetoplasma* R. W. Flynn, Univ. of South Florida.--The linear theory of a cold magnetized plasma predicts two wave modes. A factorable fourth order nonlinear d.e. describes these same modes at larger amplitudes. When, because of the excitation mechanism or boundary conditions, only one of these modes is present the many techniques developed for studying the B = 0 case may be adopted freely. Although dramatic changes in the waveform occur, the oscillation frequency is independent of amplitude.

*Research supported by Air Force Cambridge Research Laboratory.

4:10 pm PS-17 Spectrometric Measurement of Plasma Electron Temperature in a Linear Z-Pinch. J.T. Pytlinski, University of Florida and M.R. Barrault, University of Liverpool (England). The results of measurements of the electron temperature of a magnetically supported decaying hydrogen plasma in a linear Z-pinch device are presented. The measurements are performed using a Hilger & Watts model-D285 high-output monochromator with the photomultiplier attachment. Using the well known theory[1], the variation of the electron temperature as a function of the plasma decay time is determined from the ratio of the H_B line intensity to the intensity of the hydrogen continuum of 4610Å. The plasma electron temperature values are within a 0.5eV to 2eV range for the decay time of about 80μsec with B=0-2.5KG and $V_{Disch.}$=20KV. The measurement technique will also be discussed.

[1]H.R. Griem, Plasma Spectroscopy McGraw-Hill, New York, 1964, p.279.

4:25 pm PS-18 Thermal Transport of Ideal Gases RANDY SMITH* and S. B. HALEY, Florida Technological University.--The thermal transport properties of ideal gases propagating through an arbitrary concentration of randomly distributed hard sphere scattering centers are calculated. The molecular distribution function is determined by analytically solving the non-linearized Boltzmann equation, and the temperature distribution as well as the heat and particle fluxes are obtained as a function of molecular free path. The thermal conductivity and diffusion constants are compared with the values obtained by the mean free path and thirteen moment approximations.[1]

*Work completed as an undergraduate research project.

[1]E. A. Desloge, Statistical Physics, Holt, Rinehart and Winston, Inc. (1966).

4:40 pm PS-19 Thermal-Expansion Measurements on Two Ferroelectric Materials. J. S. Browder* and S.S. Ballard, Univ. of Florida.--High-resolution thermal expansion measurements have been made on oriented single-crystal samples of the ferroelectrics KDP and $LiNbO_3$. Emphasis was placed on determining the temperature dependence of the linear expansion coefficients of KDP near its Curie temperature of 122K. Similar measurements for $LiNbO_3$ in the liquid-helium-temperature region have revealed anomalies, including a marked hysteresis effect, near 60K.

*Now at Jacksonville University, Jacksonville, Florida 32211

4:55 pm PS-20 A Simple Hi-Intensity Source of H^- ions Using a Glow Discharge. W.F. Block, R.A. Rhodes II, and B.G. Wallace, Eckerd College. As an initial project in the ionics research program[1] an ion total scattering apparatus was constructed along the lines of those of previous investigators[2 3]. It uses a simple glow discharge in H_2 as a source of H^- ions, following Fite's suggestion[4] that a glow discharge gives greater current stability than does thermionic emission for H^-. We found that the gun produces mass-analyzed beams of H^- ions with currents up to 8.2×10^{-9} amp with good stability with a plasma current of 5 ma.

[1]W.F. Block, invited paper PS-21, FAS meeting, March 1973.
[2]J.H. Simons, H.T. Francis, C.M. Fontana, and S.R. Jackson, R.S.I. 13 419-426(1942).
[3]E.E. Mushlitz, T.L. Bailey, and J.H. Simons, J.Chem.Phys. 24 1202-1209(1956).
[4]W.L. Fite, Phys. Rev. 89 411-415(1953).

7:15 pm Annual Academy Banquet, Ramada Inn East

Saturday 8:30 am Room En 305

MOLECULAR PHENOENA AND ENERGY CRSIS

Hans S. Plendl, Florida State University, Presiding

8:30 am PS-21 High Resolution Infrared Spectroscopy of Small Molecules. R.H. Hunt, Florida State University, Tallahassee, Florida 32306. Features of the Florida State 4-pass infrared Grating Spectrometer and the application of high resolution to the determination of molecular parameters will be discussed. Recent results, including computer enhanced spectra, will be shown for methane, carbon dioxide, and methanol.

9:00 am PS-22 IR Absorption Spectroscopy of Hydrogen Peroxide. Greg Faulkner, Florida State University. The hydrogen peroxide infrared absorption band centered at 3600 cm^{-1} was obtained under .02 cm^{-1} resolution. The antisymmetric OH stretching vibration was examined and found to demonstrate internal rotation doubling and asymmetry effects. Molecular constants have been derived for the ground and excited states.

9:15 am PS-23 Mössbauer Spectra of ^{237}Np In Ion Exchange Resins and in a Solvent Extractant* C. A. Clausen, Florida Technological Univ.--This paper will deal with the Mössbauer effect for Np(IV) ions sorbed on a cation exchange resin from HNO_3 and HCl solutions and with $[NpCl_6]^{-2}$ and $[Np(NO_3)_6]^{-2}$ complexes sorbed on an anion exchange resin. Mössbauer spectra for $[NpCl_6]^{-2}$ and $[Np(NO_3)_6]^{-2}$ complexes extracted into a tri-octylamine-benzene solution will also be discussed. The isomer shifts and quadrupole splittings for the sorbed and extracted species have been found to agree but the quadrupole splittings were found to differ from those observed for the parent compound in the crystalline state.

*Research supported by the U. S. Atomic Energy Commission

9:30 am PS-24 Low Energy Scattering Behavior of Helium on Helium. J.G. Skofronick, Florida State University, Tallahassee, Florida 32306. Considerable understanding of the helium-helium system can be had if the intermolecular potential is known. One method of obtaining such information is by measuring the scattering behavior of these two atoms. In this talk a discussion of molecular scattering and its application to this system will be given. Particular emphasis will be given to the low energy behavior and its interpretation.

10:00 am PS-25The Energy Crisis: Past, Here or Coming? R.H. Davis, Florida State University. Permanent and changing aspects of energy supply and demand are discussed. Both problems and benefits result from energy limitation.

10:30 am COFFEE BREAK En Third Floor Lobby

10:45 am PS-26 Comments on the Feasibility of Geothermal Energy Utilization in Florida. Roman K.D. Johns, Florida Institute of Technology. The principles of geothermal energy are briefly discussed. A geophysical exploration program is outlined and cost estimates given. Existing information about terrestrial heat flow makes possible a preliminary identification of where geophysical exploration appears to be promising. It is suggested that for electrical power generation a bi-fluid turbine be used. The comparison of thermodynamic requirements with existing data lead us to believe that geothermal energy can be used to generate electricity in Florida. We believe that the results of geophysical exploration, the development of well-drilling technology for exploration and production purposes, and progress in bi-fluid turbine technology of energy have significance in the utilization of geothermal energy in many parts of the world.

11:00 am Room En 305

Business Meeting of the Physical Sciences Section

Hans S. Plendl, Florida State University, Chairman

JOINT MEETING WITH AAPT

11:15 am Room Engineering Auditorium

Hans S. Plendl, Florida State University, Presiding

11:15 am BIG MOLECULES AND ENERGY -- J.C. Slater, Graduate Research Professor of Physics and Chemistry, University of Florida -- Applications of the techniques for handling the electronic structure of big molecules containing heavy atoms to various aspects of the present energy crisis.

MEDICAL SCIENCES SECTION

Friday 8:30 am Room En 306

Ronald H. Jones, Florida Institute of Technology, Presiding

8:30 am MS-1

Studies on axonal neurotubules. R.R. Iannello and G.M. Cohen. Florida Institute of Technology, Melbourne, Florida 32901. Neurotubules are believed to be integrally involved in the process of axoplasmic flow. Agents which disrupt these proteinaceous neurotubules halt axoplasmic flow. Although elasmobranch blood contains urea concentrations high enough at 0.5 M to disaggregate many proteins, their neurotubules are unaffected by this protein denaturant and appear identical in size and structure to those observed in other vertebrate axons. The action of comparable urea levels on amphibians and mammalian neurotubules and osmotic substitutes for urea in elasmobranchs are evaluated.

8:50 am MS-2

Qualitative Maturation of Antibody-Forming Mechanism in Balb Mice. Alice M. Jones and R.J. Porter, Medical Research Institute, FIT, Melbourne, FL; School of Public Health, U of M, Ann Arbor. Antibody response to bovine serum albumin by Balb mice stimulated at numerous points of maturity from birth to 32 weeks of age was studied to determine whether immunocompetency was conferred upon an animal all at once, or whether different portions of the antibody-forming mechanism became competent at different ages. Antibody response was measured by passive hemagglutination, mercaptoethanol sensitivity of the antibody, passive cutaneous anaphylaxis, immunodiffusion, immunoelectrophoresis and density gradient analysis. Results indicated the following stages of response development: 1.) 19S antibody was produced by some mice stimulated as early as 5-7 days of age. 2.) 7S gamma antibody was first detected when mice were 6 weeks old upon first injection. 3.) 7S gamma 2 antibody production required 2 injections of antigen, with the second injection at 11 weeks of age or later. 4.) mice were primable by 2 weeks of age, however, if the second injection was given to mice less than 11 weeks old, only 19S gamma M or 19S and 7S gamma 1 were produced with secondary type kenetics, not 7S gamma 2 type of antibody.

9:10 am MS-3

Antibody Response Mechanisms of Mice Recovering from Neonatally-Induced Immunological Tolerance. Alice M. Jones and R.J. Porter, Medical Research Institute, FIT, Melbourne, FL; School of Public Health, U of M, Ann Arbor, MI. Balb mice made tolerant neonatally to bovine serum albumin (BSA) were challenged at 3 to 32 weeks of age and their antibody responses assayed. Non-challenged tolerant mice were bled biweekly to detect spontaneous antibody production during recovery. Results showed that during recovery from the tolerant state, antibody response mechanisms developed in the same sequence as did those of normal mice from birth to maturity. However, the development in recovering mice was slower and lagged behind that of normal mice by at least 6 weeks. The stages of development were as follows: 1.) Production of 19S gamma M antibody alone; 2.) Primability; 3.) Production of 7S gamma 1 antibody which increased in quantity and duration of production as age of injection increased; 4.) production of 7S gamma 2 upon restimulation; 5.) increasing resistance of the 19S gamma M mechanism to tolerance initiation by "biologically filtered" BSA. Since there was essentially no antibody produced spontaneously, all results were considered to be due to the challenge doses of BSA.

9:30 am MS-4

Morphology and Biophysical Characteristics of Cell Fractions from Leptospira and Treponema Organisms*. R.H. Jones and O.J. Carver, Medical Research Institute, FIT, Melbourne; Sylvania Laboratories, NJ. Leptospira and Treponema organisms are commonly comprised of an inner membrane-wall complex which encases the protoplasmic mieleu, an outer envelope and axial filaments which are positioned between the outer envelope and inner membrane-wall complex. The rigid inner membrane-wall complex contains muramic acid moieties. Species of Leptospira possess two axial filaments each initiating from either end of the cell with their distal ends remaining attached. Most species of Treponema possess no less than three and up to seven axial filaments initiating per cell end. Species of Treponema also contain body fibrils (up to 10) positioned in the inner membrane-wall complex and occur in a packet traversing the entire cell body terminating at each end. One species of Leptospira contains body fibrils (usually 3) but it is not clear if they traverse the entire cell. The morphology of body fibrils and

buoyant density (1.29) of axial fibers from various species of Treponema appear to be identical. The treponemal axial filaments appear to be composed of sub-fibrils helically or longitudinally arranged depending upon the plane of view. Further data on sub-fibril arrangement, axial filament immunochemistry and, axial filament and outer envelope physical purification procedures will be presented.
*Research supported by a grant 1R01 CC--430-01 from Center for Disease Control, PHS, Atlanta, GA

9:50 am MS-5

Effects of Glucose Analogs on Sucrose Utilization in in vitro Plaque Formation by S. mutans. J.J. Thomas & B.J. Thomas, Medical Research Institute, FIT, Melbourne FL 32901. A number of oral bacteria synthesize extracellular water insoluble dextrans from sucrose. These polysaccharides adhere tenaciously to tooth surfaces and aggregate bacteria, thus causing the condition known as dental plaque. Although the dextran-forming enzymes and the chemical nature of the polysaccharides have been studied, little is known of the biosynthetic mechanisms and possible enzyme inhibitors which may interfere with polysaccharide formation. Therefore, twelve (12) glucose analogs were studied for their ability to effect the sucrose conversion to adhesive dextran in vitro. Eight (8) strains of S. mutans (corresponding to the five (5) serologically defined groups of Bratthall and others) were evaluated.

10:10 am COFFEE BREAK En Third Floor Lobby

10:25 am MS-6

The Synthesis and Characterization of a Fluorogenic Substrate of Neuraminidases.* J.J. Thomas,Ph.D., E.C. Folger, B.J. Thomas, & R.H. Jones, Ph.D., Medical Research Institute, FIT, Melbourne, FL 32901. The biological activity of many polysaccharides, glycolipids, glycopeptides, and mixed biopolymers, which perform important biological functions in living cells, is determined by the presence of terminal neuraminic acid (NANA) moieties and is lost as a result of their hydrolysis by neuraminidases which specifically cleave the α-ketoside bonds of neuraminic acid. Neuraminidases have been detected in animal tissues, in pathogenic microorganisms, myxoviruses and in particular, various strains of influenza virus. The most common method currently used to determine neuraminidase activity is tedious and costly. It includes treating the enzymatically liberated NANA with various reagents which produce a chromogen which can be determined spectrophotometrically. We now report the synthesis and properties of a fluorogenic substrate of neuraminidase, 2-0-4-methyl-umbelliferyl-N-acetyl-α-D-neuraminic acid. This substrate allows a rapid and direct determination of neuraminidase activity. ---*Research supported by the Research Corporation of New York

10:45 am MS-7

Model for Study of Viral Etiology of Human Cancer.* J.W. Frankel, Life Sciences Research Laboratories, St. Petersburg, FL 33710. Marek's disease herpesvirus (MDHV) plays a role in the etiology of Marek's disease (MD), a highly contagious lymphoproliferative disease of chickens. MD resembles Burkitt's lymphoma in man with which a herpesvirus is also associated. Avian leukosis virus (ALV), a type-C virus, exerts an influential role in the pathogenesis of MD. Concurrent infection with ALV and MDHV is the only experimental condition in which gross tumorigenesis and mortality occur in specific pathogen free chickens (LSI-SPF). Exposure to both ALV and MDHV results in significantly higher levels of ALV-specific RNA. Electron microscopic studies show viral coexistence after exposure to both viruses. The implication of the findings from this model system to human cancer are discussed.
*Research supported by the Virus Cancer Program of the National Cancer Institute

11:05 am MS-8

Development of a Serum-Free Medium for Tissue Culture. Mary A. Finn and Ronald H. Jones, Medical Research Institute, FIT, Melbourne, Florida 32901.* A medium has been developed enabling the elimination of serum from tissue culture cultivation systems. An Eagle's minimal essential medium (MEM) supplemented with oleic acid and fatty-acid free bovine serum albumin can replace tissue culture media with serum. Lactoalbumin hydrolysate (10%) is initially added to enable adherence of the cells and gradually reduced in concentration until complete elimination is achieved in ten subcultures without deliterions effects to the cultures.
*Work support by grant from The John A. Hartford Foundation.

11:25 am MS-9

Growth of Various Leptospira Serotypes in Four Different Media at 30C and 37C. Mary A. Finn and Ronald H. Jones, Medical Research Institute, FIT, Melbourne, Florida* Peak yields of *Leptospira* serotypes *patoc*, *canicola*, *pomona* and *biflexa* in four different media have been determined. Growth yields (over 10^9 organisms/ml.) at 30C and 37C in a tissue culture-derived medium (Eagle's minimal essential medium (MEM) supplemented with oleic acid, lipid-poor bovine serum albumin, biotin, thiamine, and vitamin B-12) was found to be superior to the conventional leptospiral media of Ellinghausen and Johnson and Harris. Incubation at 37C enables a more efficient utilization of MEM nutrients by *pomona* and *biflexa* than incubation at 30C. A relationship between inoculum level and total incubation time in obtaining peak yields of leptospirae will be discussed.

*Work support by grant from The John A. Hartford Foundation.

11:45 am Room En 306

Business Meeting of the Medical Sciences Section

Ronald H. Jones, Florida Institute of Technology, Chairman

Friday 1:00 pm Room Engineering Auditorium

Annual Business Meeting of the Florida Academy of Sciences

James G. Potter, Florida Institute of Technology, Chairman

Friday 1:30 pm Room Engineering Auditorium

SYMPOSIUM

William H. Taft, University of South Florida, Presiding

1:30 pm FLORIDA'S ESTUARIES-MANAGEMENT OR MISSMANAGEMENT? -- Five major estuaries in Florida, Biscayne, Tampa, Charlotte, Apalachicola and Pensacola will be described in terms of physical, biological and chemical characteristics and their economic value. An attempt will be made to define present problem areas and to project what will happen to the estuary given certain development alternatives.
Speakers: Dr. Martin Roessler, Dr. Joseph Simon, Dr. Jack Taylor, Dr. Robert Livingston and Dr. Thomas Hopkins

7:15 pm Annual Academy Banquet, Ramada Inn East

SCIENCE TEACHING SECTION

Friday 8:30 am Room En 331

H. Edwin Steiner, Jr., University of South Florida, Presiding

8:30 am ST-1 Grassland Ecology - A Semi-inquiry Film. J. L. KOEVENIG, Florida Technological University.--Grassland Ecology: Habitats and Change, a 13 min, 16 mm, color, sound film written and directed by J. L. Koevenig and produced by Centron Educational Films, is shown as an example of a semi-inquiry film. The semi-inquiry utilizes both the expository and inquiry approaches and has been successfully used by elementary school teachers with little background in biology. The proper use of a semi-inquiry film is described.

8:50 am ST-2 The Origin, Filming And Use Of The Semi-inquiry Film Cave Ecology. J. L. KOEVENIG, Florida Technological University.--Cave Ecology, a 13 min, 16 mm, color, sound film written and directed by J. L. Koevenig and produced by Centron Educational Films, is shown as an example of a semi-inquiry film. The origin, filming and use of this film is described to illustrate the interaction between field trips, a private biological research station and a commercial educational film company. Research on the effectiveness of the film in an elementary school is described.

9:10 am ST-3 Why Do You Give A Final? Frank M. Dudley, Dept. of Chem., The Univ. of South Florida. A simple analysis procedure is described for test items for multiple choice type questions in Physical Science. The discussion involves a simple method for determining indices of discrimination and difficulty levels and the interpretation of these indices relevant to the student in physical science. The values for a particular test are submitted and the indices values interpreted for the content covered by the test. The test involves items in Chemistry, Geology, Geo-Chemistry processes, Ecology, and environmental factors affected by these processes. Transparancies are used to illustrate and emphasize the analysis procedure.

9:25 am ST-4 Laboratory Methods For Science Teacher Candidates. H. A. MILLER, J. H. ARMSTRONG, Florida Technological University. --Students enrolled for the science methods course at FTU are provided with formal exposure to science laboratory teaching techniques and technology in a manner consistent with usual practice. In addition, service is required in all aspects of operation of an introductory laboratory under supervision of the faculty member in charge. This provides individual professionally directed "hands on" experience not achieved in conventional courses. The program was initiated and coordinated experimentally within the College of Education (JHA) on request of the Department of Biological Sciences (HAM) because of success in a similar program previously originated by Miller at another university.

9:40 am ST-5 A Strategy For Teaching Physical Geology, Charles J. Mott, Clearwater Campus, St. Petersburg Junior College. A rational and nonpunative approach to teaching physical geology is presented. The strategy is multi-faceted because traditional and innovative information delivery systems are utilized to greatest advantage in developing the learning experience for each student.

9:55 am Room En 331

Business Meeting of the Science Teaching Section

H. Edwin Stiener, Jr., University of South Florida, Chairman

10:10 am COFFEE BREAK En Third Floor Lobby

10:25 am ST-6 Polarization of Simple Quantum-Mechanical Systems in One Dimension DOUGLAS P. STANLEY* and JAY S. BOLEMON, Florida Technological University.--Solutions to the one-dimensional time-independent Schrödinger equation have been computed for asymmetric "stationary" potentials which contain a single particle. These represent polarization of a system of one particle trapped in a symmetric potential well which is perturbed by a second particle; when the polarizing potential arises from another quantum particle, the net potential is found by averaging as in the Hartree and Hartree-Fock methods in atomic physics. These examples are useful as illustrative examples for students in elementary quantum mechanics; they can also be used effectively as student problems to be solved with computer assistance.

*Work completed as Undergraduate Research Project.

10:40 am ST-7 Nuclear Power and the Environment - A Workshop for High School Science Teachers*, E.E. Carroll, M.J. Ohanian, and J.A. Wethington, Jr.--A workshop entitled "Nuclear Power and the Environment" was conducted at the University of Florida in the summer of 1973. Forty-two high school science teachers attended and devoted one week to an intensive study program. The purpose of this workshop was to present timely and factual information about nuclear power generation, its environmental interfaces, and its role in the energy supply-demand situation. The ways in which these objectives were accomplished will be discussed. The dramatic changes in people's attitude towards nuclear power as their knowledge increased will be presented.
*Supported by United States Atomic Energy Commission.

10:55 am ST-8 The Use of Research to Avoid Curriculum Pollution*. C.C. Matthews, Florida State University--This paper will define curriculum pollution and describe one means of avoiding continued pollution of elementary and secondary curricula--especially in the areas of environmental education, career education, and science education.
*Primary research source is CSLS and SSLS Projects at Florida State University, 1968 - Present.

Friday 1:00 pm Room Engineering Auditorium

Annual Business Meeting of the Florida Academy of Sciences

James G. Potter, Florida Institute of Technology, Chairman

Friday 1:30 pm Room Engineering Auditorium

SYMPOSIUM

William H. Taft, University of South Florida, Presiding

1:30 pm FLORIDA'S ESTUARIES-MANAGEMENT OR MISMANAGEMENT? -- Five major estuaries in Florida, Biscayne, Tampa, Charlotte, Apalachicola and Pensacola will be described in terms of physical, biological and chemical characteristics and their economic value. An attempt will be made to define present problem areas and to project what will happen to the estuary given certain development alternatives.
Speakers: Dr. Martin Roessler, Dr. Joseph Simon, Dr. Jack Taylor, Dr. Robert Livingston and Thomas Hopkins

7:15 pm Annual Academy Banquet, Ramada Inn East

SOCIAL SCIENCES SECTION

Friday 8:30 am Room En 318

SUGGESTIBILITY TRAINING

Joseph B. McCawley, President of the Florida Association of Hypnosis, Presiding

Suggestibility Training and Multimodality Encoding to Improve Academic Performance. William Trantham, Florida Keys Community College. This paper will describe the use of suggestibility training and multisensory study methods which substantially improve learning as demonstrated in examination performance by the community college student.

Discussant: Joe B. McCawley

9:45 am COFFEE BREAK En Third Floor Lobby

Friday 10:00 am Room En 318
A 19TH CENTURY ENERGY CRISIS?
Robert J. Rubanowice (Florida State University) presiding

When the Coal Is Gone: Late Nineteenth Century Concerns for Energy. Edward Keuchel, Florida State University. This paper treats the late nineteenth-century concern over reputed shortages of coal as a source of energy. At that time, coal played as central a role in the American economy as petroleum does today. Attention is focused on the public image of the coal crisis, and how this image differed from the actual situation. Comparisons with today's energy crisis are made.

Discussant: Robert J. Rubanowice

11:45 am Room En 318

Business Meeting of the Social Sciences Section

John Evans, Florida Technological University, Chairman

Friday 1:00 pm Room Engineering Auditorium

Annual Business Meeting of the Florida Academy of Sciences

James G. Potter, Florida Institute of Technology, Chairman

Friday 1:30 pm Room Engineering Auditorium

SYMPOSIUM

William H. Taft, University of South Florida, Presiding

1:30 pm FLORIDA'S ESTUARIES-MANAGEMENT OR MISMANAGEMENT? -- Five major estuaries in Florida, Biscayne, Tampa, Charlotte, Apalachicola and Pensacola will be described in terms of physical, biological and chemical characteristics and their economic value. An attempt will be made to define present problem areas and to project what will happen to the estuary given certain development alternatives.
Speakers: Dr. Martin Roessler, Dr. Joseph Simon, Dr. Jack Taylor, Dr. Robert Livingston and Dr. Thomas Hopkins

3:15 pm COFFEE BREAK En Third Floor Lobby

Friday 3:30 pm Room En 318
ENGLAND, CANADA, AND AMERICAN POLITICS
Edmund F. Kallina, Jr. (Florida Technological University) presiding

English Comments on the Treaty of Versailles in the United States Senate, 1919-1920. George C. Osborn, University of Florida. Americans have, in general, been ignorant of the foreign comments on the debate in the United States Senate on the Treaty of Versailles, 1919-1920, and on the subsequent rejection of the Treaty. This paper is an attempt to correct this omission insofar as British opinion is concerned. The research was done in England using only British sources.

The Establishment of Dominion Diplomatic Representation at Washington. Harold A. Wilson, University of Florida. The question of Canada's sending a diplomatic representative to Washington involved both imperial and international considerations. According to traditional cannons of international law and diplomatic practice, Canadians and Americans were not at liberty to deal with one another directly, but only through the British Ambassador at Washington and the American Ambassador at London. Two courses of action were available. The first was to allow continual embarrassment of Canadian problems in connection with the United States and to let Canadian interests suffer as a result. The other was to develop some new approach in international and diplomatic practice to meet with the problem that existed. That the latter alternative was chosen is evidence of the strength of the empire and the vision of its statesmen.

7:15 pm Annual Academy Banquet, Ramada Inn East

Saturday 8:30 am Room En 318
GEOGRAPHY
Presiding individual TBA

Tarpon Springs, Florida--A Study in Cultural Transference. Harry J. Schaleman, Jr. and Dewey M. Stowers, Jr., University of South Florida. Tarpon Springs, Florida, a small community on the Gulf of Mexico, is a Greek enclave that has managed to maintain its cultural identity and heritage despite its peripheral setting on the northern edge of the ever-expanding St. Petersburg-Tampa metropolitan complex. Originally rooted in the sponge industry, Tarpon Springs served as the new American home for experienced sponge divers from the Dodecanese Islands. Church, customs, language, and heritage followed the early twentieth century settlers to their adopted homeland. Climate, vegetation, and economic base provided a familiarity similar to that they had left behind in the Mediterranean. Geography and history combined, therefore, to produce a thriving sponge industry that eventually eclipsed all other such American endeavors and resulted in the establishment of the Tarpon Springs Sponge Exchange, one of the world's largest even today. With the decline in the sponge industry since World War II, the community has continued to prosper and broaden its economic base.

In addition to the above papers, the Florida Bicentennial Commission is holding a meeting at Florida Technological University on March 22 and 23, 1974. Three sessions are scheduled. That on Friday morning will deal with the subject of Loyalism in the Revolution. The Friday afternoon panel will consider the topic of minority groups on the frontier. Finally, the Saturday morning session will present papers on frontier Florida's culture. Further information about specific times and locations of these papers may be obtained by contacting the Department of History, Florida Technological University at 275-2224. Members of the FAS are cordially invited to attend these sessions.

AMERICAN ASSOCIATION OF PHYSICS TEACHERS

Saturday 9:00 am Room En 306

Joseph L. Aubel, University of South Florida, Presiding

9:00 am PT-1 Storage Oscilloscopes in Physics Instruction--A New Slate for Johnny J. S. HUEBNER & J. T. HUMPHRIES, Department of Natural Sciences, University of North Florida.-- Storage oscilloscopes will record and continuously display virtually any single trace that can be projected on an oscilloscope screen. This amounts to having the advantages of a chart recorder in the oscilloscope, and it makes practical several types of lecture demonstrations and laboratory experiments. We have found that these oscilloscopes significantly speed the student's progress in several popular modern physics laboratory experiments[1]. These results will be discussed and several new (and portable) lecture demonstrations using a storage oscilloscope will be presented.

[1] J. S. Huebner & J. T. Humphries, to be published.

9:20 am PT-2 The Use of Competency-Based Instruction for Upper Level and Graduate Students. Edwaed Desloge, Florida State University.

9:50 am PT-3 INTERFERENCE OF LIGHT THROUGH WAVE DIAGRAMS. Frank A. Anderson, The Bolles School. This is a new approach to drawing wave diagrams explaining interference phenomena. A definite set of rules is established for showing change of phase. This presentation is an extension of an article published in The Physics Teacher(Mar., 1973). The level of difficulty is suitable for college as well as high school physics courses. Prepared acetates will be used to show the different uses of the wave diagrams and to explain the set of rules.

10:03 am PT-4 An Acoustics Course for Speech Pathology and Audiology S. C. BLOCH, University of South Florida.-- This paper describes a specialized course in acoustics developed and presented by the Physics Department to meet the needs of students with career goals in speech pathology and audiology. Problems and methods of presenting concepts such as spectral analysis, complex impedance and admittance, and acoustic wave phenomena are discussed. Considerable emphasis is placed on physiologically important aspects of acoustic resonance. The course usually brings students to the level at which they can comprehend many of the research-level articles in their journals, after presentation of typical case studies involving modern instrumentation in audiology and speech science.

10:15 am PT-5 PSLOT--An Observation System for Physics and Chemistry School Laboratories.* M.R.H. MAGUIRE, St. Leo College. -- The construction, results of preliminary field testing, and suggested modifications of the "Physical Science Laboratory Observation Taxonomy--PSLOT" will be described. A grid of behavioral objectives specific to school laboratories, primarily but not exclusively in the physical sciences, culled from the literature by the author, supports the PSLOT. Clusters of overt behaviors of students are organized into ten dimensions which purport to measure the general level of laboratory learning in the observed laboratory. The scoring is done on edited video-taped episodes at two-minute intervals by several independent observers. Field testing consisted in an analysis of the mean scores for each dimension on fourteen-minute episodes by twelve observers, four trained and eight untrained. A total of twenty-eight episodes was used for the field test.

*Unpublished Doctoral Dissertation, Univ. of Florida, 1973.

10:25 am PT-6 A Grid of Behavioral Objectives for Physics and Chemistry School Laboratories.* M.R.H. MAGUIRE, St. Leo College. -- A useful device for generating composite concepts is a two-way grid. This paper will describe a grid of objectives for school laboratories which was developed to support the "Physical Science Laboratory Observation Taxonomy--PSLOT."* Eight subdivisions of three domains, reminiscent of Bloom's and Krsthwohl's taxonomies, are made to intersect with eight subdivisions of the investigative and interpretative aspects of the inquiry process in the laboratory. This generates twenty-eight objectives which are attained either uniquely or most efficiently through laboratory experiences, and which correspond to laboratory objectives for the sciences frequently cited in the literature. A hierarchical classification is thus provided which facilitates clearer definitions. *MAGUIRE, Unpublished Dissertation, Univ. of Florida, 1973.

10:35 am PT-7 The Video Tape Recorder in High School Physics. Frank A. Anderson, The Bolles School, Jacksonville, Florida. This presentation will briefly explain the operation of a video tape recorder in both a 'live' mode as well as with recorded material. In addition to a list of suggested uses, a tape of actual uses will also be shown. Through the use of this machine university research as well as unusual demonstrations may be brought into the high school classroom.

10:48 am PT-8 The Recent Chicago Meeting of AAPT. Stanley S. Ballard, University of Florida. - - As Section Representative for Florida, I attended the 1974 annual meeting of the American Association of Physics Teachers, held jointly with the American Physical Society in Chicago in early February. This brief report features items of special interest to the regional sections, including a meeting of section representatives held on Monday afternoon, February 4, and the AAPT Council meeting on the evening of the 5th.

11:00 am Room En 306

Business Meeting of the American Association of Physics Teachers

Joseph L. Aubel, University of South Florida, Presiding

JOINT MEETING WITH PHYSICAL SCIENCES SECTION

11:15 am Room Engineering Auditorium

Hans S. Plendl, Florida State University, Presiding

11:15 am BIG MOLECULES AND ENERGY -- J.C. Slater, Graduate Research Professor of Physics and Chemistry, University of Florida -- Application of the techniques for handling the electronic structure of big molecules containing heavy atoms to various aspects of the present energy crisis.

AMERICAN SOCIETY FOR MICROBIOLOGY

SOUTH FLORIDA BRANCH

Saturday 9:00 am Room En 110

Foundation for Microbiology Lecture

R.J. Wodzinski, Florida Technological University, Presiding

9:00 am ASM-1 Control Mechanisms and Industrial Fermentations Arnold Demain, Massachusetts Institute of Technology

10:00 a.m. ASM-2 The Metabolic Regulation of Glutamic Dehydrogenase and Aspartic Semialdehyde Dehydrogenase in Escherichia-coli.*G. N. Cunningham and David Foster, Florida Technological University. Unusual similarities in the reduction and repression of aspartic semialdehyde dehydrogenase and glutamic acid dehydrogenase have been observed. Currently attempts are underway to elucidate the relationships of these two enzymes that function in apparently unrelated pathways.

10:15 am COFFEE BREAK En Third Floor Lobby

10:30 a.m. ASM-3 Unscheduled DNA Synthesis In Isolated Rat Myocardial Cells* T.J. LAMPIDIS, G. E. SCHAIBERGER, University of Miami. Upon exposing singly isolated myocardial cells from newborn rats to 450 ERGS/mm^2 of 254 λ ultraviolet light unscheduled DNA synthesis ensues. Under the same conditions, cells isolated from adult rats do not undergo unscheduled DNA synthesis. *Research supported by a National Institute of Health Training Grant.

10:45 am ASM-4 The Fusion of Blood Cells by Treatment with Proteolytic Enzymes and Polyethylene Glycol.* J.X. Hartmann, J.D. Galla, K.N. Kao, O.L. Gamborg, L. Garrish and M. Krutman. Florida Atlantic University and National Research Council of Canada. Blood cells from avian and mammalian sources were treated at 37°C for various time intervals in Alsever's solution containing 0.125% trypsin and 0.25% protease. Upon subsequent treatment with polyethylene glycol (Matheson Coleman Bell 6,000-7,500 M.W.) the cells became tightly apposed. After washing with Hank's balanced salt solution a high frequency (80-90%) of fusion was observed and the cells remained viable. The mechanism of fusion by this method will be discussed.* Supported by National Res. Council of Canada and Florida Atlantic University Grants.

11:00 am ASM-5 Method For The Production Of Specific FITC Labelled Globulins To Dirofilaria immitis Microfilaria. D. F. Qualls; P. J. Neuhaus; M. J. Sweeney; Florida Technological University.

11:15 am ASM-6 Extension of the host range of channel catfish virus (CCV) to the walking catfish Clarias batrachus (Linnaeus). J.D. GALLA, J.X. HARTMANN, Florida Atlantic University.--Specimens of walking catfish (*Clarias batrachus*, Linnaeus) were injected either intraperitoneally or intramuscularly with 0.1 ml of CCV produced in brown bullhead (*Ictalurus nebulosus*, LeSuer) cell cultures. All virus infected fish except one died within five days of injection while all control fish (injection with sterile cell culture medium) survived. Injection experiments were conducted in triplicate, all yielding similar results. Control fish placed in the same aquaria as infected fish did not exhibit symptoms of disease nor did the resistant fish after multiple injections of CCV.

11:30 am ASM-7 The Bacteriology of Lake Restoration* T.L. Stoddart, Orange County Pollution Control Department, Orlando, Florida

This paper outlines the results of bacteriological monitoring performed during restoration of Lake Eola. The influence of precipitation is also discussed. * This research has been supported by the Orange County Pollution Control Department.

11:45 am Room En 110

Business Session of the ASM South Florida Branch

George E. Schaiberger, University of Miami, Chairman

SOCIETY OF PHYSICS STUDENTS

Saturday 8:30 - 11:15 Room En 333

Randy Smith, Florida Technological University, Presiding

SPS-1 The Laser. Peter Wasilousky and Glenn Lippman, Florida Institute of Technology. -- Our topics of discussion will involve recent laser developments, an introduction to the basic operation of different kinds of lasers and some applications, as well as an introduction to present laser research. We will also examine laser potential with regards to induced thermonuclear fusion. Applications in materials processing and physical research will be discussed.

SPS-2 The Boltzmann Transport Equation. Randy Smith, Florida Technological University. -- Introduction to the Boltzmann transport equation and background material for the paper on thermal transport of ideal gases to be given at the F.A.S. meeting.

SPS-3 Astronomy. Karen Presley and Mike Parker, Florida Technological University. A report will presented on the weekly skywatch activities held for the student body by the S.P.S. members.

SPS-4 Bose-Einstein Statistics. Michael Hyde, Florida Institute of Technology. -- Introduction to phase spaces, micro- and macro-states, thermodynamic probability, and the Bose-Einstein distribution function. Applications to ideal gases and paramagnetism will be presented.

SPS-5 Fermi-Dirac Statistics. Michael Hyde, Florida Institute of Technology. -- Introduction to partition functions and the Fermi-Dirac distribution function. Applications to specific heats and thermionic emission will be ptesented

11:15 am Room Engineering Auditorium
Special Lecture -- Big Molecules and Energy. J.C. Slater, Graduate Research Professor of Physics and Chemistry, University of Florida. -- Applications of the techniques for handling the electronic structure of big molecules containing heavy atoms to various aspects of the present energy crisis.

1:00 pm Picnic

FLORIDA JUNIOR ACADEMY OF SCIENCE

Thirty Fifth Annual Meeting

Thursday, March 21, 1974

1:00 pm Room Engineering Auditorium

Presentation of Senior High Experimental Papers
Jerry Mullersman, Gainesville High School, Presiding

JAS-1 Total Growth and Protein Synthesis during Electrical and Mesodermal Stimulation of Mouse Appendage Explant Cultures Simulating Regeneration. Margaret Ann West, Rockledge High School

JAS-2 The n-Alkane Distribution in the Cuticle Wax of Various Ferns Native to Florida and North Carolina. John Denninghoff, Merritt Island High School.

JAS-3 The Effects of Modification of Clinical Dextran on the Agglutination of Streptococcus Mutan Cells. Carmen Maria Lauda, Hialeah High School.

JAS-4 Preparation and Properties of Metal Silicides. Mikell Seely, Northeast High School, Clearwater.

JAS-5 The Refined Period of Eclipsing Binary Star, Er Scuti. Clare Yu, Gainesville High School.

JAS-6 Detection and Dissociation of Immune Complexes Using I-25 Goat Anti (Human IgG) Fab' Fragments. Bonnie L. Bates, Gainesville High School.

JAS-7 Simplification of the Cold Phenol Extraction Procedures for RNA from Sea Urchin Eggs. Shonnie Gramly, Cocoa High School.

JAS-8 Programming a Computer to solve a 3-Dimensional Puzzle. Terry Wilkinson, Forest High School, West Palm Beach.

Alternates:

A-1 Microbiological Aspects of Experimental Composting. Sandra Simmons, Forest Hill High School, West Palm Beach.

A-2 The Effect of Solar Wind Velocity on the Decametric Radiation from Jupiter. John D. Malloy, Chipley High School.

Thursday, March 21, 1974

1:00 pm Room Engineering 360
Presentation of the Junior High Experimental Papers
Chris Willson, Merritt Island High School, Presiding

JAS-1 Determining the Degree of Phosphate Pollution in South Brevard Waterways
L. Maurice Holloman, Stone Middle School

JAS-2 Circadian Cycles and Reversal of Photoperiods in *Calendula officinalis* and *V. Tricolor hortensis*. Jeannette Norton, Rockledge High School

JAS-3 Measuring the Degree of Nitrate Water Pollution in South Brevard Waterways. Steven Boscovich, Stone Middle School.

JAS-4 Lightning and Lightning Sensing Devices. Daniel Wegerif, Edgewood Junior High School

JAS-5 The Washability of Polyester Fabrics Using Common Washing Products. Alice Senne, Stone Middle School

JAS-6 An Analysis of *Escherichia coli, Serratia marcescens,* and *Bacillus megatarium* in Relation to Bacterial Mutations. Tara F. Pesek, Kennedy Middle School

JAS-7 An Analysis of Detergent Pollution in South Brevard Waterways. Elaine A. Wensinger, Stone Middle School

JAS-8 A Study of Cell Proliferation of Hydra Using Autoradiography. Leonard McMillan, Jr., Stone Middle School

Alternates:

A-1 The Effects of Malathion, Diazinon, Chlordane, and Lindane on *Enchytraeus, Spirobolidae,* and *Lumbricus terrestis* as Related to Environmental Factors. Douglas Rowles, Kennedy Middle School

A-2 Reducing the Takeoff Stroke of a Jet Aircraft by Means of a Catapult Device. David Dambro, Stone Middle School

4:30 - 5:00 pm Planning Session (Students) Auditorium

5:00 - 5:30 pm College Representatives available to Student Inquiry regarding their School Programs.

Friday, March 22, 1974

9:00 am Room Engineering 360
Presentation of the Junior High Literary Papers
Chris Willson, Merritt Island High School, Presiding

JAS-1 Immunotherapy of Cancer: Auto and Heterovaccine Malignant Extracts from Mouse Induced Sarcomas. Gregory Miller, Rockledge High School

JAS-2 Pulsars: The Discovery. Douglas Rosinski, Edgewood Junior High School

JAS-3 Transmission of Navigational Information Utilizing Infrared Frequencies. Richard H. Mason, Jr., Cocoa High School.

JAS-4 Location of the Retinal Generator Potential Origin and Rhodopsin in the Limulus Lateral Eye. Rosalind Rafanelli, Rockledge High School.

JAS-5 The Role of the Neuron in the Regeneration and Maintenance of an End Organ. Bruce J. Meraviglia, Edgewood Junior High School.

JAS-6 The Electron Communication System. Michael Halem, Cocoa High School.

JAS-7 An Evaluation of the Effects of Malathion and Diazinon on the *Hycrilla verticillata*. Laura Dawson, Rockledge High School.

JAS-8 Simulation of Red Tide. Jon Stilley, Edgewood Junior High School.

Alternates:

A-1 Noise: Hearing It More and Enjoying It Less. Cathy Colfax, Edgewood Junior High School.

A-2 Extracting and Analyzing Effluents from Dried Citrus Pulp. Christopher M. Lohse, Cocoa High School.

Friday, March 22, 1974

9:00 am Room Engineering Auditorium
Presentation of the Senior High Literary Papers
Jerry Mullersman, Gainsville High School, Presiding

JAS-1 A Detailed Study of the Ecology of Mangroves in Florida. Lynn Vega, Naples High School.

JAS-2 Investigating Possibilities of Finding a Nonpathogenic Competitor for *Staphylococcus albus*. Nancy Sweigart, Merritt Island High School.

JAS-3 Acoustical Holography. Michael T. Dyer, Cocoa High School.

JAS-4 The Effect of Methyl Mercury and Related Compounds Upon Human Physiology. Timothy R. Sine, Naples High School.

JAS-5 A Study of Hypoglycemia. Mary Pelzer, Merritt Island High School.

JAS-6 The Infection Process of the *Rhizobium*-Legume Relationship: A Basis for Increased Symbiotic Activity. Lorraine Pillus, Cocoa High School.

JAS-7 New Techniques in Burn Treatment. Kathy Mitchell, Naples High School.

JAS-8 The Effects of Weightlessness on the Human Cardiovascular System. Jerry Bridgham, Cocoa High School.

Alternates:

A-1 Acupuncture. Fred Moulton, Naples High School.

A-2 Epilepsy. Jan Lynne Dromisky, Gainsville High School.

1:30 - 3:30 pm Symposium: Florida Estuaries: Management and Mismanagement
3:30 pm Sponsor's Meeting
4:15 pm Business Meeting - Students

7:00 pm Awards Banquet - Sweden House.

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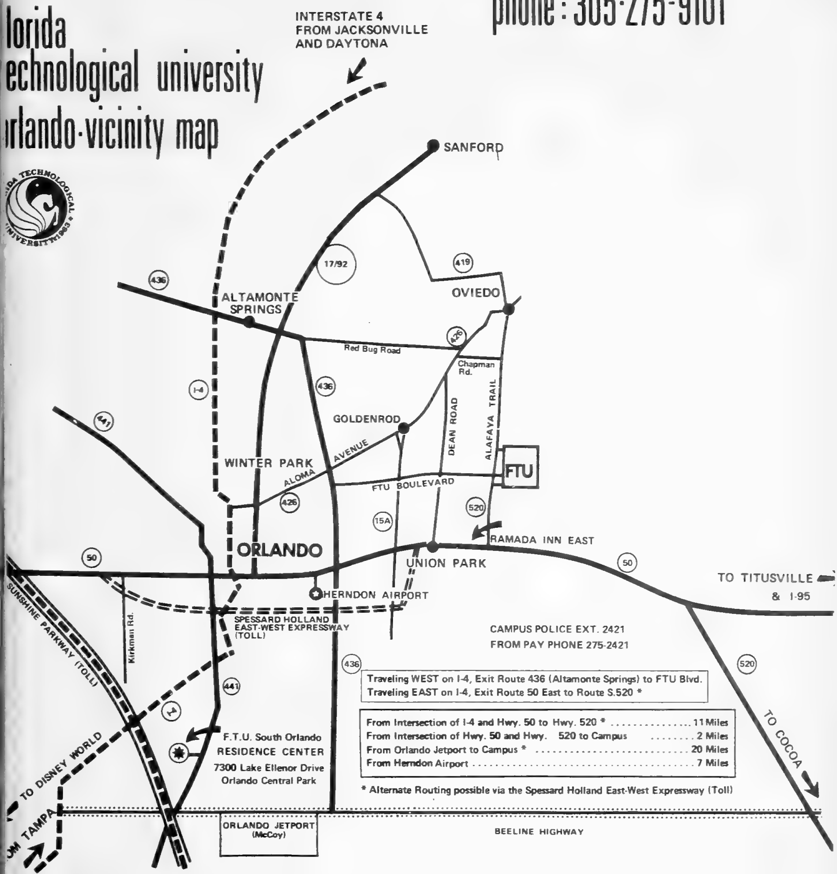

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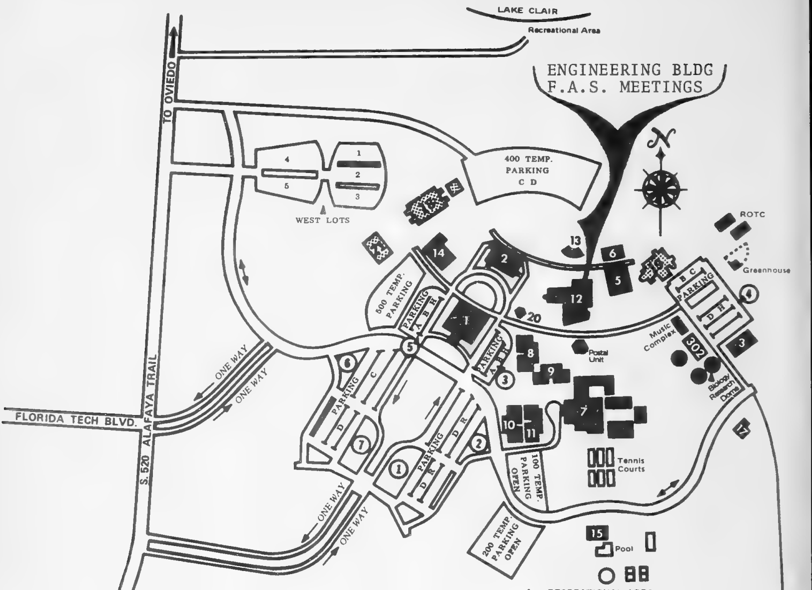

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1	ADMINISTRATION	12	ENGINEERING
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3	UTILITY PLANT	14	CLASSROOM BUILDING
4	SEWAGE PLANT	15	PHYSICAL EDUCATION BLDG.
5	SCIENCE BUILDING	16	PHYSICAL PLANT SHOPS
6	SCIENCE AUDITORIUM	17	UNIVERSITY POLICE DEPT.
7	VILLAGE CENTER	18	HUM. & FINE ARTS COMPLEX
8	RESIDENCE B	19	BIOLOGICAL SCIENCES BLDG.
9	RESIDENCE A	20	KIOSK
10	RESIDENCE D	21	EDUCATION BUILDING
11	RESIDENCE C	302	ART COMPLEX

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Dr. Harvey A. Miller, Editor
Department of Biological Sciences
Florida Technological University
Orlando, Florida 32816

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