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Biological Sciences

BENTHIC ALGAE OF THE ANCLOTE ESTUARY II. BOTTOM-DWELLING SPECIES

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ABSTRACT: *Some 122 species and 4 varieties of benthic algae are reported from one or more of 10 different substrata, excluding seagrass leaves, or in the drift in the Anclote estuary near Tarpon Springs, Florida Gulf coast.*

A THREE-YEAR study of the benthic algae of the Anclote River estuary, including Anclote Anchorage, was completed in 1974. The first part of the study dealt with those benthic algae that occur as epiphytes of seagrass leaves (Ballantine and Humm, 1975). All other benthic algae of the area comprise this concluding report.

The Anclote estuary is part of the Gulf of Mexico on the north side of Tarpon Springs, Florida. For a period of 4 yr, 1970-74, this general area was intensively studied to provide an accurate base-line description of the environment prior to construction and operation of a power plant (Humm et al., 1971; Baird et al., 1972, 1973, 1974). Power generation was initiated in October, 1974.

ENVIRONMENT—Because a detailed description of the Anclote estuary was given by Ballantine and Humm (1975), only a summary is presented. Bottom salinity generally ranged from 23 to 35 $^{\circ}/_{oo}$ with greater stability in Anclote Anchorage than in the lower part of the river. Salinities below 25 $^{\circ}/_{oo}$ were brief. Water temperature ranged 11—31°C. Natural depths range to about 2 m and light penetration is such that at least some algae can grow at the maximum depth (except in dredged channels). Nutrients were similar to levels of inshore waters of the Gulf of Mexico, but in the lower Anclote River were somewhat higher and more variable than in Anclote Anchorage (Baird et al., 1973).

PROCEDURES—In an effort to include all major habitat types in this study, periodic collections and observations were made in 11 categories as follows: (1) unconsolidated sediments; (2) scattered shells, (3) limestone rock; (4) oyster bars;

(5) mangrove aerial roots; (6) pilings, seawalls, and other submerged structures; (7) basal part of stems of the salt marsh grass, *Spartina*; (8) intertidal mud and sand; experimental substrates in the form of (9) concrete blocks and (10) plastic strips; and (11) drift algae. The 28 collection stations that included one to several of these categories were established throughout the estuary as shown in fig. 1.

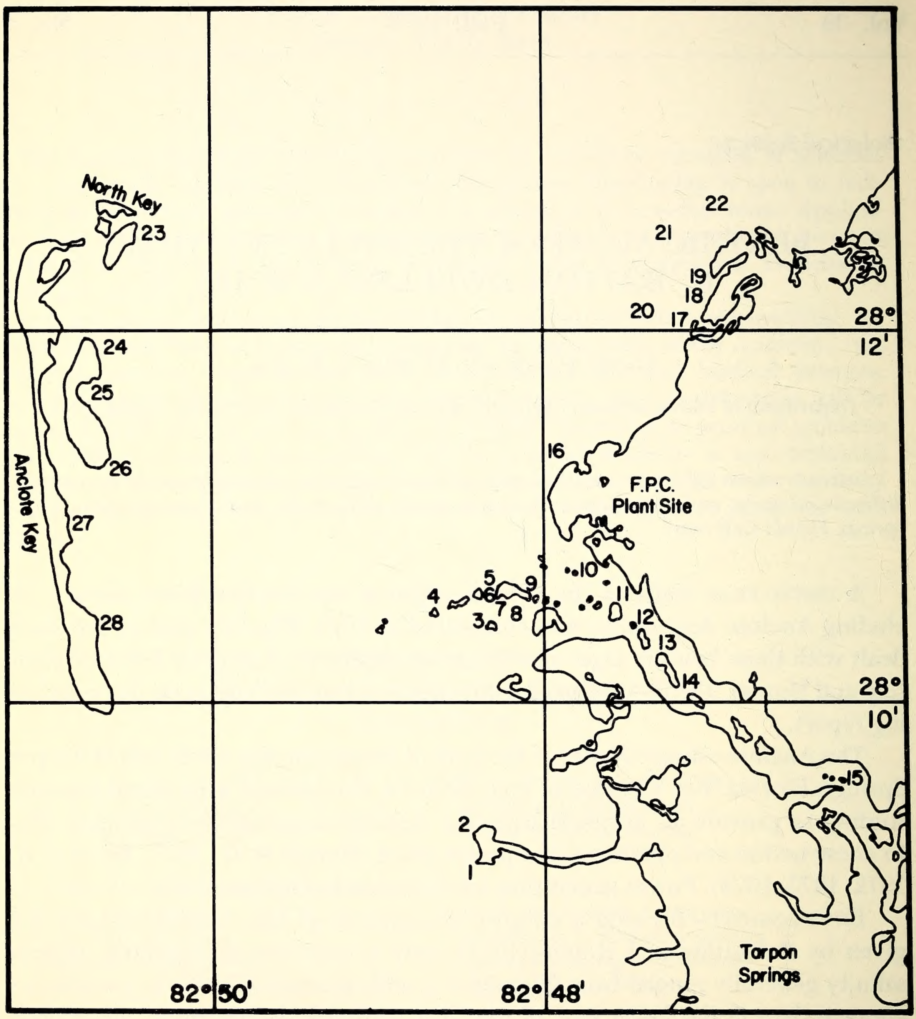

Fig. 1. Map of Anclote estuary showing location of the 28 stations at which field studies and collections were made and of the town of Tarpon Springs.

Stations 5, 6, 7, and 8 were located around an unnamed island just outside the Anclote River mouth on the south side of the channel. This island is referred to as Casuarina Key in the text in allusion to the dense stand of Australian pines, *Casuarina equisetifolia*, growing upon it.

Following is a brief characterization of the collecting stations: Stations 1 and 2: rock jetties exposed to wave action at Howard Park. Station 3: Bird Key with intertidal *Spartina* that is relatively exposed. Station 4: chain of five small spoil islands just west of Casuarina Key with mangroves and exposed limestone rocks. Stations 5-8: Around Casuarina Key with red and black mangroves, intertidal sand beaches, oyster shell ridges, and several subtidal bottom types. Station 9: small mangrove island east of Casuarina Key. Station 10: old spoil island with collapsed house, dock, pilings, old oyster shells and chunks of limestone. Station 11: Dead Fish Pass on the north side of the Anclote River near the power plant intake with *Spartina* and scattered shells. Station 12: intertidal shell-strewn beach on the north side of the Anclote River. Station 13: Paul's Fish Camp with seawall, boat ramp, docks, pilings, oyster bars and intertidal mud and muddy sand. Station 14: mangrove island opposite Paul's Fish Camp in protected area with mangroves encrusted with barnacles and oysters. Station 15: base of seawall on north side of the Anclote River near highway bridge, the lowest salinity station. Station 16: narrow, shallow inlet at Anclote Point fringed with mangroves and saltmarshes and protected from wave action. Station 17: an oyster bar perpendicular to the shore and intertidal off Bailey's Bluff. Stations 17-22: off Bailey's Bluff including an oyster bar that is intertidal and perpendicular to the shore (17), a *Spartina*-covered island (18), intertidal limestone outcropping (19), and seagrass beds with scattered shells at depths of 1-2 m (20-22). Stations 23-28: along the estuary side of the chain of keys constituting the outer (western) boundary of Anclote Anchorage having a mangrove fringe, scattered shells, and adjacent seagrass beds.

Field work was normally conducted during periods of low tide.

Voucher specimens have been deposited in the herbarium of the Department of Marine Science, University of South Florida St. Petersburg Campus.

ANNOTATED LIST OF SPECIES

The 126 taxa of benthic algae identified were distributed among the major groups as follows: Cyanophyta 18, Rhodophyta 50, Phaeophyta 17, Xanthophyta 2, Chlorophyta 39. The monographs of Drouet (1968, 1973) and of Drouet and Daily (1956) were followed in treatment of the Cyanophyta. A key to identification of nearly all species in the following list is to be found in Dawes, 1974.

CYANOPHYTA

Order Coccogonales

Family Chroococcaceae

Agmenellum quadruplicatum Brebisson. In upper intertidal muddy sand at sta. 16, where quite abundant (Humm and Hamm, 1976).

Agmenellum thermale (Kützing) Drouet and Daily. Common in intertidal sand and muddy sand as at sta. 16, and colonizing plastic strips put out at sta. 5. Yr around, principally intertidal.

Anacystis aeruginosa Drouet and Daily. Evidently the most abundant coccoid blue-green in the estuary; common on mangrove roots at sta. 16, on concrete blocks at sta. 5 and 17, on plastic strips at sta. 5, 8, and 10, on scattered shells at sta. 20-22, and on intertidal sediments in many other places. Yr around.

Anacystis dimidiata Drouet and Daily. In intertidal sand at sta. 3. Though rarely encountered because it occurs as solitary cells, pairs, or as groups of four, it is probably common and widely distributed.

Anacystis marina Drouet and Daily. From upper intertidal sand at sta. 16 only. Probably common but it is microscopic and difficult to find.

Johannesbaptista pellucida Taylor and Drouet. Occasional in the upper intertidal zone of salt marshes or protected beaches.

Family Chamaesiphonaceae

Entophysalis conferta (Kützing) Drouet and Daily. At all sta.

Entophysalis deusta (Meneghini) Drouet and Daily. Upon and penetrating shells and other forms of limestone at all sta. with this substrate yr around.

Order Hormogonales

Family Oscillatoriaceae

Microcoleus lyngbyaceus (Kützing) Crouan. One of the most abundant of bluegreens in its many forms (as interpreted by Drouet, 1968) producing intertidal mats, as an epiphyte, and in the form of massive skeins during summer on seagrasses, especially in the warm water effluent of the power plant. Found on all substrates.

Porphyrosiphon notarisii (Meneghini) Kützing. On aerial roots of black mangroves at sta. 11 only, September, 1973.

Schizothrix arenaria (Berkeley) Gomont. Common in the intertidal zone of protected beaches or mangrove areas where it formed a mat that contributed to sand stabilization at most stations the yr around.

Schizothrix calcicola (C. Agardh) Gomont. At all sta and on all substrates the yr around as an epiphyte, mixed with bluegreen mats, and boring into limestone and shells.

Schizothrix mexicana Gomont. On a cement block, sta. 17, September, 1973, and epiphytic on drifting algae, December, 1972, in the form referred to as *Lyngbya gracilis* Meneghini in the older literature.

Spirulina subsalsa Oersted. In upper intertidal sand of protected beaches the yr around at many sta.

Family Nostocaceae

Nodularia harveyana (Thwaites) Thuret. In the entire range of the intertidal zone on moist sand or muddy sand at many sta. the yr around.

Family Rivulariaceae

Calothrix crustacea (Roth) C. Agardh. Common at all sta. as an epiphyte or forming a characteristic black band high in the intertidal zone on pilings, seawalls, mangrove roots, and other substrates the yr around.

Family Scytonemataceae

Scytonema hofmanni C. Agardh. On and among pneumatophores of black mangroves in mat form at station 18, November, 1972, but not abundant.

Family Stigonemataceae

Mastigocoleus testarum Lagerheim. Common, boring into limestone at nearly all sta. the yr around, but also found penetrating red mangrove prop roots at sta. 27 and 28 where mixed with *Schizothrix calcicola*.

RHODOPHYTA

Order Bangiales

Family Bangiaceae

Erythrotrichia carnea (Dillwyn) J. Agardh. A microscopic epiphyte on larger algae at all sta. the yr around.

Erythrocladia subintegra Rosenvinge. These microscopic disk-form plants were encountered as epiphytes on larger algae in the drift in December, 1972, and in the drift and from concrete blocks in January, 1973.

Goniotrichum alsidii (Zanardini) Howe. Epiphytic on larger algae and bryozoa at sta. 17, and on plastic strips put out at sta. 5 and 10 during winter and spring.

Order Nemaliales

Family Acrochaetiaceae

Achrochaetium sagraeanum (Montagne) Bornet. Occasional as an epiphyte on larger algae during winter at sta. 17. Tetraspores were observed in January, 1973, monosporangia in December, 1972. Distribution of this species is discussed by Humm and Hamm (1976).

Acrochaetium sargassi Bϕrgesen. An epiphyte of larger algae in the drift during winter.

Acrochaetium thuretii (Bornet) Collins and Hervey. A few plants found in January, 1973, as epiphytes on larger algae growing on a cement block that had been placed at sta. 5 in December, 1972.

Order Cryptonemiales

Family Corallinaceae

Fosliella atlantica (Foslie) Taylor. On algae in the drift and on plastic strips put out at sta. 3, 5-10.

Fosliella farinosa (Lamouroux) Howe. Epiphytic on algae in the drift the yr around. Variety *solmsiana* (Falkenberg) Taylor was seen occasionally.

Jania adherens Lamouroux. In several areas of Anclote Anchorage extensive beds of this species to 50 m sq occurred as loose masses or attached in part over seagrass beds, apparently inhibiting the seagrasses. It was also an epiphyte on other algae attached to concrete blocks put out at sta. 5.

Jania capillacea Harvey. On *Sargassum* and *Laurencia* in the drift during winter.

Family Grateloupiaceae

Halymenia floresia (Clemente) C. Agardh. Occasional in the drift, April, 1974.

Order Gigartinales

Family Gracilariaceae

Gracilaria foliifera (Forsskal) Bϕrgesen. Although abundant in Tampa Bay, this species is rare in Anclote estuary, even in the drifting algae. Several small plants were found attached to a beer can at sta. 13 in November, 1973.

Gracilaria verrucosa (Hudson) Papenfuss. Occasional in the drift.

Family Solieriaceae

Soliera tenera (J. Agardh) Wynne and Taylor. Though apparently absent from the Anclote estuary during 1972 and most of 1973, this species was found in the drift and attached to shells during the winter of 1973. A heavy stand developed on the rock breakwater at Howard Park near sta. 2 at the same time.

Family Hypneaceae

Hypnea musciformis (Wulfen) Lamouroux. Occasional in the drift, and a few attached plants were found on a beer can near sta. 13 in November, 1973. Like the two species of *Gracilaria* and *Soliera*, this species is abundant in Tampa Bay but only occasional in Anclote estuary for reasons not understood.

Hypnea spinella (C. Agardh) Kützing. A single plant attached to a beer can was found at sta. 13 in November, 1973, and it was occasional in the drift.

Order Ceramiales

Family Ceramiaceae

Callithamnion byssoides Arnott, On large algae in the drift, March, 1974.

Ceramium byssoideum Harvey. One of the most common epiphytes on larger algae below low tide at most sta. the yr around and also on non-living substrates. Variety *alternans* Ballantine and Humm was less common.

Ceramium corniculatum Montagne. A single record in November, 1972, at sta. 13 on the floating dock at Paul's Fish Camp.

Ceramium fastigiatum (Roth) Harvey. Common on a variety of solid substrates at most sta., especially during the cooler months.

Spyridia filamentosa (Wulfen) Harvey. One of the most abundant of the red algae in Anclote estuary, especially during the cooler months when it formed dense, drifting layers over the seagrass beds in shallow water.

Centroceras clavulatum (C. Agardh) Montagne. Common on solid substrates in the lower intertidal zone and below at most sta. the yr around. The best development occurred on the jetties at Howard Park at sta. 1 and 2.

Family Delesseriaceae

Caloglossa leprieurii (Montagne) J. Agardh. Abundant on red and black mangrove aerial roots throughout the estuary the yr around.

Family Dasyaceae

Dasya pedicellata (C. Agardh) C. Agardh. Occasional in the drift during winter and spring; not found attached.

Family Rhodomelaceae

Acanthophora spicifera (Vahl) Bϕrgesen. Common as a constituent of the drift algae, especially in late fall; on concrete blocks at sta. 10, November, 1973.

Bostrichia moritziana (Sonder) J. Agardh. The predominant *Bostrichia* on mangrove roots at sta. 14, spring, 1973, but by January, 1974, it had been replaced almost entirely by *B. radicans*. In general, *B. moritziana* occurred in the more protected areas such as sta. 23 and 24, but was not abundant.

Bostrichia radicans Montagne. The second most abundant species in the Anclote estuary, especially on the pneumatophores of black mangroves. It was often mixed with *B. scorpioides*. About half the plants of *B. radicans* were the form previously known as *B. rivularis* Harvey, the latter occasional around the base of the stems of *Spartina* also.

In well-protected mangrove areas *B. radicans forma moniliforme* Post was present, often as much as 25% of the forms of *B. radicans* present. It bore monosiphonous branch tips 15-20 cells long.

Bostrichia scorpioides (Gmelin) Montagne, var. *montagnei* Harvey. This yr around species was the most abundant alga on mangrove aerial roots in Anclote estuary. The plants grew to 6 cm tall in dense tufts or mats.

Bostrichia tenella (Vahl) J. Agardh. The least common species of *Bostrichia*, this plant was occasional at sta. 7, 8, and 9 where it was yr around. Well-developed reproductive plants were found.

Chondria baileyana (Montagne) Harvey. A species restricted to winter and spring in this area and found only once in the drift algae in January.

Chondria collinsiana Howe. Several plants were found attached to concrete blocks at sta. 5 in March. The blocks were placed there in December.

Chondria leptacremon (Melvill) De Toni. A few plants found in the drift in January, 1973.

Chondria littoralis Harvey. Common in the drift during winter and spring. In March, 1974, many plants were present on the limestone outcropping off Bailey's Bluff, sta. 19.

Chondria tenuissima (Goodenough and Woodward) C. Agardh. Occasional on shells of living scallops during the fall and winter of 1973.

Digenia simplex (Wulfen) C. Agardh. Common throughout Anclote Anchorage the yr around, and at times made up as much as 5% of the drift algae. Attached plants were mostly on shells in seagrass beds.

Herposiphonia secunda (C. Agardh) Ambronn. Around the base of aerial roots of black mangroves at sta. 7 and 8, and on concrete blocks placed at sta. 17.

Herposiphonia tenella (C. Agardh) Ambronn. More widely distributed in the estuary than the preceding species (or form), and present in abundance the yr around on oyster bars, limestone, pilings, and on larger algae at many stations.

Laurencia intricata Lamouroux. Occasional in the drift during winter and spring.

Laurencia obtusa (Hudson) Lamouroux. Abundant on the rock jetties at Howard Park, Sta. 1 and 2, during winter and spring 1973-74, but not found at these sta. the year before. One of the two most abundant members of the drift algae, often making up over 50%.

Laurencia poitei (Lamouroux) Howe. Although common on seagrasses, this species was not found on other substrates. During the cooler months, however, it often made up 35 to 45% by wt of the drift algae.

Lophosiphonia cristata Falkenberg. Found at sta. 16 in March, 1973, attached to a log in the intertidal zone.

Lophosiphonia saccorhiza Collins and Hervey. Around the base of *Spartina* stems at sta. 3, on scattered shells at sta. 20-22, and on concrete blocks placed at sta. 5. Yr around in the lower intertidal zone and below. The rhizoids vary in size and shape with substrate.

Murrayella periclados (C. Agardh) Schmitz. Occasional around the base of mangrove roots and extending outward into the intertidal algal mat at sta. 7 and 8 the yr around.

Polysiphonia hemisphaerica Areschoug, var. *boldii* (Wynne and Edwards) Rueness. Occasional on solid substrates and also in the drift. This species until recently has been referred to *P. denudata* (Dillwyn) Kutzing. Wynne and Edwards (1970) described it as *P. boldii*. Rueness (1973), after culture and hybridization studies, decided that it was a variety of *P. hemisphaerica*; *P. denudata* apparently does not occur south of South Carolina.

Polysiphonia echinata Harvey. Common in the drift from November to April, but not found attached in Anclote estuary.

Polysiphonia subtilissima Montagne. Yr around at many sta. this is the most euryhaline species of *Polysiphonia* in Florida.

Polysiphonia havanensis Montagne. A few plants were found on the shells of living scallops at sta. 20-22 in September, 1973.

PHAEOPHYTA

Order Ectocarpales

Family Ectocarpaceae

Bachelotia antillarum (Grunow) Gerloff. On shells and other solid substrates, including plastic strips placed at sta. 10, November to April. It has been collected in the summer in Tampa Bay, however.

Ectocarpus elachisteaeformis Heydrich. On a colonial bryozoan, *Zoobotryon verticillatum*, that was loose and drifting, December, 1972.

Ectocarpus intermedius Kützing. On solid substrates from low intertidal and below, November to April, and also in the drift. This species has been known as *E. confervoides* (Roth) LeJolis. Earle (1969) pointed out that *Ceramium confervoides* Roth, upon which *E. confervoides* is based, is a *nominum superfluum*.

Ectocarpus siliculosus (Dillwyn) Lyngbye. On solid substrates low in the intertidal zone and below, February to April. Not reported south of Tampa Bay or south of Cape Canaveral on the Atlantic coast.

Giffordia conifera (Bϕrgesen) Taylor. Occasional on solid surfaces in fall and early winter. For several weeks in the fall of 1973 it was the most common alga on concrete blocks placed at sta. 10. This area is its northern known limit in the Gulf of Mexico (Earle 1969, 1972).

Giffordia mitchelliae (Harvey) Hamel. The most abundant of the brown algae. Present the yr around but best developed from September to May at most sta. on all types of solid substrates.

Giffordia rallsiae (Vickers) Taylor. Occasional during the cooler months as small plants less than 5 mm tall on a variety of solid surfaces.

Order Sphacelariales

Family Sphacelariaceae

Sphacelaria furcigera Kützing. Occasional during the cooler months as an epiphyte or around the base of larger algae, or on stones, shells, and woodwork at many sta.

Order Dictyotales

Family Dictyotaceae

Dictyota dichotoma (Hudson) Lamouroux. One plant was found in the drift in March, 1974, and it was abundant on the rock jetties at Howard Park, sta. 1 and 2, during the summer of 1975.

Order Chordariales

Family Chordariaceae

Cladosiphon occidentalis Kylin. Common in the drift from January through May; apparently plants that were originally epiphytic on seagrass leaves. It colonized plastic strips at sta. 5 and 10 in February and March, 1974, but was not found on any other nonliving substrate. The strips had been put out in February, 1973.

Order Punctariales

Family Striariaceae

Myriotrichia subcorymbosa (Holden Blomquist. Common the yr around on shoal grass, *Diplanthera wrightii*, and to some extent on other seagrasses, but also found on oyster shells at sta. 13, and on concrete blocks and plastic strips at sta. 5, 7, 8, and 10 during winter and spring.

Stictyosiphon subsimplex Holden. Previously reported (Ballantine and Humm, 1975) on seagrass leaves from November to May; recorded here on plastic strips and concrete blocks at sta. 5, 7, 8, and 10 from January to April. Apparently this species and *Myriotrichia subcorymbosa* have not been reported previously from non-living substrates. Fiore (1970) has shown by culture studies that *M. subcorymbosa* is the gametophyte and *S. subsimplex* the sporophyte of the same plant, but he has not yet published his proposed change of name.

Order Fucales

Family Sargassaceae

Sargassum filipendula C. Agardh. This most eurythermal species of the genus was found the yr around in the drift, but not attached. During winter and spring, when most common, it made up about 5% of the drift by wt.

Sargassum hystrix J. Agardh, var. *buxifolium* Chauvin. Several large plants were found in the drift in September, 1973.

Sargassum pteropleuron Grunow. Occasional in the drift the yr around but more common during winter and spring.

Sargassum natans (L.) Gaillon. See *S. fluitans*.

Sargassum fluitans Bφrgesen. These two pelagic species are occasional in Anclote Anchorage. They are blown in by prolonged westerly winds during the warmer months of the yr when the Gulf loop current is active.

CHLOROPHYTA

Order Ulotrichales

Family Chaetophoraceae

Phaeophila dendroides (Crouan) Batters. Recorded as an epiphyte on black mangrove aerial roots low in the intertidal zone at sta. 5 and 6, March, 1973. It is probably common but overlooked because of its microscopic size.

Entocladia viridis Reinke. On *Laurencia poitei* in the drift in March, 1973, but probably widely distributed in the Anclote estuary.

Ulvella lens Crouan. On larger algae in the drift, winter and spring.

Family Chaetopeltidaceae

Diplochaete solitaria Collins. Found once as an epiphyte on drifting algae in December, 1972. Easily overlooked as it is one-celled.

Family Ulvaceae

Enteromorpha chaetomorphoides Bφrgesen. Entangled in other algae on the floating dock at Paul's Fish Camp, sta. 13, November, 1972. This species is apparently a tropical *Enteromorpha*.

Enteromorpha clathrata (Roth) J. Agardh. One of the most common and conspicuous of the green algae on a variety of substrates at many sta. the yr around, but best developed during winter and spring.

Enteromorpha compressa (L.) Greville. Recorded only at sta. 13 in the river in November and December, 1972, on pilings and the floating dock.

Enteromorpha erecta (Lyngbye) J. Agardh. A common and often abundant species, especially at sta. 10, December to February, on a variety of substrates, mostly intertidal. Plants attached to limestone rocks at station 10 were trimmed to 1 cm height in late

January and placed in the upper, mid, and lower intertidal levels. After 2 wk, the upper intertidal plants had grown an av of 9.6 mm per day; those at mid-tide 15.4 mm per day; those near low tide 10.1 mm per day. At sta. 5, plants treated similarly grew 11.4 mm per day in the mid to upper intertidal level. During February, plants at sta. 10 avg 7.6 mm per day, a time when this species appeared to be declining in abundance throughout the estuary, and many plants were reproductive.

Enteromorpha flexuosa (Wulfen) J. Agardh. Abundant from September through February at many sta., especially on small shells in the intertidal zone. Probably present the yr around. At sta. 11 where sea water from a canal was being pumped over a sloping piece of plywood during construction of the power plant, this species formed two conspicuous bands on each side of a band of mixed algae during winter months.

Enteromorpha intestinalis (L.) Link. Occasional at sta. 10 from December through April, usually in small clumps. This northern species is absent in the vegetative state during the warmer months.

Enteromorpha lingulata J. Agardh. Occasional in the lower intertidal zone from September through April, sta. 10 on submerged woodwork and elsewhere on shell fragments, pebbles, limestone rocks.

Enteromorpha plumosa Kützing. Low in the intertidal zone forming a fine turf or fuzz on woodwork, and most abundant during January through March. During winter it colonized plastic strips and concrete blocks placed at sta. 5, 6, 7, 8, and 10.

Enteromorpha prolifera (Muller) J. Agardh. Found from January through April only on concrete blocks that had been placed at sta. 8 and 10.

Enteromorpha salina Kützing. Present from September through May at all sta., but most abundant in January on concrete blocks placed at sta. 17, 18, and 19. The var. *polyclados* Kützing was common in January, 1973, at sta. in the river mouth on a variety of substrates.

Monostroma oxyspermum (Kützing) Doty. Present from November to April on black mangrove aerial roots in the intertidal zone, and larger plants grew on other substrates in the drift.

Ulva lactuca L. Rarely found attached in Anclote estuary although it is abundant in Tampa Bay. Large plants occurred in the drift during winter and spring when its growth is most rapid.

Order Cladophorales

Family Cladophoraceae

Chaetomorpha brachygona Harvey. A minor component of the algal mat or mass in protected areas among mangrove roots, where it is apparently always loose.

Chaetomorpha gracilis Kützing. Present as part of the algal mat among the pneumatophores of black mangroves; occasional in most areas but abundant locally; entangled among drift algae during winter.

Cladophora crystallina (Roth) Kützing. Small plants with main axes about 35 μ in diam. were common on scattered shells, oyster bars, and mangrove roots the year around. They colonized plastic strips at sta. 5 and 8 during spring and winter.

Cladophora delicatula Montagne. On a wide variety of substrates at nearly all sta. the yr around and also on the drift algae.

Cladophora repens (J. Agardh) Harvey. Forming a thin mat in the intertidal zone under mangroves at sta. 8 and 9, apparently yr around.

Rhizoclonium kochianum Kützing, var. *kerneri* Kützing. Common on a variety of substrates on and around oyster bars (sta. 10 and 13), on mangrove roots (sta. 14), and entangled in the drift algae. Colonizing plastic strips placed at sta. 5 and concrete blocks at sta. 10. Yr around.

Rhizoclonium riparium (Roth) Harvey. Yr around on nearly all substrates at most stations, but most abundant on mangrove roots and on intertidal muddy sand under mangroves where it was a major constituent of the algal mat. The cells were 2-3 diam. long during summer and fall, 1-2 diam. long during the cooler months.

Rhizoclonium tortuosum Kützing. Occasional on or among black mangrove roots at sta. 8 and 9 the yr around.

Order Siphonocladiales

Family Dasycladaceae

Batophora oerstedi J. Agardh. Abundant along the north edge of a cove at sta. 16 near low tide line and below on mangrove roots, wood, shells, or shell fragments during the spring.

Family Valoniaceae

Cladophoropsis membranacea (C. Agardh) Børgesen. On and among the pneumatophores of black mangroves, especially on the outmost band of roots, at sta. 5, 7, 8, and 25-27. During the winter months the plants appeared to degenerate but did not disappear.

Anadyomene stellata (Wulfen) C. Agardh. Occasional as an epiphyte of large plants in the drift, especially *Digenia*, during winter.

Order Siphonales

Family Derbesiaceae

Derbesia vaucheriaeformis (Harvey) J. Agardh. At sta. 10 and 13 in December, 1972, on pilings, oysters, other shells, and stones or shell fragments on intertidal protected beaches and below.

Family Caulerpaceae

Caulerpa ashmeadii Harvey. Common in seagrass beds over a major part of Anclote Anchorage the yr around and in the drift during winter.

Caulerpa cupressoides (West) C. Agardh, var. *turneri* Weber-van Bosse. Occasional in the drift in March, 1974, but not found attached in Anclote estuary.

Caulerpa mexicana (Sonder) J. Agardh. Among the drifting algae but not found attached.

Caulerpa prolifera (Forsskal) Lamouroux. Present the yr around on seagrass beds in Anclote Anchorage but not as common as *C. ashmeadii*.

Family Codiaceae

Boodleopsis pusilla (Collins) Taylor, Joly, and Bernatowicz. Plants forming a fine turf in unconsolidated muddy-sand sediments in protected areas of the intertidal zone under mangrove thickets. Best development occurred among black mangrove aerial roots during fall and winter at sta. 4, 7, and 8, but patches were also found on an oyster bar at sta. 13 and among scattered shells at sta. 20-22. Mats of *Boodleopsis* tend to accumulate fine sediments.

Codium isthmocladum Vickers. Occasional in the drift during the winter of 1973-74, but not found the previous yr.

Halimeda incrassata (Ellis) Lamouroux. Common the yr around on seagrass beds throughout Anclote Anchorage growing upon unconsolidated sediments and spreading by elongating rhizoids under the sediments that give rise at intervals to erect branches. On September 19, 1973, several reproductive plants were found near Bailey's Bluff. The gametangia were 150-225 μ in diameter, 300-485 μ long, obovoid to pyriform, on long, dichotomously-branched pedicels in dense clusters. By September 27, all reproductive plants had lost the gametangia and were dead and decomposing.

Penicillus capitatus Lamarck. Common the year around in *Thalassia-Syringodium* beds throughout Anclote Anchorage, the plants in dense and tall seagrasses often exceeding 20 cm tall.

Penicillus lamourouxii Decaisne. Plants having the same distribution as *P. capitatus* but taller and with a less dense capitulum; probably less abundant.

Udotea conglutinata (Ellis and Solander) Lamouroux. Having essentially the same distribution as *Halimeda* and *Penicillus* though perhaps somewhat less abundant.

XANTHOPHYTA

Order Heterosiphonales

Family Vaucheriaceae

Vaucheria bermudensis Taylor and Bernatowicz. Dense mats of this alga occurred in the intertidal zone at sta. 13 and 15 from late fall until spring.

Vaucheria thuretii Woronin. Plants forming dense turf or mats low in the intertidal zone were present from September to May at sta. 8.

Distribution According to Substrate—In connection with field work, the type of substrate upon which each species was growing was recorded for 10 different types and also the loose, drifting algae that continue to grow until they wash ashore or are swept out to sea. Table 1 lists all species recorded and the substrata upon which each occurred. Epiphytes are listed with the substrate upon which their host was growing.

Table 1. Species list by habitat or substrate type:

A = Unconsolidated sediments, sublittoral
B = Spartina stems
C = Scattered shells
D = Intertidal mud and sand
E = Limestone rocks
F = Oyster bars
G = Mangrove roots
H = Pilings and other submerged structures
I = Concrete blocks
J = Plastic strips
K = Loose and drifting

	A	B	C	D	E	F	G	H	I	J	K
Acanthophora spicifera									X		X
Acrochaetium sagraeanum			X		X	X				X	X
A. sargassi											X
A. thuretii									X		
Agmenellum quadruplicatum				X							
A. thermale	X		X	X		X		X		X	
Anacystis aeruginosa			X	X			X		X	X	
A. dimidiata		X									
A. marina				X							
Anadyomene stellata											X
Bachelotia antillarum			X	X	X	X		X		X	
Batophora oerstedi	X			X			X	X			
Boodleopsis pusilla			X	X		X	X				

TABLE 1. Species list (continued)

	A	B	C	D	E	F	G	H	I	J	K
Bostrychia moritziana							X				
B. radicans		X					X				
B. scorpioides							X				
B. tennela							X				
Callithamnion byssoides											X
Caloglossa leprieurii							X				
Calothrix crustacea		X	X				X		X	X	X
Caulerpa ashmeadii	X										X
C. cupressoides											X
C. mexicana											X
C. prolifera	X										
Centroceras clavulatum			X		X		X	X	X		X
Ceramium byssoideum				X	X	X	X	X	X	X	X
C. corniculatum								X			
C. fastigiatum			X					X	X		X
Chaetomorpha brachygona							X				
C. gracilis							X				X
Chondria baileyana											X
C. collinsiana									X		
C. leptacremon											X
C. littoralis					X						X
C. tenuissima			X								
Cladophora crystalline			X	X		X	X			X	
C. delicatula			X		X	X	X		X	X	X
C. repens				X			X				
Cladophoropsis membranacea				X				X			
Cladosiphon occidentalis										X	X
Codium isthomcladum											X
Dasya pedicellata											X
Derbesia vaucheriaeformis			X	X		X		X			
Dictyota dichotoma											X
Digenia simplex			X								X
Diplochaete solitaria											X
Ectocarpus elachistaeformis											X
E. intermedius			X		X	X	X	X	X		
E. siliculosus			X		X	X	X		X		X
Enteromorpha chaetomorphoides								X			
E. clathrata		X	X		X	X		X	X	X	
E. compressa						X		X			
E. erecta			X		X	X	X	X	X	X	
E. flexuosa				X	X	X		X	X		
E. intestinalis					X				X	X	
E. lingulata			X	X				X	X		
E. plumosa								X	X	X	
E. prolifera									X		
E. salina			X	X	X	X		X	X		X
Entocladia viridis											X
Entophysalis conferta		X	X			X	X	X			X
E. deusta			X		X	X	X	X			
Erythrocladia subintegra									X		X
Erythrotrichia carnea		X	X		X	X		X	X	X	X
Fosliella atlantica										X	X
F. farinosa											X
Giffordia conifera			X		X	X			X		
G. mitchelliae		X	X	X	X	X	X	X	X	X	X
G. rallsiae			X	X		X		X	X		

TABLE 1. Species list (continued)

	A	B	C	D	E	F	G	H	I	J	K
Goniotrichum alsidii			X			X			X	X	X
Graaciilaria foliifera								X			
G. verrucosa											X
Halimeda incrassata	X										
Halymenia floresia											X
Herposiphonia secunda				X			X		X		
H. tenella			X		X	X		X			X
Hypnea musciformis								X			X
H. spinella								X			X
Jania adherens									X		X
J. capillacea											X
Johannesbaptistia pellucida				X				X			
Laurencia intricata											X
L. obtusa								X			X
L. poitei											X
Lophosiphonia cristata				X				X			
L. saccorhiza		X	X	X					X		
Mastigocoleus testarum			X			X	X				
Microcoleus lyngbyaceus	X	X	X	X	X	X	X	X	X	X	X
Monostroma oxyspermum							X				X
Murrayella periclados				X			X				
Myriotrichia subcorymbosa						X			X	X	X
Nodularia harveyana				X				X	X	X	
Penicillus capitatus	X										
P. lamourouxii	X										
Phaeophila dendroides							X				
Polysiphonia echinata											X
P. havanensis			X								X
P. hemisphaerica					X			X	X		
P. subtilissima							X	X	X	X	X
Porphyrosiphon notarisii	X										
Rhizoclonium kochianum			X			X	X		X	X	X
R. riparium	X	X	X	X		X	X		X	X	X
R. tortuosum							X				
Sargassum filipendula											X
S. fluitans											X
S. hystrix var. *buxifolium*											X
S. natans											X
S. pteropleuron											X
Schizothrix arenaria			X	X	X	X	X	X			
S. calcicola	X	X	X	X	X	X	X	X	X	X	X
S. mexicana									X		X
Scytonema hofmanni							X				
Solieria tenera								X			X
Sphacelaria furcigera			X		X	X		X	X	X	X
Spirulina subsalsa				X					X		
Spyridia filamentosa			X				X	X	X		X
Stictyosiphon subsimplex									X	X	X
Udotea conglutinata	X										
Ulva lactuca								X	X		X
Ulvella lens							X	X			X
Vaucheria bermudensis				X		X					
V. thuretii	X			X							

Unconsolidated Sublittoral Sediments: The most extensive substrate of the Anclote estuary, about 30 sq km, is in the form of unconsolidated sediments below the intertidal zone. About 40% of this area, 12 sq km, is covered by seagrass beds made up of 4 species: *Syringodium filiforme* Kützing (manatee grass), *Thalassia testudinum* Konig (turtle grass), *Halodule wrightii* Ascherson (shoal grass), and *Halophila engelmannii* Ascherson (no common name), in that order of abundance (Zimmerman et al., 1972, 1973). Shoal grass has been reported also as *Diplanthera wrightii* (Ascherson) Ascherson in the literature. An estimate of the area occupied by seagrasses in Anclote estuary was obtained by aerial photography (Feigl and Pyle, 1973).

While most benthic algae require some kind of solid substrate for attachment, there are a few species capable of developing upon unconsolidated sediments similar to land plants and seagrasses. Unique among benthic algae for the ability to anchor themselves upon unconsolidated sediments are certain genera of the order Siphonales of the green algae, an order that seems to us to be as highly evolved as the flowering plants. Representatives of this group (8 species) made up 62% total recorded on bottom sediments below the intertidal zone. Another group adapted to grow exclusively on this type of substrate is the family Vaucheriaceae of the Xanthophyta, although most stands of these are in the intertidal zone. One species, however, was found below low tide.

The bluegreen algae are a third group capable of growing upon sediments, but for different reasons. Though usually not attached, both coccoid and filamentous species occur among sand grains near the surface or they form a thin film on the surface where the prevailing turbulence of the water is low. Four such species were found in Anclote estuary.

Spartina Stems: There is a characteristic benthic algal flora upon and around the bases of the stems of salt marsh plants such as *Spartina* (Blum, 1968). In the Anclote estuary 11 species were recorded: 5 bluegreens, 45%; 3 reds, 27%; 2 greens, 18%; and, brown, 9%. Predominance of bluegreens in a salt marsh was noted by Webber (1967) in Massachusetts. The two most common bluegreens at the base of *Spartina* were *Calothrix crustacea* and *Entophysalis deusta*. The red algae *Erythrotrichia carnea* and *Lophosiphonia saccorhiza* were common; and *Bostrichia radicans* was present but rare. These species were yr around, but the one species of brown alga found on *Spartina*, *Giffordia mitchelliae*, was seasonal, but when present (April and May, 1973), exceeded all others in biomass.

Scattered Shells: Living and dead mollusc shells in the intertidal zone and below are an important attachment surface for algae in the Anclote estuary because of the scarcity of rocks; 37 species were found on shells. Red algae were predominant, making up 30% of the species, the greens 27%, bluegreens 24%, and browns 19%.

Of the bluegreens recorded, 3 species were boring into shells: *Schizothrix calcicola*, *Entophysalis deusta*, and *Mastigocoleus testarum* listed in order of abundance. The first was found in 100% of the shells examined, the second in 75%, the third only in old, dead shells. These algae probably promote the gradual fragmentation and decomposition of shells.

Of 7 species of brown algae found on shells, only *Giffordia mitchelliae* was present the yr around. All others were found only during winter and spring. Of the 11 species of red algae, all were yr around although many were best developed during spring.

Intertidal Sediments: Protected, low-energy beaches supported a greater variety of algae than exposed beaches, especially where there were aerial roots of black mangroves. Bluegreen and green algae each accounted for 33% (10 species) of the total; there were 5 species of red algae, 17%; 3 browns, 10%; and 2 species of *Vaucheria* (Xanthophyta), 7%. Although certain bluegreens, plus *Vaucheria* and *Boodleopsis*, are adapted to grow on intertidal beaches, many other genera are not but were present because of protection afforded by dense stands of black mangrove aerial roots and the tendency to form algal mats that are not readily dislodged. On a protected beach, some algae are able to stay in place even though they are attached only to a small shell fragment or large sand grain. Unless this fact is taken into consideration, the ratios among 4 major groups on intertidal sand would be misleading.

Limestone Rocks: The red, brown, and green algae comprising 22 species on limestone rocks, were equally represented with 6 species each or 27%, the bluegreens with 4 species or 18%. This type of substrate is scarce in the Anclote estuary, and most natural rocks are in the intertidal zone where many algal species cannot grow and where competition for space is greater from oysters and barnacles than it is below low tide.

Oyster Bars: Among the 33 species found on oyster bars, the green algae were predominant with 11 species (36%), 5 belonging to *Enteromorpha*. Bluegreen, red, and brown algae were about equal in numbers of species and there was one xanthophyte. Oyster bars are mostly intertidal and do not permit colonization of most species that require constant submergence. *Vaucheria bermudensis* grew on soft sediments among oyster shells and over them to some extent. *Myriotrichia subcorymbosa* was an epiphyte of larger algae on the oyster bars. Rhodes (1970), in a study of algae of an oyster bar on the Eastern Shore of Virginia both summer and winter, found 43 species of which 65% were red algae, 21% browns, and only 14% were greens. He omitted bluegreens. His area, however, was of uniformly higher salinity than the Anclote river mouth.

Mangrove Roots: Of 38 species recorded from mangrove roots, 15 were greens (39%), 11 were reds (29%), 9 were bluegreens (24%), and 3 were browns (8%). In tropical and subtropical waters, few species of brown algae grow in the intertidal zone. The high percentage of green algae in this habitat was not because of *Enteromorpha* as on oyster bars, but because of Cladophoraceae with 3 genera represented. *Enteromorpha* does not do well in the shade.

Two types of mangrove roots are found in the intertidal zone in Anclote estuary, both in abundance: the pencil-like pneumatophores of the black mangrove, *Avicennia germinans* (L.) L. and the arching prop roots of the red mangrove, *Rhizophora mangle* L. Each provides a habitat that is somewhat different and the algal communities differ mainly in the proportion of species present rather than a qualitative difference. Roots of both species are mostly shaded by the trees but, in the case of black mangroves, rows of pneumatophores often extend out beyond the canopy where they receive full sunlight at least part of the day.

Mangrove roots support a characteristic algal community that has been intensively studied by Post (1963) and referred to by her as a BOSTRICHIETUM in allusion to the dominance of species of the strictly intertidal genus *Bostrichia.* Four species of this genus and two varieties colonize the mangrove roots in the Anclote estuary, along with their common associates *Caloglossa* and *Murrayella. Catenella*, a component of the BOSTRICHIETUM in south Florida was not found at Anclote.

The most abundant green alga on and among mangrove roots was *Cladophoropsis membranacea.* At sta. 7 and 8 it grew attached to almost all the pneumatophores and formed dense cushions of coarse filaments between them in the outer m of the root fringe where light was most intense. Mangrove roots more exposed to wave action supported fewer algal species, but during the cooler months the proportion of green algae was higher, especially abundant were *Monostroma oxyspermum* and *Enteromorpha erecta.* In March these were replaced by 3 species of filamentous brown algae until mid-May: *Ectocarpus intermedius. E. siliculosus*, and *Giffordia mitchelliae.* From late May and throughout the summer, this area was colonized only by bluegreens.

Rehm (1973), in a study of the algae of prop roots of red mangroves around the Florida coast, recorded 73 species of which 40% were greens, 51% reds, 5% browns, and 4% bluegreens. His work included the Florida Keys where mangroves grow in clear, highly saline water and algal diversity is high.

Pilings and Other Submerged Structures: Included here are all forms of submerged wood, buoys, tin cans, tires, and the rock breakwaters at Howard Park where 40 species were recorded upon them; 15 were red algae (38%), 12 were greens (30%), 8 were bluegreens (20%) and 5 were browns (12%). The 12 green algae included 8 species of *Enteromorpha.* Of the 5 brown algae, only *Giffordia mitchelliae* was yr around, the others restricted to winter and spring.

Concrete Blocks: Concrete blocks and polyethylene plastic strips were placed at 12 sta in order to determine the season of colonization of some species, to obtain an estimate of growth rates of *Enteromorpha*, and to provide a new surface for attachment by species that might otherwise be missed, especially small species that would be evident on the plastic strips. Concrete blocks were placed on December 12, 1972, and August 23, 1973, and examined at weekly or biweekly intervals.

Colonization of the blocks required 5 wk during December-January. On January 19, pieces were chipped off, examined in the laboratory, and 10 species identified. A wk later 7 additional species were found. These 17 were the principal constituents of the winter-spring seasonal flora of the estuary. After 15 wk (March 27, 1973), the previously-abundant species of *Enteromorpha*, had declined, filamentous brown algae had become predominant, and 4 additional species were recorded. During April and May the winter-spring flora on the blocks declined and disappeared and was replaced by a variety of bluegreens, the only algae on the blocks during the summer. Blocks set out in August were colonized faster, but initially only by green and bluegreen species. They were replaced or overgrown by the winter-spring flora beginning in November.

During the second yr, algal colonization on the blocks was less dense, apparently because of the development of many barnacles and oysters, but the pattern was the same, and additional species were found bringing the total to 42. Three species were found only on concrete blocks: *Acrochaetium thuretii*, *Chondria collinsiana*, and *Enteromorpha prolifera*.

Plastic Strips: Clear plastic strips were placed in the environment so that the substrate could be placed under a microscope to observe microscopic or very small species *in situ*. Strips 30 × 3 cm were put out on February 9, 1973, at the same stations as the concrete blocks. They were weighted at one end and allowed to trail in the water. After 4 wk, 2 brown algae, *Myriotrichia subcorymbosa* and *Stictyosiphon subsimplex*, and a bluegreen, *Calothrix crustacea* were present in abundance. After 6 wk 7 more species were present. Ultimately, 26 species were identified that were rather evenly distributed among the 4 major groups. There were 6 each of bluegreens, reds, and browns, and 8 greens. All species on the strips were found on other substrates as well.

Drift Algae: Anclote estuary is an area where masses of loose and drifting algae can occur for long periods of time and continue to grow. The water is shallow enough for light penetration and the currents weak enough so that the drifting masses are only occasionally washed ashore or swept out to sea.

Drift algae occur in greatest abundance from October to April, with a peak in the spring. Apparently northerly winds favor the accumulation of loose plants and large quantities tend to move into Anclote Anchorage from the Gulf of Mexico. The species are those characteristic of the open Gulf rather than of the estuary, and the biomass of the standing crop in the estuary is inadequate to account for the quantities found in the drift.

A sample of drift algae that covered an area 0.5 × 1 m was collected and analyzed for algal species and associated fauna. Three small fish and a large blue crab were seen to escape when the mass was netted. Wet wt of the mass was 2494 g, of which 60 g were animals. The 2434 g of algae had a dry wt of 240 g. Most of the animals were crustaceans, but there were also tunicates, bryozoans, annelids, molluscs, and fish.

During winter months, 2 species of red algae made up about 90% of the drift: *Laurencia obtusa* (about 50%) and *L. poitei* (30 to 45%). The red alga, *Digenia simplex*, and several species of *Sargassum* often made up 5% of the drift.

Including epiphytes, 65 species were found in the drift. Of these, 32 were red algae (49%), 15 were greens (23%), 13 were browns (20%), and 5 were bluegreens (8%). Most of the bluegreens were epiphytes.

Percentages on Substrates: Table 2 indicates the relative adaptation of species of each major group in Anclote estuary for attachment to the 10 substrates that were recognized. Bluegreen algae colonized the bases of *Spartina* stems more than any other group and made up 45% of the species found there. The red algae made up nearly 50% of species present in the drift, mainly species that had originally grown upon some substrate in the open Gulf of Mexico and after breaking

TABLE 2. Percentage of the species of each of the major groups of benthic algae found on 10 different substrates or in the drift in Anclote estuary, 1972-74. Substrates are listed in decreasing order of occupancy by the species.

CYANOPHYTA	%	RHODOPHYTA	%
Spartina stems	45	Drifting	49
Intertidal sediments	33	Pilings, etc.	38
Bottom sediments	31	Concrete blocks	36
Scattered shells	24	Scattered shells	30
Mangrove roots	24	Mangrove roots	29
Plastic strips	23	Limestone rocks	27
Oyster bars	21	*Spartina* stems	27
Pilings, etc.	20	Plastic strips	23
Limestone rocks	19	Oyster bars	18
Concrete blocks	16	Intertidal sediments	17
Drifting	8	Bottom sediments	0

PHAEOPHYTA	%	CHLOROPHYTA	%
Limestone rocks	27	Bottom sediments	62
Oyster bars	24	Mangrove roots	39
Plastic strips	23	Intertidal sediments	33
Drifting	20	Oyster bars	33
Concrete blocks	19	Plastic strips	31
Scattered shells	19	Pilings, etc.	30
Pilings, etc.	12	Concrete blocks	29
Intertidal sediments	10	Limestone rocks	27
Spartina stems	9	Scattered shells	27
Mangrove roots	8	Drifting	23
Bottom sediments	0	*Spartina* stems	18

loose drifted into the estuary. Brown algae made up a larger proportion of species found on limestone rocks than on any other substrate, but they were also well represented on oyster bars and plastic strips during the cooler months. The green algae accounted for 62% of species colonizing subtidal bottom sediments because of the abundance of members of the Siphonales, but they were also well represented on intertidal mangrove roots, especially the Ulvaceae and Cladophoraceae.

DISCUSSION—The algal population of the Anclote estuary is that of an area of fluctuating but relatively high salinity consisting of species that are moderately to highly euryhaline. During winter and spring, the dry season in Florida, there are more species present that are sensitive to salinity fluctuations, as there is greater stability than during summer and fall.

Geographically, the flora is closely allied to that of the coastline of North and South Carolina, an area occupied by species of tropical affinities during the warmer months and by species of north temperate affinities during the cooler months. Within the Gulf of Mexico, the Anclote estuary is at the southern margin of Earle's (1969) subregion C, Apalachicola to Anclote Keys, and at the northern edge of her subregion D, Tampa Bay to Cape Romano. Although just north of the latter, the Anclote estuary is more closely related to subregion D than to C because of its shoreline of barrier islands and bottom characteristics. In her treatment of the entire Gulf of Mexico, Earle (1972) recognized the coastline from Port St. Joe to Cape Romano as "area E" in which the Anclote estuary is at the center.

A total of 122 species were recorded in our study. In addition to these, Ballantine and Humm (1975) list 15 found only on seagrass leaves. This brings the total benthic algal flora of Anclote estuary to 136. Earle indicates that a total of 351 species had been recorded in her "area E" of the Florida Gulf coast to 1972. Thus the Anclote estuary supports about 36% of all species known for the Florida Gulf coast between Port St. Joe and Cape Romano. If comparisons of each of the 5 major groups are made, the Anclote area supports 67% of the bluegreens, 45% of the greens, 39% of the browns, and 33% of the reds. The high percentage of bluegreen algae in Anclote estuary is accounted for by the fact that these are typically inshore, estuarine species. The relatively high percentage of green algae is accounted for by the fact that members of two families, Ulvaceae and Cladophoraceae, are also highly tolerant of estuarine conditions and their species constitute nearly half of the green algae known for the Anclote estuary. The relatively high percentage of brown algae in Anclote estuary results from the fact that many species of browns, especially Ectocarpaceae and Chordariaceae, are winter-spring species that occur in shallow water and become abundant in the estuary when the salinity is relatively high and stable.

The red algae, with the lowest percentage of any group in the estuary, are to a great extent characteristic of warm, clear water of high and stable salinity like that of the open sea or among the Florida Keys. Relatively few species tolerate the fluctuating conditions of estuaries.

Of the 610 species recorded for the Gulf of Mexico (Earle 1972), only about 22% have been recorded for the Anclote estuary.

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LITERATURE CITED

AZIZ, K. M. S. 1965. *Acrochaetium* and *Kylinia* in the Southwestern North Atlantic Ocean. Ph. D. dissert. Duke Univ. Durham, N. C.

BALLANTINE, D., AND H. J. HUMM. 1975. Benthic algae of the Anclote estuary. I. Epiphytes of seagrass leaves. Florida Sci. 38:150-162.

BAIRD, R. C. (ed.) 1972. Anclote Environmental Project Report for 1971. Dept. Marine Sci. Univ. S. Florida. 251 pp. (Mimeographed)

———. 1973. Anclote Environmental Project Report for 1972. Dept. Marine Sci. Univ. S. Florida. 219 pp. (Mimeographed)

———. 1974. Anclote Environmental Project Report for 1973. Dept. Marine Sci. Univ. S. Florida. 136 pp. (Mimeographed)

BLUM, J. L. 1968. Salt marsh *Spartinas* and associated algae. Ecol. Monogr. 38:199-221.

DAWES, C. J. 1974. Marine Algae of the West Coast of Florida. Univ. Miami Press. Coral Gables.

DROUET, F. 1968. Revision of the Classification of the Oscillatoriaceae. Acad. Nat. Sci. Philadelphia Monogr. 15.

_________. 1973. Revision of the Nostocaceae with Cylindrical Trichomes. Hafner Publ. Co. New York.

_________, AND W. A. DAILY. 1956. Revision of the coccoid Myxophyceae. Butler Univ. Bot. Stud. 12:1-218.

EARLE, S. 1969. Phaeophyta of the eastern Gulf of Mexico. Phycologia 7:71-254.

_________. 1972. Benthic algae and seagrasses. Folio 22:15-18; pl. 6. *In* BUSHNELL, V. C. (ed.) Serial Atlas of the Marine Environment. Amer. Geogr. Soc. New York.

FEIGL, J. L., AND T. E. PYLE. 1973. Application of aerial photography to the study of seagrass beds and turbidity in a Florida estuary. Appendix 3B:199-204. *In* Anclote Environmental Report for 1972. Dept. Marine Sci. Univ. S. Florida. (Mimeographed)

FIORE, J. 1970. Life History Studies of Phaeophyta from the Atlantic Coast of the United States. Ph. D. dissert. Duke Univ. Durham, N. C.

HUMM, H. J. 1971. Anclote Environmental Project Report for 1970. Dept. Marine Sci. Univ. S. Florida. 172 pp. (Mimeographed)

_________, AND D. HAMM. 1976. New records and range extensions of benthic algae in the Gulf of Mexico. Florida Sci. 39:42-45.

POST, E. 1963. Zur Verbreitung und Okologia der *Bostrich-Caloglossa* Assoziation. Internat. Rev. Gessamten Hydrobiol. 48:47-152.

REHM, A. 1974. A Study of the Marine Algae Epiphytic on the Prop Roots of *Rhizophora mangle* L. from Tampa to Key Largo, Florida. Ph. D. dissert. Univ. S. Florida. Tampa.

RHODES, R. G. 1970. Seasonal occurrence of marine algae on an oyster reef in Burton's Bay, Virginia. Chesapeake Sci. 11:61-71.

RUENESS, J. 1973. Speciation in *Polysiphonia* in view of hybridization experiments: *P. hemisphaerica* and *P. boldii*. Phycologia 12:107-109.

WEBBER, E. E. 1967. Bluegreen algae from a Massachusetts salt marsh. Bull Torrey Bot. Club 94: 99-106.

WYNNE, M. J., AND P. EDWARDS. 1970. *Polysiphonia boldii sp. nov.* from Texas. Phycologia 9:11-16.

ZIMMERMAN, R. J., R. A. DIETZ, T. E. PYLE, S. W. ROGERS, N. J. BLAKE, AND H. J. HUMM. 1973. Benthic community—seagrasses. pp. 115-141. *In* Anclote Environmental Report for 1972. Dept. Marine Sci. Univ. S. Florida. (Mimeographed)

Florida Sci. 39(4): 209-229. 1976.

ERRATA: In *Florida Scientist* 39(3), the following corrections are noted: page 191, line 11 for 400 psig *read* 40 psig; page 191, line 20 for at least 50% *read* at least 60%; page 196, line 24 for 120 psi *read* 1200 psi.

Biological Sciences

VEGETATION OF SOUTHEASTERN FLORIDA–I. PINE JOG

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Abstract: *Historical documents, aerial photography and on-site studies have been used to document vegetation changes on the quarter-section where Pine Jog Environmental Sciences Center is located. Data indicate that the entire Pine Jog region is undergoing secondary succession. All analyses show that the original vegetation was wet prairie, marsh and low hammock. Due to lowering of the water table by drainage, many of the wet prairies have changed to pine flatwoods. Frequent burning shortly after the turn of the century reduced diversity in the remaining wet prairies and marshes. The disturbance caused by drainage and fires has enhanced invasion by exotic plants, particularly* Schinus terebinthifolius *and* Melaleuca quinquenervia.

In Florida as elsewhere, vegetation patterns are largely controlled by physical features. Davis (1943) and others have pointed out the close correlations between hydrology, soil types, elevations and plant communities. Because of these interrelations any changes in the physical factors may greatly alter community structure. A factor that is at times even more important than the physical features is manipulation by man (Alexander, 1958; Austin and Weise, 1973). Some apparently harmless events may have long-range effects on the habitats (Austin, 1976). The following report is the first of several sites studied to determine how the major communities of southeastern Florida have changed in the past few decades. Once the data for the communities are compiled we will have a better understanding of secondary succession which is poorly understood at present (Alexander and Crook, 1974).

History—Pine Jog Environmental Sciences Center, now affiliated with Florida Atlantic University, is located in the S. E. quarter of Section 3, Township 44S, Range 42E, west of the city of West Palm Beach. Henry M. Flagler was the first owner, obtaining the land shortly after 1893 when he made his first land purchase on Lake Worth and established West Palm Beach. For several years land including Pine Jog was held by Flagler's company, the Model Land Company.

In March of 1929 land now including Pine Jog was offered for sale at the West Palm Beach Court House, and the Lake Worth Drainage District took control of the land in May of 1930. Between the time it was purchased in 1930 and the next time it changed owners, the land was occupied by a few "squatters" but there were apparently no permanent dwellings. The area around Pine Jog was "open" between the 1920's and 1940's, and various farm plots were prepared without regard to ownership (Klein, personal communication). The main crops of that time were squash, tomatoes and peppers.

A substantial difficulty with farming during this period was fire. Palm Beach County was open range and had numerous semi-wild cattle. Because of this the cattlemen periodically burned hundreds of acres. These annual or perhaps more frequent fires were designed to stimulate new tender forage for the cattle by releasing nutrients and reducing competition. The fires and the cattle had considerable effect on the natural vegetation and on the scattered farms.

Mr. and Mrs. Alfred G. Kay purchased the quarter-section now including Pine Jog in April of 1946. The Kays, after numerous discussions with John Storer, David Fairchild, Marston Bates, and others, decided to provide the area with an environmental center. Early in 1960 Pine Jog was established as a conservation education center.

Since it was purchased in 1946 by the Kays, the land has been protected from fire. Farming has been eliminated from the Center property since at least the early 1950's. The quarter section is now owned by the Kays, the State of Florida and Milton Klein, in order of size of land holdings.

Physiography—As in much of southern Florida, the relief on the Pine Jog property is slight (U.S.D.A., 1967). Elevations range from a 15 ft m.s.l. low in the marsh to a high of 18 ft in the hammock. Scattered through the property are ponded areas where the elevations are mostly near 16 ft; some of these dip to 15 ft. The "ridges" between these ponds are mostly 17 ft or slightly more.

Some ponded areas have Basinger-Myakka soils (U.S.D.A., 1946, 1973). These are low soils, seasonally flooded, usually white or light grey in color and extending down six feet or more to rock. The ponded marsh is Placid soil with a thin muck layer of up to 1-2 ft; below this is white or yellow sand supported by a shellrock layer 6-10 ft below the surface. On the higher ridges the soils are Basinger. These soils are similar to the ponded Basinger-Myakka series, but have a darker color and shellrock within about 6 ft of the surface. Moreover, there is often a weakly cemented hardpan in Basinger soils.

The Pine Jog property lies within a shallow drainage basin between the major systems of the Loxahatchee Slough on the west and the Lake Osborne Basin to the east. Since the ridges on both sides of the Pine Jog Basin direct water flow, much of the local surface runoff and water from farther north originally flowed south through the area.

Drainage in this part of the state began as early as the 1870's when former Lieutenant Governor W. H. Gleason started canals on Lake Worth. The first effective drainage, however, occurred in the first years of the 1900's. During that time several canals were finished from Lake Okeechobee to the ocean. The canals included the Miami Canal, the North New River Canal and the South New River Canal finished in 1912, and the Palm Beach Canal finished in 1917. The Palm Beach Canal was enlarged during the 1920's, in part to provide fill for Connor's Highway. Before the Palm Beach Canal was opened water was high enough in Lake Clarke east of Pine Jog that Seminoles came along the marsh edge to a trading post near what is now Dreher Park (T. T. Sturrock, personal communication). Enough water was removed when the canal opened that the Indians could not use their canoes on the old lake route. Before the reduction of the water table through drainage (Parker, 1974) the water table in the region was at least 6 ft higher (Thomas, 1974).

VEGETATION—Several documents indicate the past and present patterns of plant communities on Pine Jog. The earliest reports were made by MacKay (1845) who surveyed the township and range boundaries, and Reyes (1858) who laid out the section lines. Klein (personal communication) has pointed out several features that he remembers have changed since the 1930's. Aerial photography (U.S.D.A., 1940), and soils maps (U.S.D.A., 1946) are consistent with the earlier reports. Plant community names used here follow Davis (1943).

Original Associations: All of the early materials show that Pine Jog was low wetland from the late 1800's to as late as 1940 (MacKay, 1845; U.S.D.A., 1940, 1946). Between 1900 and 1929 the pine trees were harvested in the area surrounding Pine Jog. Following this harvesting there were annual fires and by 1934 there were few pine seedlings on the property over 1 m tall (Klein, personal communication). The present ponded prairies were termed in the 1930's "cypress bottoms." This term historically has been used for wet prairies dominated by sand cypress or *Hypericum fasciculatum*. The present marsh has been similar in size and shape since before the year 1900, but before drainage there were two other marshes (Fig. 1).

As late as 1940 (U.S.D.A., 1940) most of the ridges between the ponded prairies and marshes were also wet prairies. By 1940 pines had grown to several ft in a few areas, but most of the quarter-section was still wet prairie. Prior to this date all of the ridged land was covered by a wet prairie community.

Fig. 1. Detail of plant associations on the Pine Jog property about the year 1900. Interpreted from 1940, 1965 and 1973 aerial photography.

The low hammock was similar in shape in the 1940's, but with smaller oaks (*Quercus virginiana*) and cabbage palms (*Sabal palmetto*). This habitat is not indicated in the 1800 reports and may have developed since the turn of the century. Fires in the early 1900's may also have been responsible for altering the hammock in the 1940 photography.

Ponded wet prairies were only slightly different from the other prairies before drainage. The largest difference was the abundance of *Hypericum fasciculatum* and *Stillingia aquatica* in the ponded prairies and the reduced density of these species in the ridged prairies. There were three communities on the property before drainage: wet prairie, marsh and low hammock.

Present Associations: All of the plant associations at Pine Jog are now in different stages of secondary succession. Two of the original marshes have been all but obliterated by drainage, excessive burning and farming. These processes did not change the third marsh as drastically, probably because it was lower than the others and retained more water. A pond was dug in the third marsh in 1967 and enlarged in the Spring of 1974. Several native plants were introduced to the pond margins in order to stabilize the soil more rapidly. Thirty percent of the 175 species now found on the property are marsh plants.

While the low hammock has recently decreased in size, it still contains many of the plant species originally present. Eight percent of the species present in Pine Jog are found in the hammock.

The wet prairies are the most altered community on the property. Since the period of drainage and fires, pines have invaded from the northeast and northwest. These pines were beginning to become established in the 1930's when they were seedlings (Klein, personal communication). Seventeen percent of the Pine Jog flora is found in the pine flatwoods. From all available data, the pine flatwoods areas now on Pine Jog are less than 40 yr old (Fig. 2).

Another indicator that the vegetation of the Pine Jog area was originally prairie is the presence of scattered cypress, *Taxodium distichum*. Several other wet prairie systems in the county, such as Corbett Conservation Area, include cypress heads and scattered individuals or clumps of cypress trees. Were it not for parallel cases, the *Taxodium* at Pine Jog would appear anomalous. Before it was bulldozed in late 1974, there was a fairly large cypress head north of the Palm Beach Canal. This head was only about 2 miles from Pine Jog. Without doubt the south-flowing water during wet seasons and storms carried *Taxodium* seeds and fruits into Pine Jog. The previously wet prairie margins and marshes were suitable habitat for the cypress to germinate.

Ponded wet prairies have experienced two changes in the past 70 yr. First, the frequent fires between the 1920's and 1946 decreased total floristic diversity. Many wet prairie species were totally eliminated from several ponded prairies. This is the major reason that only 10% of the plants on the property are wet prairie species. In many sites it is still possible to walk on totally barren pond bottoms. The margins of these ponds retain a few wet prairie species such as *Fuirena scirpoidea, Lachnanthes caroliniana, Syngonanthus flavidulus,* and scattered *Xyris* sp. Furthermore, the majority of these ponds are fringed by lines

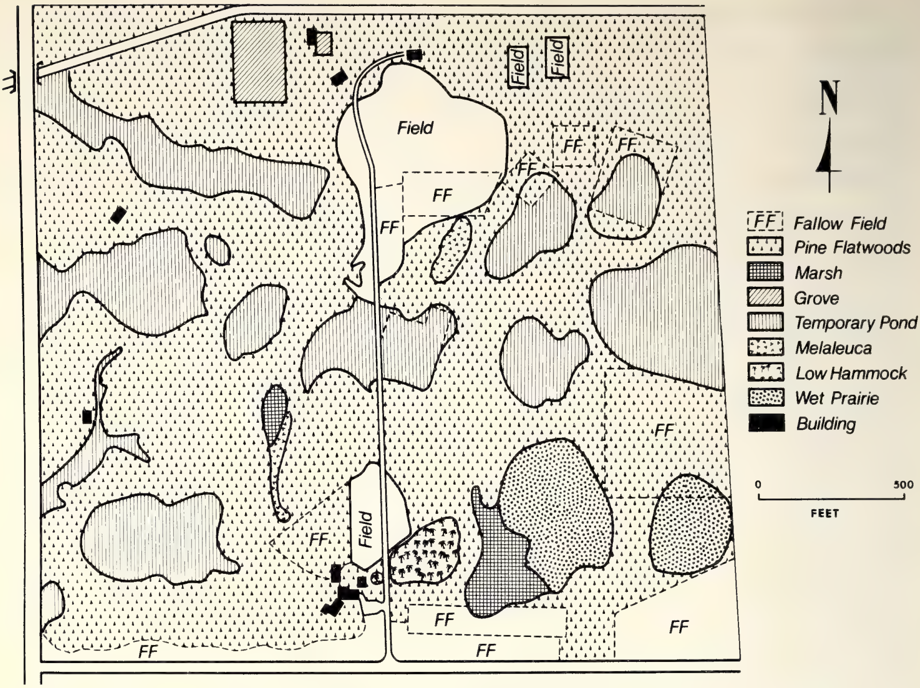

Fig. 2. Detail of the plant associations and major cultural features of Pine Jog in 1974. Interpreted from 1965 and 1973 aerial photography.

of *Chrysobalanus icaco* which delimit with some detail the old boundaries. During the past 5 yr, several of these plants have begun to invade the pond bottoms. The second change has been caused by the exotic tree *Melaleuca.*

Exotics: Certainly the most abundant and noticeable exotic plant on the property is *Melaleuca quinquenervia.* In 1946 there were only six of these trees on the entire tract. Even at that time they were in such demand that they were periodically stolen for landscaping. Since 1946 these trees have reproduced prolifically both by seeds and vegetative suckers. In 1973 there were three large *Melaleuca* copses on the property. Two occupied former marshes degraded to wet prairies; the third had multiplied on the scarified surface of a wet prairie on the southeastern part of the property. Disturbed wet prairie sites are particularly favored by these trees. During the 5 yr that my study has spanned, *Melaleuca* has rapidly encroached on some of the other wet prairies.

Various other exotic species are among the 35% disturbed site plants but the majority appear to be ephemeral and to compete little with native species. Three, I believe, are noteworthy.

The second most frequent exotic tree at Pine Jog is the pepper tree, *Schinus terebinthifolius.* This tree was first introduced into Florida from Brazil and Paraguay in 1898 and has become widely naturalized since the 1950's (Alexander and Crook, 1974). At Pine Jog it has invaded the margins of the marsh and disturbed sites near buildings.

A plant called Florida elodea, *Hydrilla verticillata*, was introduced into the state in 1959. Until the artificial pond was enlarged in 1974, there was little problem with this species. Now the population in the pond is increasing rapidly. While it provides some protection for young fish and micro-animals, the large masses of decaying plants usually cause a decrease in dissolved oxygen and lead to decreased productivity.

The last exotic to be mentioned has apparently never been reported before in our state: *Passiflora foetida*. This is a West Indian species and the source of its introduction to Pine Jog remains unknown. Between 1971 and 1973 a single plant was noted on the property. If the plant flowered during this period, no one discovered the blossoms. In the fall of 1974 the first flowers were noted. Later seedlings were found in several sites on the property. Near Christmas of that year, plants were found in fruit 1-1.5 miles south of Pine Jog. The impact this species will have on the native flora cannot be predicted.

Acknowledgments—The staff at Pine Jog, particularly my wife Sandra Austin, as well as Sarah Cass and the Director, Ray M. Iverson, have been most cooperative in helping with this study. Mr. Milton Klein has given me his impressions of the property and vegetation since he first saw it in the 1930's. To all of these I extend my thanks. Mr. Donald Vandergrift of the Soil Conservation Office was most helpful in providing copies of unpublished U. S. Department of Agriculture Soil Conservation Service soil maps. This study was supported in part by a grant from the Joint Center for Environmental and Urban Issues. The checklist of plants and more detailed report has been deposited at Pine Jog and the Florida Atlantic University Library.

LITERATURE CITED

Alexander, T. R. 1958. Ecology of the Pompano Beach Hammock. Quart. J. Florida Acad. Sci. 21: 299-304.

———, and A. G. Crook. 1974. Recent vegetational changes in South Florida. *In* Gleason, P. J., ed. Environments of South Florida: Present and Past. Mem. Miami Geol. Survey 2:61-72.

Austin, D. F. 1976. Mangroves as monitors of change in Spanish River. Florida Environm. Urb. Issues 3:4-7; 15-16.

———, and J. G. Weise. 1972. Annotated checklist of the Boynton Beach Hammock. Quart. J. Florida Acad. Sci. 35:145-154.

Davis, J. H. 1943. The natural features of southern Florida. Florida Geol. Bull. 25:6-301.

MacKay, G. 1845. United States Survey of Township 44S, Range 42E, Florida.

Parker, G. G. 1974. Hydrology of the pre-drainage system of the Everglades in southern Florida. *In* Gleason, P. J., ed. Environments of South Florida: Present and Past. Mem. Miami Geo. Survey 2:18-27.

Reyes, W. J. 1858. The United States Survey of Township 44S, Range 42E, Florida.

Thomas, T. M. 1974. A detailed analysis of climatological and hydrological records of South Florida with reference to man's influence upon ecosystem evolution. *In* Gleason, P. J., ed. Environments of South Florida: Present and Past. Mem. Miami Geol. Survey 2:82-122.

U.S.D.A. 1940. Soil Conservation Service, Aerial Photographs. Project ASI 20674. Philadelphia, Pa.

———. 1946. Florida Everglades Drainage District Soils Maps. Univ. Florida Agr. Exp. Sta., Soil Conservation Service, Washington, D. C.

———. 1967. Greenacres City, Florida, Topographic quadrangle. Washington, D. C.

———. 1973. Soil Survey Special Report, Palm Beach County, Florida. Unpublished county document.

Florida Sci. 39(4): 230-235. 1976.

Biological Sciences

COLLECTION OF POSTLARVAL AND JUVENILE *HOPLIAS MALABARICUS* (CHARACOIDEI: ERYTHRINIDAE) IN FLORIDA[1]

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Abstract: *Twenty-four postlarval and juvenile specimens of* Hoplias malabaricus *were collected in the Little Manatee River drainage, Hillsborough County, Florida. This collection confirms that* H. malabaricus *has become established in Florida.*

Occurrence of the South American erythrinid *Hoplias malabaricus* in Florida has been documented by Hensley and Moody (1975). They presented strong evidence that the species has reproduced in the drainage of the Little Manatee River. A large number of specimens (126-325 mm SL) was collected in one pond in this drainage system, and histological examination of the gonads has shown that they can become reproductively active in Florida. Because of research priorities, only a small section of the Little Manatee River drainage was sampled extensively. *H. malabaricus* was found in only one pond. Water levels at that time were low and the pond was isolated. In hopes that this was the only locality where *H. malabaricus* was found, they treated the pond with an ichthyocide. This effort failed to eradicate the species. The present paper verifies the establishment of this species in Florida.

During August and September 1975, 24 postlarval and juvenile specimens of *H. malabaricus* were collected by seine in the same small system of drainage ditches and ponds where Hensley and Moody originally collected them. Due to recent rains, water levels in the area were high, forming a system of interconnected swamps and weed-choked ditches and ponds. Aerial surveillance indicated that during periods of high water levels, this system has extensive connections with the remainder of the Little Manatee River drainage (Vernon Ogilvie, personal communication). Two water temperature readings of 27 and 29°C were taken on two separate days in the area where the specimens were collected. Seventeen of these specimens are at the Exotic Fish Research Laboratory, Florida Game and Fresh Water Fish Commission, Boca Raton. The smallest specimens (18.7-43.3 mm SL) are deposited at the Florida Department of Natural Resources Marine Research Laboratory, St. Petersburg, and were the only ones available to me for examination.

An 18.7 mm SL specimen is illustrated in Fig. 1. With the exception of the pectoral fins this specimen resembles the adult. The pectoral fins are the "larval" type with a fleshy base and a fan-shaped membrane bearing only actinotrichia.

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[1]Contribution Number 268, Florida Department of Natural Resources Marine Research Laboratory.

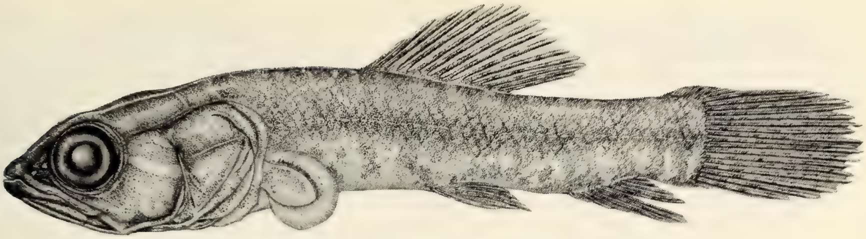

Fig. 1 Postlarval *Hoplias malabaricus*, 18.7 mm SL.

Pectoral lepidotrichia appear to begin to develop between 22 and 30 mm SL (Table 1). With development of the lepidotrichia, the fleshy fin base becomes reduced. Since none of the specimens available to me had developed the adult complement of pectoral lepidotrichia (14-15 total), I have called them postlarvae (Hubbs, 1943). The canine teeth were well developed in all specimens examined. The gut of a 30.6 mm SL specimen was found to contain two fishes which could not be positively identified due to the state of digestion; one cyprinodontiform (16.5 mm SL), probably *Gambusia affinis*, and one small unidentifiable specimen.

TABLE 1. Number of pectoral lepidotrichia for postlarval *Hoplias malabaricus*.

SL (mm)	Number of pectoral lepidotrichia
18.7	0
21.0	0
22.6	0
30.6	9
36.0	12
41.5	13
43.3	13

Due to the great amount of interconnection between localities where this species has been collected and the remainder of the Little Manatee River drainage during periods of high water levels, *H. malabaricus* is probably widely distributed within this drainage system. Thus, efforts to eradicate this species seem futile. However, due to its great potential for causing damage to native freshwater fish populations (Hensley and Moody, 1975), its dispersal should be rigorously monitored. It may be possible to contain this species to some extent or to prevent its dispersal into particular areas.

ACKNOWLEDGMENTS—I thank Charles Futch, Derril Moody, and Mark Berrigan for assistance in the field. I am grateful to Vernon Ogilvie and Paul Shafland of the Florida Game and Fresh Water Fish Commission for their interest in this species and for their time spent with me collecting. I am especially thankful to James Seagle for the drawing of the postlarval specimen. Critical review of the manuscript was kindly furnished by Charles Futch, Gregory Smith, Dr. Walter R. Courtenay, Jr. and Dr. Frederick A. Kalber.

LITERATURE CITED

Hensley, D. A., and D. P. Moody. 1975. Occurrence and possible establishment of *Hoplias malabaricus* (Characoidei; Erythrinidae) in Florida. Florida Sci. 38:122-128.

Hubbs, C. L. 1943. Terminology of early life history stages of fishes. Copeia 1943:260.

Florida Sci. 39(4): 236-238. 1976.

Biological Sciences

TWINNING IN THE GULF COAST BOX TURTLE, TERRAPENE CAROLINA MAJOR

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Observations of complete twinning in turtles are rare (for a review, see Yntema, 1970). The only example reported for *Terrapene* is in *T. carolina triunguis* (Agassiz) (Crooks and Smith, 1958). The present paper reports the first set of twins known for *T. c. major* (Agassiz).

An adult female *T. c. major* collected 30 May 1975 on Fla. Hwy. 22, 2.3 km W of Wewahitchka, Gulf Co., Fla., laid 4 eggs 2 July, 3 of which hatched 12 Sept. 1975. The fourth egg containing dead twins was opened 13 Sept. Measurements of the first three eggs and their single hatchlings will be reported elsewhere. The twins were photographed before preservation and measured with vernier calipers shortly after preservation.

The egg that contained the twins was somewhat smaller than the other eggs of the clutch at the time of oviposition. The twins' egg was 32.9×21.2 mm while the other three eggs averaged 34.7×21.7 mm.

Apparently the smaller twin died first; when injected with formalin, it failed to harden properly, while the larger one reacted normally to preservation. It is likely that decomposition products of the smaller twin poisoned the larger one. These twins, like those reported by Yntema (1970) and Crooks and Smith (1958), had a common yolk sac but separate allantoises and amnions. They were oriented plastron to plastron inside the egg, with their posterior ends directed toward the widest end of the egg (Fig. 1). The larger twin is morphologically normal but smaller than any of the normal hatchlings of the same clutch. The three normal sibling hatchlings averaged 32.1 mm in carapace length while the larger twin was 23.6 mm in carapace length. The measurements of the twins are not strictly comparable to those of normal hatchlings because the living hatchlings were measured after normal post-hatching carapace expansion had occurred. But all body parts of the twins are smaller than normal hatchlings. The

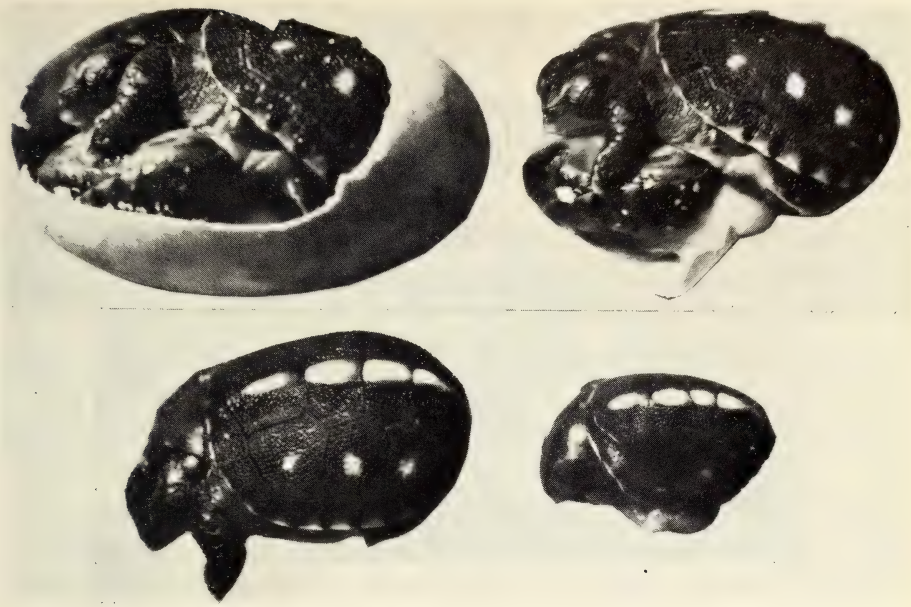

Fig. 1 (upper left). Twin *Terrapene carolina major* in situ, with part of egg shell cut away. Fig. 2 (upper right). Twins with entire egg shell cut away, showing intact embryonic membranes of small twin and position of common yolk sac. Fig. 3 (below). Twins removed from egg, showing size disparity and posterior curvatures of carapaces.

small twin (carapace length 17.2 mm), like the small members of other known sets of turtle twins is deformed, with right pleurals 1-4 divided, central 2 divided, left pleural 4 divided, and left pleurals 1 and 2 fused.

Acknowledgments—We thank L. E. Brown and D. Moll for reviewing the manuscript.

LITERATURE CITED

Crooks, F. D., and P. W. Smith. 1958. An instance of twinning in the box turtle. Herpetologica 14:170-171.

Yntema, C. L. 1970. Twinning in the common snapping turtle, *Chelydra serpentina*. Anat. Rec. 166:491-498.

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Biological Sciences

ELEMENT CONTENT OF HYDRILLA AND WATER IN FLORIDA[1]

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Abstract: Hydrilla verticillata *and the water in which it grew were analyzed from a lake and a ditch over 12 mo. Hydrilla from the ditch, compared to that from the lake had more Ca (2.6), Fe (3), Na (1.8), similar amounts of P, Mg, Cr, and less Zn (.8), K (.66), Cu (.07), Mn (.25). Ditch compared to lake water had more Ca (5), Fe (9), Na (3), P (10), Mg (4), Zn (4), Cu (1.6), and similar amounts of Cr, K, Mn.*

Mechanical methods of harvesting aquatic weeds (Grinwald, 1968; Wunderlich, 1967) are used at times because chemicals may leave undesirable residues and biological controls are not available for most species of weeds. Chemical analysis (Boyd, 1968) and feeding trials with steers (Stephens et al., 1972) demonstrated that significant amounts of many mineral nutrients are present in aquatic plants. Plants used as feed should have a quantitative elevation of the elements as to season and collection site. Concentrations of 10 nutrient elements in hydrilla (*Hydrilla verticillata* Royle) and in water at the growing site were compared at approximately monthly intervals throughout a year.

Methods—Hydrilla and water were obtained from Little Lake Fairview, Winter Park and a drainage ditch on the eastern side of Sarasota. Samplings were made at intervals from March 1970 through February 1971. Hydrilla was removed from the lake with a mechanical harvester 5-15 m from shore and 1-2 m deep. The ditch was 3 m wide and 1 m deep. Plants from the ditch were gathered with large hand fork and samples of surrounding water were taken in plastic bottles and stored at 4°C. Hydrilla samples were air dried at 60°C and ground in a Wiley mill. Phosphorus was determined by the method of Fish and Subbarow (1925). Atomic absorption spectrophotometry was used to determine Ca, Mg, K, Na, Fe, Cu, Zn, Mn and Cr (Anonymous, 1964). Element content was calculated on the dry wt basis.

Results and Discussion—*Calcium.* Lake hydrilla contained 1.8-5.6% (avg 3.2) Ca and ditch plants had 4.8-14.6% (avg 8.3), $P < 0.01$ (Table 1). Boyd (1969) reported mean Ca values greater than 4% for hydrilla. Calcium in lake water varied throughout the year from 14-21 mg/1 (avg 16) and in ditch water from 54 to 105 mg/1 (avg 75), $P < 0.01$, as shown in Table 2. The higher concentration of Ca in ditch water may account for the high Ca content of ditch plants. Calcium content varied little from month to month in both lake water and hydrilla.

[1]Florida Agricultural Experiment Station Journal Series No. 4841.

TABLE 1. Concentration of nutrient mineral elements in hydrilla from two sources in Florida[1]

		1970									1971		
		3/12	4/27	6/2	6/25	7/24	8/27	10/1	10/29	12/2	1/1–1/8	2/10	avg.
Ca, %	Lake	1.9	2.2	2.9	5.5	4.7	5.6	2.4	2.3		1.8	2.5	3.2
	Ditch	5.4	4.8	8.9	6.2	9.0	8.0	10.0	5.5	14.6	10.8	7.9	8.3
P, %	Lake	.3	.4	.3	.3	.4	.3	.7	.6		.7	.3	.4
	Ditch	.7	.8	.4	.4	.3	.3	.5	.7	.6	.6	.2	.5
Mg, %	Lake	.4	.4	.4	.9	.8	.7	.6	.6		.4	.3	.6
	Ditch	.5	.5	.6	.6	.6	.5	.8	.5	.6	.6	.4	.6
K, %	Lake	10.2	8.2	6.3	7.8	7.8	7.7	8.1	7.9		8.9	7.9	8.1
	Ditch	6.8	7.3	4.6	4.1	3.2	4.2	5.9	4.9	5.3	5.9	4.2	5.1
Na, %	Lake	.9	.8	.7	.8	.8	.8	.8	.9		.9	.9	.8
	Ditch	1.6	1.2	1.7	2.0	2.0	.8	1.7	1.2	1.1	1.2	.9	1.4
Fe, mg/kg	Lake	3490	5180	3510	1491	1764	1104	1918	1358		2212	2252	2428
	Ditch	5170	7292	4565	5108	2526	15271	3558	8846	9095	9351	7520	7118
Cu, mg/kg	Lake	36	135	222	138	132	61	328	177		109	116	145
	Ditch	12	11	16	14	14	25	9	4	8	2	0	10
Zn, mg/kg	Lake	1476	1612	191	109	123	137	177	119		187	1218	535
	Ditch	1626	191	1253	196	108		140	121	115	116	108	397
Mn, mg/kg	Lake	866	735	217	97	104	108	273	225		517	458	360
	Ditch	45	44	66	35	40	165	155	91	137	131	104	92
Cr, mg/kg	Lake	3	26	32	11	16	6	12	3		5	10	12
	Ditch	6	11	4	13	10	32	19	15	9	12	11	13

[1]Dry weight basis.

The Ca values for hydrilla are greater than those given for 12 land forages in Florida that ranged from 0.2 to 1.6% (Cunha et al., 1964).

Phosphorus. Phosphorus concentrations in the water samples from the lake and ditch ranged from 0-0.4mg/1 (avg 0.2) and 0.4-4 mg/1 (avg 1.9), respectively, $P < 0.01$. The mean P concentration of 1729 samples of surface water in the United States was 0.087 mg/1 (0.001-5.0) in Storet (NAS, 1972). Hydrilla from the two sources was quite similar in P content, 0.3 to 0.7% (avg 0.4) and 0.2-0.8% (avg 0.5), respectively. These values are quite close to the 0.4% P for hydrilla reported by Steward (1970). Ditch water contained approximately 9 times more P than lake water, but hydrilla from the ditch had only slightly more P.

The overall range in P values from 0.2 to 0.8% in the aquatic plant is double the range of 0.1-0.4% P reported in 12 land forages (Cunha et al., 1964). It is possible to obtain a very wide ratio of Ca to P by including hydrilla at high levels in diets. Stephens et al. (1972) observed that a Ca:P ratio of 17.6:1 in a 33% hydrilla ration resulted in a retention of only 2.0 g P per day per steer whereas with a Ca:P ratio of 2.7:1 in a 33% hyacinth (*Eichhornia crassipes*) ration 6.1 g P was retained.

Magnesium. Magnesium levels were 3 to 5 mg/1 (avg 3.4) in the lake and 7-16 mg/1 (avg 12.1) in the ditch, $P < 0.01$. Lake values are quite low as concentrations in 1143 waters had a mean of 14.3 mg/1 (8.5-137) (Storet NAS, 1972). The values for hydrilla from the lake and ditch, 0.3-0.9% (avg 0.6) and 0.4-0.8% (avg 0.6), were not influenced by the approximately 4-fold greater content of Mg in the ditch water. Boyd (1969) reported similar Mg values in three species of water weeds though other macrominerals varied. Values of 12 Florida land forages ranged from 0.02 to 0.5% (Cunha et al., 1964).

Potassium. Potassium values for the lake were 2-4 mg/1 (avg 3.0) and 0.8-9 mg/1 (avg 3.3) for the ditch. The mean concentration of 1804 water samples in Storet (NAS, 1972) was 4.3 mg/1 (0.06-370). Hydrilla from the lake, however, had 6.3-10.2% (avg 8.1) K compared to 3.2-7.3% (avg 5.1) from the ditch, $P < 0.01$. These values are very high as 48 samples of pangola grass analyzed in our laboratory had 0.11-1.08% (avg 0.54) and 29 samples of Pensacola Bahia grass had 0.72-2.0% (avg 1.31) K.

Sodium. Hydrilla from the lake contained 0.7-0.9% (avg 0.8) Na compared to 0.8-2.0% (avg 1.4) from the ditch, $P < 0.01$. Lake water varied from 9 to 36 mg/1 (avg 13) and ditch water 15-57 mg/1 (avg 39), $P < 0.01$. The amount of Na in the plants appears to be related to that in the water as occurred with Ca.

Iron. Values for Fe in the hydrilla ranged from 1,104 to 5,180 mg/kg (avg 2,428) for the lake and 2,526-15,271 mg/kg (avg 7,118) for the ditch, $P < 0.01$. Concentrations of Fe in the water from the lake and ditch were 19-51 μg/1 (avg 34) and 45 to 1718 μg/1 (avg 314), respectively. The mean of 1836 samples in Storet (NAS, 1972) was 43.9 μg/1 (0.10 to 4600). The elevated levels of Fe in the water were accompanied by greater concentrations of Fe in the plant.

TABLE 2. Concentration of nutrient mineral elements in water from two sources in Florida.

		1970									1971		
		3/12	4/29	6/2	6/25	7/24	8/27	10/1	10/29	12/2	1/1-1/8	2/10	Avg.
Ca, mg/l	Lake	14	17	14	14		21	19	20		15	14	16
	Ditch	57	105	63	59	101	79	73	93	66	54		75
P, mg/l	Lake	.3	0	.1			.4	.2			.1	.1	.2
	Ditch	4	.9	1	2	3	2	2	3	.6	.4		1.9
Mg, mg/l	Lake	3	3	3	3		5	5	3		3	3	3.4
	Ditch	8	16	10	7	13	13	12	13	15	14		12.1
K, mg/l	Lake	4	3	3	3		2	2	3		3	4	3.0
	Ditch	3	6	.8	.8	1	3	2	9	4	3		3.3
Na, mg/l	Lake	10	11	12	11		9	10	36		10	11	13
	Ditch	39	43	19	15	26	54	57	53	40	41		39
Fe, µg/l	Lake	33	37	23	25		51	41	48		19	26	34
	Ditch	77	117		45	82	51	329	362	47	1718		314
Cu, µg/l	Lake	10	14	12	11		8	16	15		14	11	12
	Ditch	19	29		18	22	24	17	10	18	18		19
Zn, µg/l	Lake	61	32	16	17		42	28	24		18	13	28
	Ditch	38	51		29	54	28	32	48	59	676		113
Mn, µg/l	Lake	5	10	4	6		4	4	4		5	6	5.3
	Ditch	4	7		5	5	4	5	10	6	10		6.2
Cr, µg/l	Lake	4	5	3	0		2	2	0		3	2	2.3
	Ditch	5	3		2	4	2	1	2	1	3		2.6

Copper. Copper concentrations in the water were generally higher in the ditch, 10-29 μg/1 (avg 19) than in the lake which ranged 8-16 μg/1 (avg 12), $P < 0.01$. The mean Storet (NAS, 1972) concentration in 1871 samples was 13.8 μg/1 (0.8-280.0). Hydrilla samples from the lake, however, were much higher in Cu, 36-328 mg/kg, (avg 145) than those from the ditch, range 0-25 mg/kg (avg 10), $P < 0.01$. Values for the hydrilla from the ditch are typical of land forages. The high concentrations of Cu in the hydrilla from the lake may have been due to treatment of the water for algae. The applied Cu may have remained at a high concentration only a short time due to rapid assimilation in the plant tissue, precipitation in sediment, or by dilution with fresh water. Sutton and Blackburn (1971) reported increased amounts of copper occurred in hyacinths when Cu in the water was increased from 0.5 to 4.0 mg/1. Buchman, Shirley and Killinger (1968) found that top-dressing star millet (*Pennisetum americanum* (L.) K. Schum.) with 28 kg copper sulfate per hectare 7 days prior to harvest increased Cu content from 8 to 88 mg/kg though the millet was irrigated with overhead sprinkling.

Zinc. Ranges in zinc values for the hydrilla were similar; from the lake 109-1612 mg/kg (avg 535) compared to 108-1626 mg/kg (avg 397) from the ditch. Land forages usually contain 15-30 mg of Zn/kg. Zinc concentrations in water from the lake and ditch were 13-61 μg/1 (avg 28) and 28-676 μ/1 (avg 113), respectively. The mean Storet (NAS, 1972) value of 1883 samples was 51.8 μg/1 (1.0 to 1,182).

Manganese. Lake hydrilla ranged from 97-866 mg Mn/kg (avg 360) with January, February, March and April values 2-4 fold higher than other months. Hydrilla from the ditch was in the range of land forage, 35-165 mg/kg (avg 92). Concentration in lake water was 4-10 (avg 5.3) and in the ditch, 4-10 μg/1 (avg 6.2). The mean Storet (NAS, 1972) Mn in 1818 samples was 29.4 μg/1 (0.2-3,230).

Chromium. The Cr in hydrilla from the lake and ditch was 3-32 (avg 12) and 4-32 mg/kg (avg 13), respectively. Concentrations of Cr in the water from the lake and ditch were 0-5 (avg 2.3) and 1-5 μg/1 (avg 2.6). Chromium has been demonstrated to be required in carbohydrate metabolism (Schwarz and Mertz, 1959).

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LITERATURE CITED

Anonymous. 1964. Analytical Methods for Atomic Absorption Spectrophotometry. Perkin-Elmer Corp. Norwalk, Connecticut.

Boyd, C. E. 1968. Evaluation of some common aquatic weeds as possible feedstuffs. Hyacinth contr. J. 7:26-27.

__________. 1969. The nutritive value of three species of water weeds. Economic Bot. 23:123-127.

Buchman, D. T., R. L. Shirley and G. B. Killinger. 1968. Nitrate, ammonia and methemoglobin in sheep when fed millet containing different levels of copper. Proc. Soil Crop Sci. Soc. Florida 28:209-215.

Cunha, T. J., R. L. Shirley, H. L. Chapman, Jr., C. B. Ammerman, G. K. Davis, W. G. Kirk and J. F. Hentges, Jr. 1964. Minerals for Beef Cattle in Florida. Agric. Exper. Sta. Univ. Florida Bull. 683. Gainesville.

FISKE, C. A., AND I. SUBBAROW. 1925. The colorimetric determination of phosphorus. J. Biol. Chem. 66:375-400.

GRINWALD, M. E. 1968. Harvesting aquatic vegetation. Hyacinth Contr. J. 7:31-32.

NATIONAL ACADEMY OF SCIENCES. National Academy of Engineering. 1972. Water Quality Criteria. Supt. of Doc. Washington, D. C.

SCHWARZ, R., AND W. MERTZ. 1959. Chromium (111) and the glucose-tolerance factor. Arch.Biochem. Biophys. 85:292-295.

STEPHENS, E. L., J. F. EASLEY, R. L. SHIRLEY AND J. F. HENTGES, JR. 1972. Availability of nutrient mineral elements and potential toxicants in aquatic plant diets fed steers. Soil Pl. Sci. Soc. Florida Proc. 32:30-32.

STEWARD, K. K. 1970. Nutrient removal potentials of various aquatic plants. Hyacinth Contr. J. 8: 34-35.

SUTTON, D. L., AND R. D. BLACKBURN. 1971. Uptake of copper by water hyacinth. Hyacinth Contr. J. 9:18-20.

WUNDERLICH, W. E. 1967. The use of machinery in the control of aquatic vegetation. Hyacinth Contr. J. 6:22-24.

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EFFECTS OF A HURRICANE ON THE FISH FAUNA AT DESTIN, FLORIDA—*Stephen A. Bortone*, Faculty of Biology, University of West Florida, Pensacola, Florida 32504

ABSTRACT: *A pre- and post-storm SCUBA inspection of relative abundance of fish species was conducted at a rock jetty in the northern Gulf of Mexico. As little or no change occurred in the fish fauna between the sampling dates, it is concluded that the storm had little effect on the fauna.*

EFFECTS of severe storms and hurricanes on fish communities are documented (e.g., Breder, 1962; Tabb and Jones, 1962; Hubbs, 1962). Additionally, several studies have assessed the effects of storms and hurricanes on fishes occurring at reef and reef-like areas in tropical-subtropical regions. However, reports of those effects have not shown consistent results. Robins (1957) indicated that several reef-associated fish species were found dead or injured because their gill areas were damaged by the heavy sand load and seas during a tropical storm near Key Biscayne, Florida. Beecher (1973) noticed a slight decrease in avg length of a population of *Pomacentrus variabilis* after the occurrence of hurricane winds and seas near a rock jetty at St. Andrews Bay, Florida. Springer and McErlean (1962) noted a lack of displacement of reef fish populations by a severe storm which otherwise destroyed much of the coral formation in the area.

On the morning of 23 September 1975 Hurricane Eloise reached the coastal northern Gulf of Mexico between Destin and Panama City, Florida. The occurrence of this storm presented a unique opportunity to evaluate the potential effects such a severe storm may have on a shallow rock-jetty community composed of many reef fishes.

No weather recording station is located at Destin, but the storm severity was recorded a few km east of Destin at Fort Walton Beach. The highest winds were recorded at 145-195 kph and the severest winds were from the north. The tide surge was 1.5 m above normal and seas were approximately 4 m high.

The east and west jetties at East Pass, Destin, Florida were finished in 1968 and numerous reef fishes have since taken up permanent or transitory residence at the jetties (Hastings, 1972). Hastings noted a preponderance of reef fishes during his long term study of seasonal and successional fish populations on these jetties.

Pre-storm inspection of the ocean side of the west jetty was conducted on 20 September 1975 and a post-storm investigation was done on 28 September 1975. Pre-storm site data were: tide, flooding and flood; bottom and surface water temp, 28°C; bottom and surface salinity, 32 ‰; time, 11:00-14:30 CDT; depth, 2-6 m; visibility, 3-5 m. Post-storm site data were: tide, ebbing; bottom water temp, 27°C; surface water temp, 23°C; bottom salinity, 32‰; surface salinity, 18 ‰; time, 11:30-14:30 CDT; depth, 2-6 m; visibility, 1-2 m. SCUBA was utilized to conduct the underwater assessment of species present and their approximate abundance according to the following scale: A = abundant, more than 25 individuals of a species per inspection dive; C = common, 11-25; F = frequent, 6-10; 0 = occasional, 2-5; R = rare, 1.

Species occurrence and abundance data for both pre- and post-storm inspection dates are presented in Table 1. Twenty-seven fish species (90% of the total fauna seen on both dates) were observed on the pre-storm inspection and only 20 (66.7% of the total fauna) were seen after the storm. However, a faunal comparison through SCUBA observation is affected by water clarity and other factors, thus it is reasonable to exclude from this analysis species which were recorded but once on either sample date. Even under ideal conditions experience indicates that a single representative of a species may be missed. If we exclude species which were seen once as single individuals, 91.7% of the total fauna (22 species) was present before the storm and 79.2% (19 species) after the storm. A Sign test (Seigel, 1956) indicated there is a significant difference (at the 0.05 level) between the pre- and post-storm fish faunas including all species. However, if species recorded only once are again excluded from the comparison, there is no statistically significant difference in the fish fauna between sampling dates.

Little observable change was strongly evident in species populations which were abundant or common. However, I did note decreases in *Orthopristis chrysoptera* and *Chaetodipterus faber* and an increase in *Lutjanus griseus* after the storm. The most obvious change in the rock-jetty community was reduction in length of attached algae (principally *Polysiphonia* and *Gracilaria*) from approximately 50-75 mm to only 10-20 mm. Also, more sand was seen on the rocks comprising the jetty. No apparent behavioral differences were noted in the species common to both sample dates. Also, I saw no injuries or unusual wounds which may have been caused by large waves or tidal surge.

Discussion—Few major changes in the fish community occurred as a result of a severe hurricane in the immediate vicinity of the Destin jetty in the Fall 1975. Some authors have noted dramatic changes in fish faunas due to storms, but the apparent lack of effect at Destin may be explained in several ways.

Changes in fish populations in estuarine areas have been attributed to oxygen depletion brought on by the vertical mixing caused by turbulent seas (Creaser, 1942). Although dissolved oxygen was not measured during this study, the ocean

TABLE 1. Relative abundance of species observed prior to (20 September 1975) and after (28 September 1975) Hurricane Eloise at the West Jetty, Destin, Florida. (A = abundant, 25; C = common, 11-25; F = frequent, 6-10; O = occasional, 2-5; R = rare, 1; +, -, and ϕ refer to an increase, decrease, or no change in the number of individuals seen after the storm).

Species	Sampling Date 20 Sept. '75	28 Sept. '75	Net Change
Narcine brasiliensis (Olfers)	R	-	(-)
Dasyatis sp.	R	R	ϕ
Gobiesox strumousus Cope	R	R	(-)
Serraniculus pumilio Ginsburg	-	O	+
Serranus subligarius (Cope)	C	F	-
Caranx bartholomaei (Cuvier)	O	O	ϕ
C. hippos (Linnaeus)	O	R	-
Lutjanus griseus (Linnaeus)	C	A	+
L. synagris (Linnaeus)	O	R	-
Orthopristis chrysoptera (Linnaeus)	F	-	-
Diplodus holbrooki (Bean)	C	C	ϕ
Lagodon rhomboides (Linnaeus)	A	A	ϕ
Chaetodipterus faber (Broussonet)	F	-	-
Chaetodon ocellatus Bloch	O	-	-
Holacanthus bermudensis Goode	-	O	+
Abudefduf saxatilus (Linnaeus)	R	O	+
Pomacentrus variabilis (Castelnau)	A	A	ϕ
Halichoeres bivittatus (Bloch)	A	A	ϕ
Thallassoma bifasciatum (Bloch)	F	F	ϕ
Nicholsina usta (Valenciennes)	F	O	-
Sparisoma radians (Valenciennes)	O	O	ϕ
Astroscopus y-graecum (Cuvier)	R	-	(-)
Hypleurochilus geminatus (Wood)	A	A	ϕ
Acanthurus chirurgus (Bloch)	C	F	-
A. randalli Briggs and Caldwell	C	C	ϕ
Paralichthys albigutta Jordan and Gilbert	O	-	-
Balistes capriscus Gemlin	-	R	(+)
Cantherhines pullus (Ranzani)	R	-	(-)
Sphoeroides nephelus (Goode and Bean)	R	-	(-)
Chilomycterus schoepfi (Walbaum)	O	-	-

side of the jetty is constantly flushed by oxygenated ocean water. Therefore, oxygen depletion is not likely to occur at the Destin jetty.

Robins (1957) attributed deaths and injury to the strong surge and sediment load caused by storm winds. Even though seas and tidal surge were higher than normal at Destin, one must consider that the strongest storm winds were from the north. The ocean side of the jetty, therefore, was not subject to a long fetch and correspondingly, the severest storm seas. Springer and McErlean (1962) and Bortone (1971) noted that reef species may protect themselves from a strong surge or current by taking up positions under or behind reef structures. Numerous such protected areas exist at the Destin jetty which is composed of large, irregular rocks.

Changes observed in several species may be explained by factors other than the storm. *Orthopristis chrysoptera* forms loosely aggregated schools and may have migrated as a group to the bay side of the jetty. This species is often considered an estuarine-bay species. *Chaetodipterus faber* has pelagic habits and schools are observed irregularly at reef sites and as they constantly move a diver may miss seeing them. *Lutjanus griseus* was more numerous after the storm, but they normally increase during the fall at the Destin jetties (Hastings, 1972).

The storm may have long term effects on the area. Many species at Destin are presumed to migrate to deeper, offshore reefs at the onset of colder weather (Hastings, 1972). The hurricane may have lowered the water temperature in the coastal northern Gulf which could initiate a precocious offshore movement. Also the obvious depletion of algae may subsequently limit the number of grazers (Scaridae and Acanthuridae) which occur in the area. The apparent "survival" of the reef-fish fauna at Destin may be attributed to several of the previously mentioned factors or that the fauna is comprised of colonizing species, and these may be hardier and less susceptible to fluctuations in parameters than are other reef species which are indigenous to lower latitude coral reefs.

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LITERATURE CITED

BEECHER, H. A. 1973. Effects of a hurricane on a shallow-water population of damsel fish, *Pomacentrus variabilis*. Copeia 1973:613-615.

BORTONE, S. A. 1971. Studies on the biology of sand perch, *Diplectrum formosum* (Perciformes: Serranidae). Florida Dept. Nat. Res. Tech. Ser. 65:1-27.

BREDER, C. M. 1962. Effects of a hurricane on the small fishes of a shallow bay. Copeia 1962:459-462.

CREASER, E. P. 1942. Fish mortality resulting from effects of a tropical hurricane. Copeia 1942:48-49.

HASTINGS, R. W. 1972. The Origin and Seasonality of the Fish Fauna on a New Jetty in the Northeastern Gulf of Mexico. Ph.D. dissert. Florida State Univ. Tallahassee.

HUBBS, C. 1962. Effects of a hurricane on the fish fauna of a coastal pool and drainage ditch. Texas J. Sci 14:289-296.

ROBINS, C. R. 1957. Effects of storms on the shallow-water fish fauna of Southern Florida with new records of fishes from Florida. Bull. Mar. Sci. Gulf Carib. 7:266-275.

SIEGEL, S. 1956. Nonparametric Statistics for the Behavioral Sciences. McGraw-Hill. New York.

SPRINGER, V. G., AND A. J. MCERLEAN. 1962. A study of the behavior of some tagged South Florida coral reef fishes. Amer. Midl. Nat. 67:386-397.

TABB, D. C., AND A. C. JONES. 1962. Effect of Hurricane Donna on the aquatic fauna of north Florida Bay. Trans. Amer. Fish. Soc. 91:375-378.

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Biological Sciences

PARTIAL FOOD LIST OF THREE SPECIES OF ISTIOPHORIDAE (PISCES) FROM THE NORTHEASTERN GULF OF MEXICO

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ABSTRACT: *Stomach analyses were performed on 53 white marlin,* Tetrapturus albidus; *11 sailfish,* Istiophorus platypterus; *and 5 blue marlin,* Makaira nigricans *captured in the Gulf of Mexico, 30-100 km S of Pensacola, Florida from May to October, 1974. Stomach content analyses were conducted using frequency of occurrence, numerical, and gravimetric (wet wt) methods. Stomachs of white marlin and sailfish most frequently contained* Euthynnus *sp.,* Auxis *sp., squid, and Atlantic moonfish,* Vomer setapinnis. *White marlin were also reported for the first time feeding on barracuda and puffers.* Thunnus *sp.,* Euthynnus *sp., and* Auxis *sp. were most common food items of blue marlin, however, cephalopods may be of some importance in their diet.*

BILLFISHES are economically important to the marine sport fishing industry of many coastal areas in the United States. Commercial longline fishing may be endangering this industry by over-fishing billfish populations in certain areas. Talbot and Wares (1975) reported that after entry of commercial longline fishing in the Pacific Ocean off Mexico, there was a decrease in the catch-per-unit-effort of striped marlin, *Tetrapturus audax* (Philippi); blue marlin *Makaira nigricans* Lacépède; and black marlin, *Makaira indica* (Cuvier) and a decrease in the avg wt of striped marlin. In order to effectively manage existing billfish stocks, an understanding of their biology is essential. An analysis of the food of these fishes will help define the trophic relationships of billfishes and their pelagic environment.

While associated with the National Marine Fisheries Service at Panama City, Florida, the senior author had an opportunity to collect stomach contents of billfishes captured with hook-and-line by sport fishermen. These data are the first indication of the food of billfishes in the northeastern Gulf of Mexico.

MATERIALS AND METHODS—The stomach contents of 53 white marlin, *Tetrapturus albidus* Poey; 11 sailfish, *Istiophorus platypterus* (Shaw and Nodder); 5 blue marlin, *Makaira nigricans* Lacépède captured in the Gulf of Mexico, 30-100 km S of Pensacola, Florida from May to October, 1974 were examined. Upon landing, stomachs (including the esophagus, but excluding the intestine) were removed and the contents preserved in 10% formalin. Some loss of food by regurgitation may have occurred prior to removal of stomachs. Body length of billfish was measured from the anterior tip of the lower jaw to the posterior margin of the middle caudal rays according to Rivas (1956). Food items were identified to species whenever possible. Hard parts such as skulls, gillrakers, vertebrae,

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spines and rays proved valuable in the identification of fish items. Data presented by Mansueti and Mansueti (1962), de Sylva (1955) and Starks (1950) were used to identify scombrids. Carangids were identified according to Ginsburg (1952).

TABLE 1. List of food items found in 53 white marlin stomachs (145-185 cm Body Length) collected in the northeastern Gulf of Mexico.

Food Item	Number	Percent Number	Wet Wt (g)	Percent Wt	Frequency of Occurrence	Percent Occurrence
SCOMBRIDAE:						
Euthynnus alletteratus	44	4.7	1235.8	19.5	16	30.1
Euthynnus sp.	73	7.8	1096.7	17.3	22	41.5
Auxis sp.	51	5.5	1322.4	20.9	20	37.7
Thunnus sp.	1	0.1	19.0	0.3	1	1.8
Unidentified scombrids	10	1.0	70.2	1.1	8	15.0
TOTAL SCOMBRIDS	179	19.3	3744.1	59.3	34	64.1
CARANGIDAE:						
Caranx crysos	3	0.3	902.4	14.2	3	5.6
Caranx sp.	2	0.2	13.9	0.2	1	1.8
Chloroscombrus chrysurus	3	0.3	2.6	0.0	3	5.6
Vomer setapinnis	683	73.6	1136.8	18.0	15	28.3
Unidentified carangids	8	0.8	27.0	0.4	7	13.2
TOTAL CARANGIDS	699	75.4	2082.7	33.0	23	43.3
EXOCOETIDAE:						
Hemiramphus brasiliensis	2	0.2	196.0	3.1	2	3.7
Hemiramphus sp.	3	0.3	154.9	2.4	2	3.7
TOTAL EXOCOETIDS	5	0.5	350.9	5.5	4	7.5
SPHYRAENIDAE:						
Sphyraena sp.	1	0.1	1.1	0.0	1	1.8
TETRAODONTIDAE:						
Unidentified tetraodontids	7	0.7	9.9	0.1	4	7.5
BALISTIDAE:						
Balistes sp.	2	0.2	3.2	0.0	2	3.7
Unidentified fish	9	0.9	19.7	0.3	7	13.2
CEPHALOPODA:						
Unidentified squid	25	2.6	99.6	1.5	17	32.0
Empty	----	----	----	----	16	30.1

Coryphaenids were identified according to Collette et al. (1969). Stomach analyses were conducted according to methods described by Windell (1971): frequency of occurrence, number of stomachs in which each food item occurred; numerical, number of individuals of each food item; and gravimetric, wet wt of each food item, measured to nearest 0.1 g.

OBSERVATIONS AND DISCUSSION—The exocoetids (Tables 1 and 3) probably represent bait since ballyhoo, *Hemiramphus brasiliensis,* are a popular bait of local anglers and because all exocoetids found in billfish stomachs were relatively undigested compared to other food items examined.

Stomachs of white marlin most frequently contained squid, *Auxis* sp., *Euthynnus* sp., and Atlantic moonfish, *Vomer setapinnis* (Table 1). The blue runner, *Caranx crysos*, accounted for 14.2% of the food by wt, but was not important in number or frequency of occurrence. Food item wt may be exaggerating the importance of this species in white marlin diet as one blue runner weighed 977 g and accounted for 97.1% of the food item wt. Importance of blue runner as a food item is probably more accurately reflected in the number of individuals (3) found and its low frequency of occurrence (5.6%). Wallace and Wallace (1942) and de Sylva and Davis (1963) reported round herring, *Etrumeus teres*, as occurring most frequently in stomachs of white marlin caught off the coast of Maryland, while scombrids and carangids occurred at a lower frequency of occurrence than reported in the present study. Differences in diet between areas may reflect dif-

TABLE 2. List of food items found in 5 blue marlin stomachs (180-254 cm body length) collected in the northeastern Gulf of Mexico

Food Item	Number	Percent Number	Wet Wt (g)	Percent Wt	Frequency of Occurrence	Percent Occurrence
SCOMBRIDAE:						
Euthynnus sp.	4	30.7	77.5	3.0	2	40.0
Auxis sp.	2	15.3	28.6	1.1	1	20.0
Thunnus thynnus	1	7.6	30.7	1.2	1	20.0
Thunnus sp.	2	15.3	38.8	1.5	2	40.0
TOTAL SCOMBRIDS	9	69.2	175.6	6.9	3	60.0
CARANGIDAE:						
Caranx crysos	1	7.6	713.9	28.3	1	20.0
Chloroscombrus chrysurus	1	7.6	0.5	0.0	1	20.0
TOTAL CARANGIDS	2	15.3	714.4	28.4	1	20.0
CORYPHAENIDAE:						
Coryphaena hippurus	1	7.6	1622.3	64.5	1	20.0
Unidentified fish	1	7.6	2.8	0.1	1	20.0
Empty	----	----	----	----	1	20.0

ferences in distribution of prey species and their abundance between localities. Squid was one of the three most frequently occurring food items of white marlin in this study and studies by Wallace and Wallace (1942), de Sylva and Davis (1963), and Krumholz and de Sylva (1958). The present study reports for the first time white marlin feeding on barracuda and puffers.

Euthynnus sp., *Auxis* sp., Atlantic moonfish, and squid were the most common items in stomachs of sailfish (Table 3). Only one pompano dolphin, *Coryphaena equisetis*, was found, and it accounted for 17.0% of the food wt. Voss (1953) examined 241 sailfish and reported little tuna, *Euthynnus alletteratus*; and flying squid, *Stenoteuthis bartrami*, as numerically important foods.

Scombrids (i.e., *Euthynnus* sp., *Auxis* sp., and *Thunnus* sp.) comprised the largest portion of blue marlin stomach contents by frequency of occurrence and number of individuals, while blue runner and dolphin, *Coryphaena hippurus*, were dominant food items by wt (Table 2). The disparity between analytical methods occurs because only one blue runner and one dolphin were found, but they were large fish and accounted for 28.3% and 64.5%, respectively, of food wt.

TABLE 3. List of food items found in 11 sailfish stomachs (149-167 cm body length) collected in the northeastern Gulf of Mexico.

Food Item	Number	Percent Number	Wet Wt (g)	Percent Wt	Frequency of Occurrence	Percent Occurrence
SCOMBRIDAE:						
Euthynnus alletteratus	8	2.2	344.6	18.8	4	36.3
Euthynnus sp.	12	3.4	228.1	12.4	4	36.3
Auxis sp.	5	1.4	174.6	9.5	3	27.2
TOTAL SCOMBRIDS	25	7.1	747.3	40.9	8	72.7
CARANGIDAE:						
Caranx crysos	1	0.2	14.3	0.7	1	9.0
Vomer setapinnis	310	88.3	632.8	34.6	6	54.5
Unidentified carangid	1	0.2	21.4	1.1	1	9.0
TOTAL CARANGIDS	312	88.8	668.5	36.6	6	54.5
EXOCOETIDAE:						
Unidentified exocoetidae	2	0.5	37.8	2.0	1	9.0
CORYPHAENIDAE:						
Coryphaena equisetis	1	0.2	311.4	17.0	1	9.0
Unidentified fish	5	1.4	34.8	1.9	3	27.2
CEPHALOPODA:						
Unidentified squid	6	1.7	25.2	1.3	5	45.4
Empty	----	----	----	----	3	27.2

Frigate mackerel, *Auxis thazard*; blackfin tuna, *Thunnus atlanticus*; skipjack tuna, *Euthynnus pelamis*; dolphin, and cephalopods occurred in stomachs of blue marlin caught off the Bahamas (Krumholz and de Sylva, 1958). De Sylva (1974) reported tunas, frigate mackerel, and cephalopods as comprising the main food items of blue marlin in the Atlantic Ocean.

Euthynnus sp., *Auxis* sp., Atlantic moonfish and squid apparently comprise the main food of white marlin in the northeastern Gulf of Mexico. Conclusions concerning the main diets of sailfish and blue marlin could not be made because of limited sample size (N = 16). However, stomach contents of sailfish were similar to white marlin. The five blue marlin had consumed mostly scombrids, (*Thunnus* sp., *Euthynnus* sp., and *Auxis* sp.,) but cephalopods may also be important in their diet. Additional studies are still needed to make comparisons of billfish food from the Gulf of Mexico with other areas.

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LITERATURE CITED

COLLETTE, B. B., R. H. GIBBS, AND G. E. CLIPPER. 1969. Vertebral numbers and identification of the two species of dolphin (*Coryphaena*). Copeia 1969:630-631.

GINSBURG, I. 1952. Fishes of the family Carangidae of the northern Gulf of Mexico and three related species. Publ. Inst. Mar. Sci. Texas 2:43-118.

KRUMHOLZ, L. A., AND D. P. DE SYLVA. 1958. Some foods of marlins near Bimini, Bahamas. Bull. Amer. Mus. Nat. Hist. 114:377-416.

MANSUETI, R. J., AND A. J. MANSUETI. 1962. Little tuna, *Euthynnus alletteratus*, in northern Chesapeake Bay, Maryland, with an illustration of its skelton. Chesapeake Sci. 3:257-263.

RIVAS, L. R. 1956. Definitions and methods of measuring and counting in billfishes (Istiophoridae, Xiphiidae). Bull. Mar. Sci. Gulf Carib. 6:18-27.

STARKS, E. C. 1950. The osteology and mutual relationships of the fishes belonging to the family Scombridae. California Fish Game, Fish Bull. 79:77-99.

SYLVA, D. P. DE 1955. The osteology and phylogenetic relationships of the blackfin tuna, *Thunnus atlanticus* (Lesson). Bull. Mar., Sci. Gulf Carib. 5:1-41.

———. 1974. Life history of the Atlantic blue marlin, *Makaira nigricans*, with special reference to Jamaican waters (abstract). p. 80. *In* R. S. SHOMURA AND F. WILLIAMS (ed.). Proc. Internat. Billfish Symp. Kailua-kona, Hawaii, 9-12 August 1972. Part 2. Review and contributed papers. NOAA Techn. Rept. NMFS SSRF-675.

———, AND W. P. DAVIS. 1963. White Marlin, *Tetrapturus albidus*, in the Middle Atlantic Bight, with observations on the hydrography of the fishing grounds. Copeia 1963:81-99.

TALBOT, G. B., AND P. G. WARES. 1975. Fishery for Pacific billfish off Southern California and Mexico, 1903-69. Trans. Amer. Fish. Soc. 104:1-12.

VOSS, G. L. 1953. A contribution to the lift history and biology of the sailfish, *Istiophorus americanus* Cuv. and Val., in Florida waters. Bull. Mar. Sci. Gulf Carib. 3:206-240.

WALLACE, D. H., AND E. M. WALLACE. 1942. Observations on the feeding habits of the white marlin *Tetrapturus albidus* Poey. Publ. Chesapeake Bio. Lab. Maryland Dept. Res. Educ. 50:1-10.

WINDELL, J. T. 1971. Food analysis and rate of digestion. Pp. 215-226. *In* W. E. RICKER (ed.) Methods for Assessment of Fish Production in Fresh Water (2nd ed.). Blackwell Scientific Publ. Oxford.

Florida Sci. 39(4): 249-253. 1976.

Biological Sciences

THE INFLUENCES OF INTRAVENOUSLY ADMINISTERED DIMETHYL SULFOXIDE ON REGIONAL BLOOD FLOW

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Abstract: *The effects of dimethyl sulfoxide (DMSO) on regional blood flow were determined in rats using Sapirstein's method for the fractional distribution of* ^{86}Rb. *In the control, 60 white rats were anesthetized with sodium pentobarbital and then given approximately 4.5 million dpm of* ^{86}Rb *by the femoral vein. The experimental group was given 0.5 gskg of pure DMSO via the contralateral vein 5 min prior to* ^{86}*Rb injection. Animals in both groups sacrificed at 2, 5, 10, 30, 60, and 300 sec showed no significant changes in the blood flow to the heart, lungs, kidneys, thyroids, brain or skin; however, changes were observed in the livers, stomachs, spleens, guts, and carcasses of the experimental group.*

Dimethyl sulfoxide (DMSO) has been used in the treatment of arthritis and has been reported to possess unique medicinal properties (Jacab and Wood, 1971). Clinical studies with DMSO began in the United States in 1963. However, its use was temporarily halted by the FDA when it was suspected that DMSO was capable of producing opacities in lenses. A partial resumption of clinical testing was permitted in 1966. Despite the wealth of information concerning the effects of DMSO, its exact mechanism of action remains a subject for debate. Many investigators have described its ability to enhance the absorption of other drugs by serving as a penetrant carrier (Jacab et al., 1969). Kligman (1965) and Adamson et al. (1966) suggested that the primary action of DMSO is to provoke a histamine-like response and therefore cause vasodilation of the peripheral arterioles.

In the present study we wanted to determine whether DMSO (1) produces the same effect on the capillary beds of all organs, (2) alters blood flow or capillary permeability and, (3) has any effect on the permeability of the blood-brain barrier. We used Sapirstein's technique (1956, 1958) for the determination of regional blood flow by the fractional distribution of an indicator. Accordingly, intravenous injections of ^{86}Rb were followed by rapid sacrifice of the animals at a predetermined exposure time and the removal of the organs for the determination of their isotope content. This method has been widely used for the measurement of regional blood flow in small laboratory animals under a number of experimental conditions.

Materials and Methods—Sixty young rats of uniform stock ranging from 133-346 g wt were divided into a DMSO-treated series and a control series. All animals were in the post-absorptive state, having been fasted 12-16 hr. They were anesthetized with sodium pentobarbital injected intraperitoneally at a dose of 40 mg/kg body weight.

The control series consisted of 30 animals subdivided into 6 groups of 5 rats each. These rats were used to establish the normal accumulation pattern of ^{86}Rb

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into the extravascular spaces or compartments described by Black et al. (1956). Following anesthesia, each animal received approximately 4.5 million dpm pf ^{86}Rb administered directly into the femoral vein. The animals were subdivided according to the following schedule and sacrificed with a mallet driven hatchet. In this technique the blood flow is abruptly interrupted by cutting through the thorax just below the axillae. The heart is unharmed by this action; however, the large vessels are severed and the circulation immediately interrupted.

Subgroup	Time of Sacrifice After Injection in Seconds	Number of Rats
1	2	5
2	5	5
3	10	5
4	30	5
5	60	5
6	300	5

The various organs were immediately removed, weighed and placed in plastic counting vials for assay in a gamma well. A vial containing ^{86}Rb of equivalent activity and volume as the injected dose was prepared for each subgroup. It was absorbed in sponge strips of sizes approximating the mean volumes of the organ samples to be examined. These vials were counted and served as standards for each group.

The DMSO treated series consisted of 30 rats subdivided in the same manner as the controls. Both femoral veins were exposed and 0.5 g/kg of pure analytical grade dimethyl sulfoxide was administered into one vein 5 min prior to the injection of ^{86}Rb into the contralateral vein. Blood samples were not taken for assay and consequently a significant percentage of the injected ^{86}Rb was lost due to blood loss associated with the sacrifice procedure. The counts for each organ were, therefore, converted to percentage of recovered dose rather than the percentage of the injected dose to maintain the quantitative relationship in flow distributions. The regional blood flow per g of organ wt was then calculated from these data in concert with the cardiac output taken to be 205 ml/kg/min as reported by Sapirstein (1956).

Results—Table 1 summarizes the fractional distribution of ^{86}Rb (regional blood flow) per g of organ wt. Intravenous injections of DMSO produced no significant changes in the blood flow to the heart, lungs, kidneys, thyroids, brain or skin. Although these organs exhibited several variations in flow patterns, none of the fluctuations between control and DMSO treated groups for the same time period were statistically significant. We noted that DMSO, under these experimental conditions, produced no significant changes in the permeability of the blood-brain barrier.

Table 1 shows that DMSO influenced blood flow changes in the liver, stomach, spleen, gut and carcass (musculature minus the skin and viscera). The liver, gut and carcass each demonstrated a significant blood flow change during only one observational interval. The stomach, on the other hand, demonstrated changes at 2, 5 and 300 sec after the injection of ^{86}Rb, while the flow in the spleen was changed at 5 and 300 sec.

TABLE 1. Regional blood flow expressed in g/min as determined by the fractional distribution of ^{86}Rb including control (Contr.) and experimental (Expt.) animals. Each value represents the mean of 5 rats. The (*) indicates that DMSO treatment produced a significant change (a = .05).

	Time, seconds											
	2		5		10		30		60		300	
ORGAN	Contr.	Expt.	Contr.	Expt.	Contr.	Expt.	Contr.	Expt.	Contr.	Expt.	Contr.	Expt.
Heart	3.56	3.60	2.22	2.22	1.91	2.41	2.70	2.82	2.55	1.51	3.26	2.75
Lungs	4.23	2.67	1.55	1.36	1.23	1.38	1.10	1.25	.99	1.10	1.20	1.23
Liver	.21	.19	.33	.23	.40	.27	.58	.41*	.48	.47	.76	.68
Stomach	.13	.23*	.21	.44*	.30	.27	.65	.37	.51	.60	.49	.69*
Spleen	.97	1.07	1.23	.67*	.65	.81	.83	.67	.88	.92	1.29	.81*
Gut	.29	.46*	.45	.53	.55	.40	.55	.46	.41	.50	.53	.61
Kidneys	2.63	3.25	3.35	3.78	3.45	3.18	4.20	4.05	3.69	4.59	4.79	4.16
Thyroids	.81	1.13	2.74	3.68	1.17	1.58	1.39	1.80	1.84	1.52	3.07	2.27
Brain	.25	.25	.20	.18	.05	.04	.04	.04	.03	.04	.04	.04
Skin	.11	.11	.12	.14	.12	.11	.11	.12	.14	.13	.11	.11
Carcass	.16	.16	.16	.15	.16	.17	.15	.15	.16	.14*	.14	.14

Table 2 lists the percentage distribution of ^{86}Rb per g of organ weight. It compares the percentage of ^{86}Rb found in the control and DMSO treated groups of each organ.

TABLE 2. Distribution of ^{86}Rb in the organs of rats after single intravenous injection. *Legend:* a. the upper figures in this row represent sacrifice times used by Sapirstein (1958); b. the lower figures represent sacrifice times used by us; c. the upper figure in each box represents Sapirstein's data; d. the lower figure in each box represents our data.

ORGAN	Percentage of ^{86}Rb Per Organ Sacrifice Time in Seconds							
	3[a]	6	9	12	16	32	64	-
	2[b]	5	10	-	-	30	60	300
Heart	-[c]	-	2.7	2.7	2.4	2.7	2.6	-
	5.2[d]	3.6	2.6	-	-	3.6	3.3	3.8
Lungs	-	-	-	-	-	-	-	-
	10.4	3.4	3.0	-	-	3.6	2.9	3.8
Liver	3.1	4.1	6.3	6.8	-	7.7	8.1	-
	3.0	4.7	5.6	-	-	7.3	6.2	9.1
Stomach	-	-	-	-	-	-	-	-
	0.4	0.7	0.9	-	-	1.7	1.2	1.3
Gut	9.3	14.7	19.7	19.3	18.5	22.4	23.0	-
	8.8	13.1	14.7	-	-	14.7	12.2	15.1
Kidneys	10.5	14.9	14.3	14.4	13.7	15.8	16.1	-
	9.7	11.4	13.8	-	-	14.7	11.8	14.6
Thyroids	-	-	-	-	-	-	-	-
	0.03	0.1	0.05	-	-	0.06	0.08	0.09
Skin	3.9	7.2	8.8	9.1	12.5	9.5	12.2	-
	11.3	12.3	11.1	-	-	10.4	13.5	9.6
Carcass	31.4	42.5	45.5	46.5	48.1	43.2	43.9	-
	50.1	49.7	48.0	-	-	43.8	48.6	44.6
Brain	0.7	0.8	0.1	0.1	0.1	0.1	0.1	-
	0.8	0.8	0.1	-	-	0.1	0.1	0.1

DISCUSSION—We sought to determine the efficacy of dimethyl sulfoxide to penetrate and pass through the blood-brain barrier. Such a demonstration would indicate that DMSO might serve as a vehicle for the transport of other chemicals across the barrier. It is well known that one of the principle obstacles in the treatment of neural infections is the resistance encountered in transporting medication into the brain. Brink and Stein (1967) reported barrier breakdown as a result of intraperitoneal injections of pemoline-C^{14} dissolved in DMSO. However, their interpretations were challenged by Kocsis et al. (1968) who, in analyzing Brink and Stein's data, concluded that it was not clear that DMSO affects either the brain's uptake of pemoline specifically, or the blood-brain barrier in general.

Our results seem to corroborate Kocsis et al's conclusion and extend it to indicate that, under the regime of this experiment, DMSO treatment has no effect on the blood-brain barrier (Table 1).

We sought to evaluate the influence of DMSO on the capillary beds of the various organs. We wished to determine whether DMSO caused changes either in permeability or blood flow. The sacrifice intervals were subdivided into 3 phases for analytical purposes. Firstly, the 2-10 sec phase was the accumulation period. Immediately after injection, the values obtained represent transient concentrations of ^{86}Rb. These values were artificially high in organs which received blood almost directly from the heart, such as the lungs and the brain, and probably reflect portions of the injected bolus present intravascularly. The 5-10 sec segment is assumed to represent the period during which the tracer is being distributed. This was a highly unstable phase and should not be used to measure blood flow to the organs.

The 10 through 60 sec interval represents the second phase. It was considered to be the period in which regional blood flow is measured. Only two observations of possibly significant changes between the 2 groups occurred during the 10 through 60 sec interval indicating that DMSO generally affects neither the permeability nor the blood flow at the capillary beds of the organs. It was assumed that permeability changes would be manifested by significant increases in flow values at 10 sec followed by decreases at 30 sec. This would indicate an increase in diffusion to the extravascular pools. Thus the pools would fill faster under the influence of DMSO and, consequently, begin returning the labelled Rb to the vascular system faster.

The 60 through 300 sec interval constituted the third phase and represents the redistribution of ^{86}Rb. Sapirstein (1956) observed that with the passage of time (1-2 min) a sufficient quantity of measuring agent will then yield false values for flow. In the case of organs with high perfusion rates, the apparent fractional flow will become falsely low; organs with low perfusion rates will yield fractional flows which are correspondingly high.

LITERATURE CITED

Adamson, J. E., C. E. Horton, H. H., Crawford, and W. L. Ayers. 1966. The effects of dimethyl sulfoxide on the experimental pedicle flap: a preliminary report. Plast. & Reconstruct. Surg. 37:105-110.

Black, D. A. K., H. E. F. Davies, E. W. Emery, and E. G. Wade. 1956. Renal uptake of radioactive potassium. Clin. Sci. 14:241-244.

Brink, J. J., and D. G. Stein. 1967. Permoline levels in brain enhancement by dimethyl sulfoxide. Science 158:1479-1480.

Jacab, S. W., and D. C. Wood. 1971. Dimethyl sulfoxide (DMSO) a status report. Clin. Med. 78(11): 21-31.

———, ———, and J.H. Brown. 1969. Therapeutic potential of dimethyl sulfoxide (DMSO) in aerospace medicine. Aerospace Med. 40:75-84.

Kligman, A. M. 1965. Tropical pharmacology and toxicology of dimethyl sulfoxide (DMSO). J. Amer. Med. Assoc. 193:796-804.

Kocsis, J. J., S. Harkaway, and W. H. Vogel. 1968. Dimethyl sulfoxide: breakdown of blood-brain barrier? Science 160:1472-1474.

Sapirstein, L. A. 1956. Fractionation of the cardiac output of rats with isotopic potassium. Circulation Res. 4:689-692.

———. 1958. Regional blood flow by fractional distribution of indicators. Amer. J. Physiol. 193:161-168.

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Conservation

THE SPIDER CRAB, *MITHRAX SPINOSISSIMUS*: AN INVESTIGATION INCLUDING COMMERCIAL ASPECTS

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Abstract: Mithrax spinosissimus *in Lower Florida Keys canals has an avg density of 2-4 individuals larger than 6 cm carapace width per 100 sq m of canal wall; abundance increased with more and larger crevices. Tagged adults had an 18 mo molt period. Males comprised 25%, were territorial, and showed a marked increase in claw size near 8 cm carapace width. Avg crab size was estimated, 5-10% were missing claws, and 15-20% were missing walking legs. Although loss of a claw seems to have little effect on survival, claw removal and release is not recommended for commercial use. Commercial exploitation does not appear sustainable at this time.*

In recent years the fishing industry for the Alaskan King Crab, *Paralithodes camtschatica,* has declined (Idyll, 1971), resulting in the search for other species. One suggested possibility (Bayer, in prep.) is the spider crab (Fig. 1), *Mithrax spinosissimus* (Lamark), common in Florida waters and about which little is known. One characteristic of potential economic significance is the herbivorous nature of this crab, based on the chela structure, suggestive of greater production from a given area compared with carnivorous crabs. A field study was initiated in the fall of 1973 and continued for one yr to obtain information necessary before commercial exploitation occurs.

Hazlett and Rittschof (1975) made a detailed study on the behavior and movements of *M.spinosissimus* in a canal on the Florida Keys. Determining the full range and distribution of *M. spinosissimus* was not an objective of that study. Rathbun (1897, 1825) reported a geographical distribution from Carolina to the West Indies. Most crabs were observed in artificial habitats, either in holes in canal walls or under bridge pilings. Few were observed in what can be called "natural" environments. A female was observed on Looe Key Reef at night and several juveniles were seen in cavities of sponges (*Speciospongia* sp.) in Newfound Harbor Channel. Local divers report large numbers of these crabs in shallow "potholes" and small caves such as those found near the Content Keys, Florida. My observations suggest *M. spinosissimus* tends to occupy rocky substrate with suitably sized holes or crevices.

Methods and Materials—Four study sites were used (Fig. 2). Site 1 was an artificial enclosure at Newfound Harbor Marine Institute (N.H.M.I.) on Big Pine Key, Florida and was used only to test tagging and claw removal techniques. Site 2 consisted of caves formed by erosion under the east seawall of N.H.M.I. Site 3, on the eastern side of Little Torch Key, was a 130 m section of canal wall exposed on one side to the open water of Newfound Harbor Channel. Other sections in this area lacked suitable rocky substrate and were not used. Site 4, on Little Torch Key, consisted of a series of inland finger canals, each approximately 90 m long. Most of the information came from site 4 because crabs were numerous, the area was sheltered from wind, the canal limited crab movements and was easy to search.

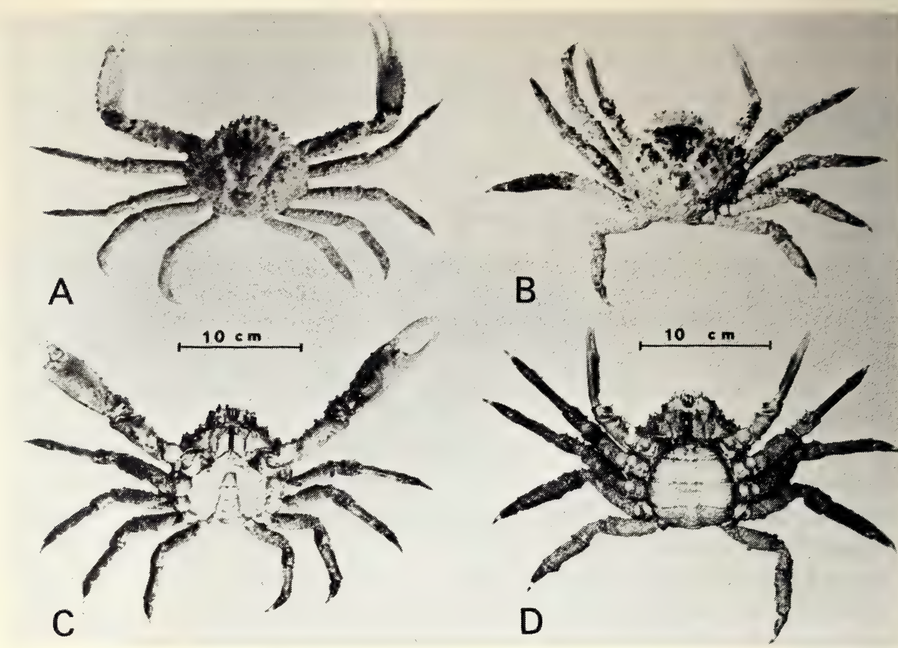

Fig. 1 *Mithrax spinosissimus*. A. Male, dorsal view; B. Female, dorsal view; C. Male, ventral view; D. female, ventral view.

Spider crabs were sought by swimming an up and down search pattern along a canal wall. Data were recorded underwater on plastic sheets on sex, carapace width (C. W.), ventral claw length (C. L.), lost appendages, and the position and depth along the canal. Crabs were handcaught using heavy gloves and a small dip net. After tagging, each individual was returned to the location where initially sighted. Crabs caught in holes were released at the mouth of the hole. When several crabs occurred in one hole (referred to as a cluster), I first attempted to determine the number and sex of all individuals before capturing them. If a crab could not be captured, I moved along and returned later to try again. Approximately 15% of the observed crabs (28 of 181) evaded capture.

Tagging and recapture attempts occurred from September through December 1973 and in August 1974. Tags consisted of nylon self-locking wire ties numbered by burning near the base and by punching holes in a binomial code. Tags were placed at the base of the merus and the excess cut off. I observed that tags did not adversely affect claw movement and could not be removed. One obvious disadvantage of this tagging method was that tags were lost upon molting. Spaghetti tags used elsewhere (e.g., Cleaver, 1963) were not available and could not be adequately tested in time for this study.

During most of the study I removed one claw underwater from every other tagged crab, just before release. Both breaking off a claw and cutting off a claw at the merus were investigated.

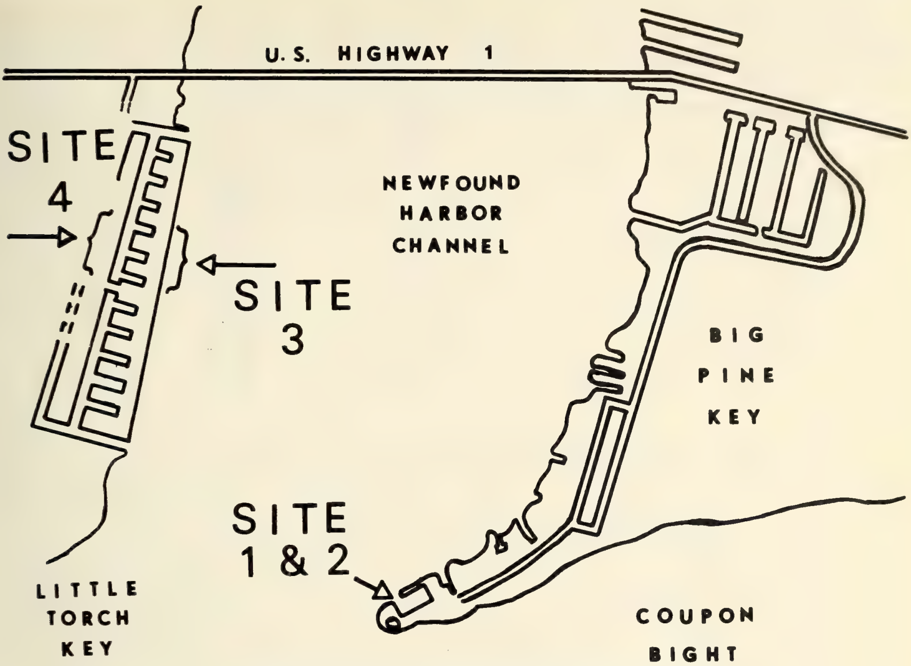

Fig. 2 Location of study sites on the Lower Florida Keys.

Population sizes were estimated by two methods: a visual census and an unbiased estimate given by the following formula as described by Ricker (1958), based on Bailey's modification (1951) of the Peterson type single census estimate.

$$\overline{N} = \frac{M(C+1)}{R+1}$$

Where: $\overline{N}$ = population estimate
M = number of marked crabs released
C = total number of crabs captured
R = recaptured crabs

Population estimates apply only to site 4 because other sites lacked replicate samples or the recapture interval was excessive. The Schnabel type of multiple census estimate was considered inappropriate because of the time interval between samplings and tag loss from molting.

Results and Discussion—Table 1 summarizes field data from initially sampled populations. Approximately 5-10% of the population had only one claw and 15-20% were missing walking legs. The largest observed crab (out of approximately 300) had an 11.5 cm C. W. and 12.5 cm C. L. which was considerably smaller than the largest reported by Rathbun (1925): 17.4 cm C. W. and 18.7 cm C. L. The relationship between carapace width and total crab weight is shown in Fig. 3. Males were slightly heavier than females with the same carapace width because of larger claws.

TABLE 1. Field data on initially sampled populations of *Mithrax spinosissimus*. The numbers in parentheses refer to the total number of crabs used to determine the estimate. The avg wt were based on the avg carapace width and wt curves plotted in Fig. 3. Confidence intervals were determined according to Clopper and Pearson (1934).

	Total	Males	Females
Avg Claw Length (cm)	6.7 (101)	9.7 (27)	5.6 (74)
Avg Carapace Width (cm)	8.9 (101)	9.6 (28)	8.6 (73)
Avg Weight (gm)	333	430	290
Percent Missing a Claw	7% (103)	10% (29)	5% (74)
(95% C. I.)	2%-13%	5%-28%	2%-13%
Percent with One Small Claw	4% (103)	7% (29)	3% (74)
(95% C. I.)	1%-10%	0%-22%	0%-10%
Percent Missing Legs	17% (103)	21% (29)	15% (74)
(95% C. I.)	10%-26%	10%-39%	8%-27%

Cleaned crab meat from both males and females avg 15% of fresh wt. The maximum yield was 20% from a large male, compared to 25% for a king crab (Iverson, 1966). Mechanical processing could possibly increase the yield.

Almost all observed crabs were larger than 6 cm C. W. The reason for not seeing smaller crabs is unknown. Eggs were observed on females from August through November. None were observed in December. Observations were not made during other months although Hazlett and Rittschof (1975) reported a few ovigerous females between January and May. Male sexual maturity may occur near 8 cm C. W. based on increased claw size (Fig. 4). Age could not be determined although an 18 mo interval between molts was calculated for adults based on tag returns (Fig. 5).

A total of 103 crabs were tagged of which 6 died from claw removal and 12 were tagged too late for recapture. Over 50% of the remaining crabs were recaptured at least once. The possibility that crabs were harvested from the study sites during the study was unlikely. Recapture results appear in Table 2. Crabs with a claw removed had nearly the same recapture rate as crabs with both claws, suggesting claw loss does not significantly affect survival. However, when

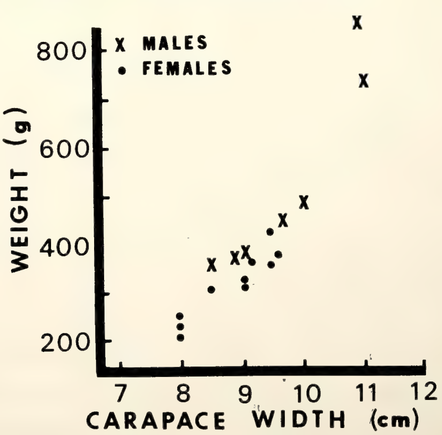

Fig. 3. Crab weight as a function of carapace width.

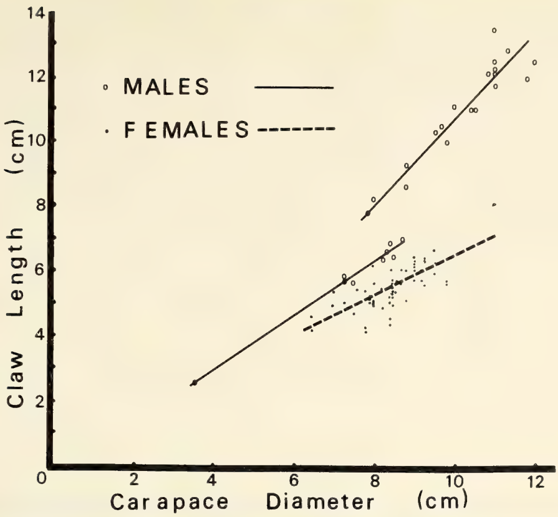

Fig. 4. Claw size as a function of carapace width.

claws were broken off, the crabs resisted autotomy and damage often occurred at the base of the coxa; 5 of 10 crabs bled to death and the other 5 moved out of sight and were not seen again. Cutting off the claw at the merus was more successful because a crab could autotomize the stub with minimum blood loss by using its remaining claw. Only one of 40 was known to die.

Eight visual estimates avg 8 crabs (s.d. = 3.6) per 100 m of canal wall and was considered the minimum estimate because some crabs were undoubtedly not observed. The Peterson method avg 17 crabs (s.d. = 8.7) based on 13 samples and was considered the maximum estimate because of bias from tag loss due to molting and possible amputation mortality. Assuming 4 m avg depth, the calculated density was 2-4 adults per 100 m of canal wall. The standing crop was 3000-5600 g per 100 m of canal wall (7.5-14 g/m^2) based on 333 g avg wt. My observations agreed with Hazlett and Rittschof's findings (1975) that crab density was highly correlated with crevice density, and food was probably not limiting. This suggests that increasing the number of suitable holes could increase crab production.

My observations confirmed Hazlett and Rittschof's findings (1975) that *M. spinosissimus* remained in crevices during the day, moved and fed nocturnally, ate algae scraped off rocks, and usually returned to the same crevice occupied the day before. In addition, one crab was seen eating *Cassiopeia* sp. and crabs in aquaria ate dead meat.

Table 3 gives crab composition for 151 occupied holes. Almost 55% of the crabs were in clusters of 2 to a maximum of 11 individuals. A chi-square test for goodness of fit showed male and female presence in any sized cluster was no different than expected by chance ($p < .05$). However, results suggest aggression occurs between males because only one of 42 clusters had more than one male. The one exception had two males in a large partially divided cave. Possible aggression between males could account for males comprising only 25% of the sample (64 of 241) and having greater incidence of claw and walking leg losses

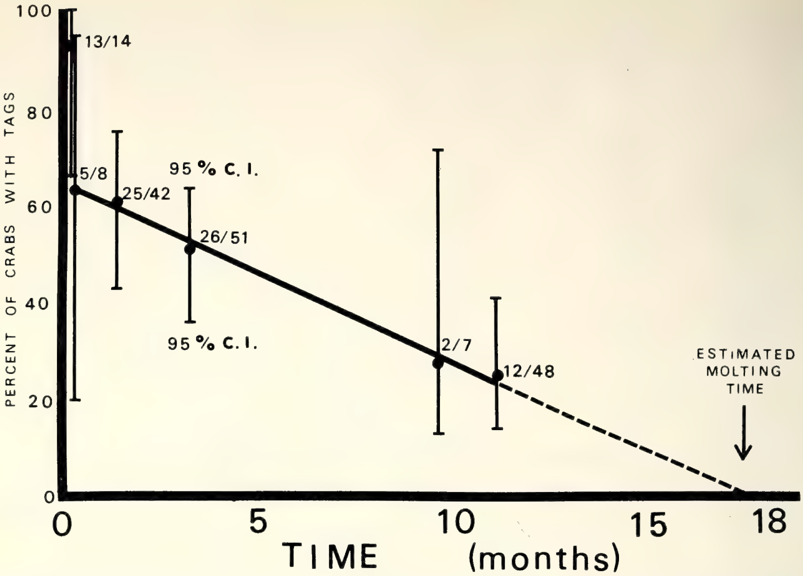

Fig. 5. Estimated molting time based on loss of tags for *Mithrax spinosissimus* larger than 6 cm carapace width. Loss of tags is assumed to be due to molting. The ratio at each point is the number of crabs confirmed to possess tags per number of crabs initially tagged. Confidence intervals were calculated according to Clopper and Pearson (1934).

(Table 1). Hazlett and Rittschof (1975) did not report sex ratios but my analysis of their data for 75 pairs gave a different sex ratio: 60% male (89 of 150) versus my 29% (14 of 48) for paired crabs. Hazlett and Rittschof (1975) analyzed 75 pairs and concluded "the occurrence of more than one male in a crevice was what would be expected by chance, but multiple female occupation was rare and male-female pairs more common than expected by chance alone." However, their numbers expected by chance (their Table II) were not calculated on binomial probability or corrected for sex ratio. Recalculation of their data showed significant difference from randomness ($p < .05$) by giving an expected composition of 26.4 male-male, 36.2 male-female, and 12.4 female-female pairs, compared to 22, 45, and 8 observed pairs, respectively. The level of significance dropped to $p < .10$ when either the Yates correction factor for small sample size was applied or when my pair data (Table 3) were added (with or without the

TABLE 2. Recapture data on *Mithrax spinosissimus*.

	Total	Males	Females
Total Tagged Crabs	103	32	71
Recoverable Crabs	85	22	63
Total Crabs Recaptured	47 (55%)	14 (64%)	33 (52%)
Crabs With One Claw Removed	40	10	30
Crabs Recaptured (One Claw)	20 (50%)	6 (60%)	14 (47%)
Crabs With Two Claws	45	12	33
Crabs Recaptured (Two Claws)	27 (60%)	8 (67%)	19 (59%)

Table 3. Distribution of males and females found in holes or caves in 151 encounters.

Number of Crabs per Hole	Total Frequency Encountered	Number of Males per Hole (all others are females)			
		0	1	2	3
1	109	72	37	--	--
2	24	10	14	0	--
3	10	6	4	0	0
4	2	0	2	0	0
5	0	0	0	0	0
6	2	0	2	0	0
7	2	0	2	0	0
8	0	0	0	0	0
9	1	0	0	1	0
10	0	0	0	0	0
11	1	0	1	0	0

correction factor). I concluded that female pairs were *not* rare although male-female pairs were more common than expected by chance alone.

In general these crabs were slow, relatively docile, and easily caught. Even with extreme care taken to avoid crab injury, the majority of the population were caught in one pass over an area. Many were prodded out of holes although usually they wedged into a crack and hung on tightly, especially if an initial capture attempt failed.

CONCLUSIONS—New information on the behavior, abundance and ecology of *M. spinosissimus* has been reported. Assuming the crabs and habitats studied were representative, commercial exploitation does not appear feasible at this time. Large scale exploitation probably cannot be sustained. Unless the reproductive potential is very high, the 18 mo interval between adult molts suggests a slow replacement rate. Diving, which is expensive, would probably be the best method of harvest. These crabs are rarely taken in stone crab and lobster traps and their territorial nature suggests trapping would be difficult. Because they are so easily captured, shallow water areas could be easily overexploited by divers. Despite their large size, the amount of edible meat per crab is low and large claws only occur on adult males. The drab color and epibiotic growth gives the species an unappetizing appearance which could inhibit its public acceptance as a food item unless used as a crab meat supplement or in crab cakes. Breaking off one claw and releasing a crab is not recommended because of possible fatal injury to the crab. The possibility of increasing production by altering the habitat needs further investigation.

ACKNOWLEDGMENTS—I wish to thank Newfound Harbor Marine Institute and its staff for use of their facilities; Robert P. Beech and Eric Linblad for assistance in collecting; and Dr. Edwin S. Iversen of the Rosenstiel School of Marine and Atmospheric Science and Dr. Leonard J. Greenfield of the University of Miami for critically reviewing the manuscript.

LITERATURE CITED

BAILEY, N. J. J. 1951. On estimating the size of mobile populations from recapture data. Biometrika 38:293-306.

BAYER, F. M. (in prep). The potentially commercial crabs of Florida, the Gulf of Mexico and the Caribbean area. Sea Grant Field Guide Series (no number yet assigned). Univ. Miami Sea Grant Prog. Miami, Florida.

CLEAVER, F. C. 1963. Bering Sea King Crab *Paralithodes camtschatica* tagging experiments. Inter. Comm. N.W. Atlantic Fish. Spec. Publ. 4:59-63.

CLOPPER, C. J., AND E. S. PEARSON. 1934. The use of confidence or fiducial limits applied to the case of the binomial. Biometrika 26:404-413.

FUTCH, J. W. 1966. The stone crab in Florida. Florida St. Bd. Conserv. Salt Water Leaflet Ser. 2:1-6.

HAZLETT, B. AND D. RITTSCHOF. 1975. Daily movements and home range in *Mithrax spinosissimus* (Majidae, Decapoda). Mar. Behav. Physiol. 3:101-118.

IDYLL, C. P. 1971. The crab that shakes hands. Nat. Geogr. Mag. 139:254-271.

IVERSEN, E. S. 1966. The king-sized crab. Sea Frontiers 12:228-237.

RATHBUN, M. J. 1897. List of the decapod crustacea of Jamaica. Inst. Jamaica Annal. 1(1):1-46.

__________. 1925. The spider crabs of America. U. S. Nat. Mus. Bull. 129:1-613.

RICKER, W. E. 1958. Handbook of computations for biological statistics for fish populations. Fish Res. Bd. Canada Bull. 119:1-300.

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OCCURRENCE OF BONEFISH IN TAMPA BAY—*Lawrence J. Swanson, Jr.* Conservation Consultants, Inc, P. O. Box 35, Palmetto, Florida 33561.

On October 21, 1975, Mr. Donald Mead, of Palmetto, Florida, brought me a bonefish (*Albula vulpes* [Linnaeus]) which he had caught the night before while fishing for mullet. The 390 mm SL fish was caught in a gill net at the mouth of Critical Creek, on the southeastern shore of Tampa Bay.

Although bonefish are known from the Bay of Fundy to Rio de Janeiro (Hildebrand, 1963), they have been reported only once from Tampa (Henshall, 1895). Henshall obtained specimens from commercial fishermen at Tampa and there is no record of the location of capture. Springer and Woodburn (1960) included bonefish in their list of Tampa Bay area fishes based on Henshall's report, adding, "No catches have been made in the memory of any of the local fishermen with whom we spoke." Bonefish are familiar, however, to many commercial fishermen around Palmetto, Florida, who call it "Mexican mullet" (D. Mead, pers. comm.). Mr. Mead estimates that, in 40 yr of fishing in Tampa Bay, he has caught more than 100 bonefish.

While bonefish are certainly not abundant in Tampa Bay, they are more common than has generally been appreciated.

LITERATURE CITED

HENSHALL, J. A. 1895. Notes on fishes collected in Florida in 1892. Bull. U. S. Fish. Comm. 14(1894): 209-221.

HILDEBRAND, S. F. 1963. Family Albulidae. Pp. 132-145, *In*: H. B. BIGELOW (ed.). Fishes of the Western North Atlantic. Mem. Sears Found. Mar. Res. (1) part 3.

SPRINGER, V. G., AND K. D. WOODBURN. 1960. An ecological study of the fishes of the Tampa Bay area. Florida Bd. Conserv. Prof. Pap. Ser. (1):104 pp.

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Biological Sciences

EFFECTS OF SEWAGE EFFLUENT ON GROWTH OF *ULVA LACTUCA*

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Marine Colloids, Inc., Rockland, Maine 04841, and Department of Marine Science, University of South Florida, St. Petersburg, Florida 33701

Abstract: *Sea lettuce was grown in a circulating sea water system in 5, 10, 15, 20, and 25% sewage effluent in Tampa Bay sea water and in unenriched sea water as a control. Plants in 5, 10, and 15% effluent grew progressively faster than controls, but all plants in effluent exhibited higher nitrogen content than the controls. In all experiments ammonia was rapidly reduced to a low level or zero, while phosphate was not taken up more rapidly than it was regenerated.*

Two genera of marine algae, *Ulva* and *Enteromorpha*, contain certain species which are evidently stimulated by sewage effluent and may therefore produce a heavy biomass in an area near an outfall. These green algae tolerate wide ranges of salinity and other environmental conditions, but they may be somewhat sensitive to water temperature with the result that they produce an annual bloom alternating seasonally with a period of low biomass. Most marine algae are inhibited by sewage outfall resulting from reduced salinity or by sensitivity to unusually high concentrations of nutrients, organic matter, or other substances, but they may respond with increased growth after the effluent has been considerably diluted at some distance from the outfall.

An annual bloom of *Ulva* in Boston Harbor during the warmer months of the year has been described by Sawyer (1965). In Australia, Borowitzka (1972) observed that *Ulva*, *Enteromorpha*, and a species of *Chaetomorpha*, also a green alga, were the only marine algae present near sewage outfalls.

In Tampa Bay, large masses of *Ulva*, with smaller quantities of *Enteromorpha*, produce a great biomass near sewage outfalls each year beginning in November and increasing until March or April. From May to October, only small quantities are present.

We sought to determine, by means of laboratory culture, the extent to which ammonia and phosphates in secondarily treated domestic sewage effluent were utilized in Tampa Bay water by sea lettuce, *Ulva lactuca* L., and what proportions of effluent and sea water were most stimulatory. Information of this kind is needed if nutrients in domestic sewage are to be recovered in the future rather than wasted by dumping into the sea, as is the present custom in coastal cities.

Methods and Materials—A laboratory aquarium table about 10 ft long was divided into two sections, each with 200-300 l reservoirs underneath. Each was equipped with a small pump that circulated the water from the reservoirs into an overhead horizontal polyethylene pipe fitted with outlets having adjustable valves and tubing that conducted the water into 1-gal experimental containers. The overflow returned to the reservoir from which it came.

Two Westinghouse "warm-white" 40-watt fluorescent lamps were the light source over each of the two sections. These provided 3.3-8.4 lux at night, 5.6-12.5 lux during the day when supplemented by a small amount of natural light. Water circulation through the plant containers and the illumination were continuous. Sea water from Bayboro Harbor, Tampa Bay, St. Petersburg, was used to fill the aquarium table reservoirs.

Secondarily treated domestic sewage effluent was obtained from the Albert Whitted Sewage Treatment Plant located adjacent to Bayboro Harbor and Albert Whitted Airport near downtown St. Petersburg, and only about 0.5 km from the laboratory facilities of the Department of Marine Science, University of South Florida St. Petersburg Campus.

Plants of *Ulva lactuca*, collected in Tampa Bay, were brought into the laboratory and allowed to adjust to laboratory culture conditions for 2 days with constant circulation and illumination as described above. After acclimatizing, plants were blotted and weighed to the nearest 0.1 g, and one plant was placed in each of 8 1-gal jars on the aquarium table. Four containers were placed in the experimental section of the circulating sea water system and four were placed in the control section. Secondarily treated sewage effluent was added to the experimental section in the proportion of 5, 10, 15, 20, or 25%. The other reservoir, the control, contained Tampa Bay sea water only plus the amount of deionized water required to adjust the salinity to that of the experimental section.

Each of the 6 experiments was of 7 days duration. The wet wt and appearance of each plant were recorded daily as well as salinity, water temp, ammonia, and orthophosphate of both experimental and control reservoirs. Upon termination of each experiment, the plants were given a final wet weighing, rinsed in tap water, and dried to constant wt at 60°C. Their dry wt was recorded and they were ground to powder by means of a mortar and pestle and analyzed for total nitrogen (mg N per g dry wt tissue) by use of the Kjeldahl technique as modified by Strickland and Parsons (1972).

One experiment (no. 6) was conducted without *Ulva* in the 8 jars in order to obtain information on the activity of bacteria, diatoms, and other microorganisms present in Tampa Bay water. The experimental reservoir contained 15% sewage effluent. Water in both systems was circulated for 7 days with constant illumination and the usual daily analyses were done on water samples from each system.

RESULTS—*Ulva lactuca* grown in 5, 10, and 15% sewage effluent exhibited a progressively increasing growth rate in comparison to plants grown in untreated Tampa Bay water as shown in experiments 1-3, table 1. Plants in 20 and 25% effluent did not grow as fast as the controls, as they became reproductive (experiments 4 and 5, table 1). All experimental plants increased in nitrogen content over the control plants.

In all experiments, ammonium nitrogen was taken up rapidly and reduced to low or undetectable levels by the third day. A somewhat less rapid uptake occurred in the two highest concentrations of effluent (20 and 25%) in which growth also was somewhat slower. When reproduction occurred, regeneration of

TABLE 1. Summary data for six experiments on algal growth in sewage effluent.

Exper. No.	% sewage effluent	% gain in fresh wt.		mg N/gram dry wt.		initial/final NH_3 con. in medium (ppm)		initial/final PO_4 con. in medium (ppm)	
		Exp.	Con.	Exp.	Con.	Exp.	Con.	Exp.	Con.
1	5	27.17	39.95	28.7	14.5	.595/.015	.003/.012	1.280/1.296	1.170/1.157
2	10	62.32	33.00	33.3	13.0	.297/.004	0/0	1.233/1.256	1.100/1.076
3	15	24.27	14.19	35.1	12.6	17.150/0	.025/0	1.410/1.458	.936/ .948
4	20	7.79	34.16	34.3	12.0	2.950/.081	.015/.002	1.197/1.288	.866/ .878
5	25	-30.30	5.73	16.5	6.6	3.800/.257	.004/0	1.762/1.398	.784/ .830
6	15					13.840/.011	.031/.014	1.197/1.311	.809/ .866

ammonia may have increased in rate as a result of bacterial decomposition of empty cell walls and other left-over material after discharge of zoospores or gametes. The plants became somewhat slimy as reproduction occurred.

Phosphate was not taken up in any of the experiments faster than it was regenerated.

When *Ulva* was left out of the aquarium system and it was operated and analyzed in the same manner, ammonia uptake was similar to experiments in which *Ulva* was present, although somewhat slower. Table 1 is a summary of data from the 6 experiments.

Discussion—*Ulva lactuca* is one of the most euryhaline and eurythermal of benthic marine algae other than bluegreens. It occurs from arctic to tropical waters. Along the Atlantic coast of North America from North Carolina southward, it is much more abundant during winter than summer, suggesting a cool or cold water origin and subsequent invasion of warm water (Humm, 1969). South of North Carolina, *Ulva lactuca* begins to grow more rapidly in October or November and it reaches a peak of biomass in March or April. Along the middle Atlantic states, the growth rate becomes slower during the coldest months and the high rate occurs again in the spring. In Florida, the November to March growth rate appears to be continuous. As a result, large quantities of *Ulva* accumulate in bays where water fertility is high, especially in the vicinity of sewage outfalls or in areas into which significant amounts of sewage effluent are carried by currents before the ammonia content is drastically reduced. In Tampa Bay, it appears that *Ulva* and the closely related genus *Enteromorpha* are the benthic algae that take up major quantities of ammonia from the many sewage outfall sources during the cooler months.

In the spring, when water temperatures rise above the apparent optimum for *Ulva* and prevailing winds change from northerly to southerly, *Ulva* growth slows and the loose masses that have accumulated in certain areas during the cooler months are moved out by the change in prevailing winds, ultimately washing ashore or drifting into deeper water, and are widely distributed by tidal currents. These masses probably decompose under low light intensity or become reproductive, leaving only the empty cell walls and surface polysaccharides to decompose. In a number of areas in Tampa Bay great masses of *Ulva* wash ashore in April or May and create a public nuisance as they decompose. In some areas, these masses remain over seagrass beds long enough to kill the seagrass beneath them. In areas where current velocity and wave action is low for a few wk, sheets of *Ulva* more than 10 ft in diam will develop during early spring.

Gemmill and Galloway (1974) have shown that *Ulva lactuca* has the ability to take up acetate from the surrounding water and that the process is a form of photoassimilation. Since acetate is probably a major by-product of bacterial decomposition of the organic matter in sewage effluent, it seems likely that this is another reason for the response of *Ulva* to concentrations of effluent that are inhibitive to other marine algae.

LITERATURE CITED

BOROWITZKA, M. A. 1972. Intertidal algal species diversity and the effect of pollution. Australian J. Marine Freshwater Res. 23:73-84.

GEMMILL, E. R., AND R. A. GALLOWAY. 1974. Photoassimilation of ^{14}C-acetate by *Ulva lactuca.* J. Phycol. 10:359-366.

HUMM, H. J. 1969. Distribution of marine algae along the Atlantic coast of North America. Phycologia 7:43-53.

SAWYER, C. N. 1965. The sea lettuce problem in Boston harbor. J. Water Pollu. Contr. Fed. 37:1122-1133.

STRICKLAND, J. D. H., AND T. R. PARSONS. 1971. A Practical Handbook of Seawater Analysis. Fish. Res. Bd. Canada. Ottawa.

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I certify that the statements made by me above are correct and complete. (*signed*) *Harvey A. Miller, Editor.*

REVIEWERS FOR 1976

THE SUCCESS of a scientific journal depends upon cooperation among many persons giving freely of their time. Authors are recognized for the contributions published bearing their name but the unseen hero of the journal is the specialist reviewer. Many authors in our journal and others have been spared embarrassment by sympathetic and painstaking reviewers who have fingered lapses in the manuscripts submitted. Recommendations of our reviewers have been cherished by the editor although he has sometimes accepted an author's viewpoint if well-defended and reasonable. It is with sincere pride and warmest thanks that I acknowledge the invaluable assistance of the following persons in publication of the issues which appeared in 1976.—*Editor.*

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Dedicated to the memory of

ROBERT W. LONG, Jr.

(1927-1976)

Past President
and
Devoted Servant of the Academy

ROBERT W. LONG, JR., 1927–1976

OUR FRIEND and colleague, Robert W. Long, died in his sleep July 21 after a long and incapacitating illness. Dr. Long served as Secretary (1970-1973) and President (1973-1974) of the Florida Academy of Sciences and was an active participant and strong supporter of the Florida Academy of Sciences. Because we have been privileged to work and socialize with him for the past twenty or so years, we feel obligated to write the following testimonial to him and his life work. Although we believe Bob would have expected only a forthright assessment of his contributions to his beloved botany and not a personal eulogy, we are compelled to say some things about his personal qualities as well as his professional accomplishments.

Bob Long was a complete man both in work and play. He enjoyed good food, drink, books, music and company as well as mild sports. He was something of a romantic and was addicted to history. We recall, after the AIBS meetings at College Park, Maryland, spending three days with him touring Civil War battlefields. No matter where he journeyed he detoured to visit the scenes of the past. A pleasant companion, he could also be a blunt critic and his bluntness could hurt. But he was never petty and he was always a defender of human rights and professional standards. He always supported and advocated the position that the rights of faculty were paramount in the life of the university, and he spent much of his valuable time in support of his colleagues, his students and his university.

We, Bob's friends, colleagues, and family, have known for several years that we would lose him. Since 1973, he was on a heavy dialysis schedule (12 hours a week) due to nearly complete loss of kidney function. However, we had thought we would have more warning of the end, which came after he had put in a normal day of teaching, research and advising students. His last professional act was to arrange for the next day's botany laboratory which he was reorganizing along audio-tutorial lines. During his years of illness he continued to work a full schedule although repeatedly urged to slow down. In the past year, six books and at least five articles were published under his authorship without letting up on his teaching duties. He had his work and he was bound to do it. How he managed and at what a cost in misery we can only imagine. Yet he was always the optimist and though not a stoic took a dispassionate view of his difficulties. To us his courage was completely magnificent and we will never forget it.

Robert W. Long, Jr. was born in Ashland, Kentucky on November 23, 1927, the only son of Naomi Long and Robert W. Long, Sr., the Chief Accountant for the Allied Chemical and Dye Corporation. Both parents are deceased. In 1953, he married Gloria Overstreet whom he met at the University of Indiana where she was an undergraduate music major, and he was a graduate student in botany working under the tutelage of Charles Heiser. Bob and Gloria have four children, Alice Ann, 20; Nancy Kathleen, 19; Robert W., 15; and Celia Rose, 12. When Bob was just a youngster, the family moved to Ironton, Ohio, where he completed grammar school and high school. He then entered Ohio Wesleyan University where he studied under Claude Neal, a botany teacher whom he greatly admired. After his graduation in 1950, he attended the University of Indiana and received the Ph.D. in 1954. The title of his dissertation is "A biosystematic investigation of *Helianthus giganteus* L. and related species." Biosystematics continued to be his chief research interest and he was occupied for a number of years with investigations of breeding systems in *Helianthus*. Later in his career he worked with the Acanthaceae, in particular members of the genus *Ruellia*, as well as floristic and ecological studies of the vegetation of South Florida. During his career, he authored more than 35 technical papers, about 20 non-technical articles, a number of book chapters and nine books. Foremost among the latter is the *Flora of Tropical Florida* published in 1971 with Olga Lakela. It will no doubt stand as a monument to the authors for years to come.

In his teaching career, Bob served as Instructor at Southern Methodist University (1953-54); Associate Professor at Ohio Wesleyan University (1954-62); and as Professor at the University of South Florida (1962-76). He played a major role in the establishment of botanical sciences as a viable field in the University of South Florida, and served as first Chairman of the Department of Botany and Bacteriology. He guided and developed the proposals that lead to the establishment of the undergraduate and graduate degrees in Botanical Science and was highly instrumental in the establishment of the Ph.D. in Biology at the University of South Florida. He became Curator of the Herbarium in 1963, and was appointed its Director in 1965. During this period (1963-present) the Herbarium has been recognized one of the most important in the Southeast; in 1974 it contained over 100,000 specimens. In addition, Bob was directly instrumental in the establishment of the Botanical Garden in 1968. He took an active part in the hiring of its first director and has served as Chairman of the Botanical Garden Committee.

Although Bob was a tireless research scientist, and the author of numerous technical papers, popular articles and books, he considered himself first and foremost a teacher, both of undergraduate and graduate students. He served botanical education at the national level as a commissioner of CUEBS (Commission on Undergraduate Education in the Biological Sciences) during the years 1970-1971, as a consultant for the Office of Biological Education of AIBS, and as a panelist and consultant for the National Science Foundation. At the University of South Florida, Bob was active in the formation of the botany and biology curricula and he guided many students, both undergraduate and graduate to the successful conclusion of their botanical academic programs.

Throughout his teaching career, Bob maintained an active interest in academic affairs in the University. He was very active in the early years of the University of South Florida in the formation of a faculty constitution and senate. He served on many University committees including the Undergraduate Council. Because of his experience in directing and administering of departmental affairs, he acquired a strong reputation for consistent and wise counseling and his advice was often sought.

Until his recent illness, Bob was an active field botanist, traveled and collected extensively in the southern and mid-western United States and in the Caribbean, especially Mexico and Central America. His field and laboratory studies were continuously supported since 1953 by grants from the National Science Foundation as well as other funding agencies. He is a world recognized authority in his area of study.

Bob was an active and recognized member of several professional societies including the Botanical Society of America, American Association of University Professors, Association for Tropical Biology. He served as Treasurer for the American Society for Plant Taxonomists, Secretary and later as President of the Florida Academy of Sciences, and Editor of the *Plant Science Bulletin* of the Botanical Society of America.

One of Bob's great professional concerns was that botanical studies not be lost in the current trend toward the merging of biological disciplines. While he had no strong objections to the concept behind such mergers, he was greatly disturbed over the frequent loss of botanical curricula as a consequence of departmental mergers. He had no personal fear for his position in a biology department, having faith in his own worth and that of this work, but he worried that students would not have the opportunity for the same exposure to botanical subjects that he had enjoyed. He was always the champion of Botany as a valid, nay indispensible, discipline and readers of the *Plant Science Bulletin* will remember the thought provoking articles on the subject that appeared during his editorship. Regardless of future trends in biological education, Robert Long's work as a student and teacher of botany will endure and, though we could have wished many more years for him, his work was essentially complete.—Clinton C. Dawes, Department of Biology, University of South Florida.

EDITOR'S NOTE: The Robert W. Long, Jr., Memorial Lecture Fund has been established with the Biology Department, USF, by friends and colleagues. The purpose of the fund is to sponsor an annual Botanical Lecture. Individuals or groups who would like to contribute may send contributions made out to the Robert W. Long Memorial Fund, c/o Biology Department, University of South Florida, Tampa, Florida 33620.

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