BIOLOGICAL EVALUATION

OF THE

PORT SONOMA PROJECT

by

Gordon L. Chan
College of Marin
Kentfield, Ca 94904

January 25, 1974

ABSTRACT

The biological evalution of the Port Sonoma Project to develop a boat marina was conducted during a three-week span, December, 1973 to January, 1974. Additional months should have been allowed to permit study of seasonal changes.

Sampling data for this period revealed many live organisms, from plankton to birds and mammals. No contaminants were detected to be at pollutant levels, because of the probable large intrusion of freshwater during these winter days. The existing dredged dead-end channel, Area 3 of the study, contained a higher proportion of dead (shells) and a smaller proportion of living organisms than Area 2 of the existing harbor channel. A projection of the proposed Port Sonoma 3,000-foot boat harbor would result in a large dead-end basin that could be an entrapment for eutrophication processes during the warm summer days. Together with the increased recreational activities in the area, such conditions could be a threat to the existing wildlife of the entire Petaluma River area.

The most logical mitigation alternative is a partial development with strict controls and an ecological monitoring program over a long period of time to measure the effects of such recreational activities on the additional and present marsh communities.

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telephone (415) 454-3962, ext. 381

Introduction

The County of Sonoma has requested an environmental report on the proposed construction of a boat harbor by Shellmaker, Inc., called Port Sonoma, at the mouth of the Petaluma River.

My report deals with the biological evaluation of this proposed project. However, limitations are involved because of the short time allotted for this. The sampling investigations began on December 27, 1973, and ended January 16, 1974, a period of 22 winter days. In this brief time, it is very difficult for any one or even a group of individuals to gather adequate data and properly evaluate a biotic community and, in addition, predict the possible effect on this habitat from the construction of a boat harbor with capacity to house 400 boats. An investigation spanning eight to twelve months including the seasonal changes would provide a more appropriate evaluation.

I. PRESENTATION OF THE PROBLEM AND HYPOTHESIS

A. The Problem

Given the study period of three winter weeks, can I observe some biotic conditions which would enable me to predict the outcome of constructing a boat harbor at the Port Sonoma area?

B. Major Hypothesis

Winter conditions are an important part of any temperate ecosystem; a brief review of this Port Sonoma area would reveal some biotic observations which should necessitate further investigations during other seasonal times. The data will not provide sufficient information to properly mitigate the construction of the Port Sonoma project.

II. METHODS AND PROCEDURES

The sampling investigations will be directed towards the review of the total community, that is, an examination of representative organisms from the planktonic trophic level to the top predators of the food pyramid.

A. Sample Sites

1. The existing Port Sonoma facilities, Figure 1, were divided into three major sampling areas. These were:

   Area 1: Petaluma River, perpendicular to the harbor

   Area 2: Outer dredged harbor channel of Port Sonoma

   Area 3: Inner dredged channel of Port Sonoma

2. Each of the three sampling sites were divided into grids, and transects to be sampled were selected through a drawing of random numbers.

B. Benthic Samples

1. Linear sampling along each transect was selected as the most accurate; ten benthic samples were taken every 50 feet along each of the transects, labeled AT-1,AT-2,AT-3 on Figure 1. There were sampling difficulties in AT-3 because of the interference of dredges and dredge-pipes. However, the ten sampling intersections followed closely the established transect. A compass and transit triangulation method were used to align distances.

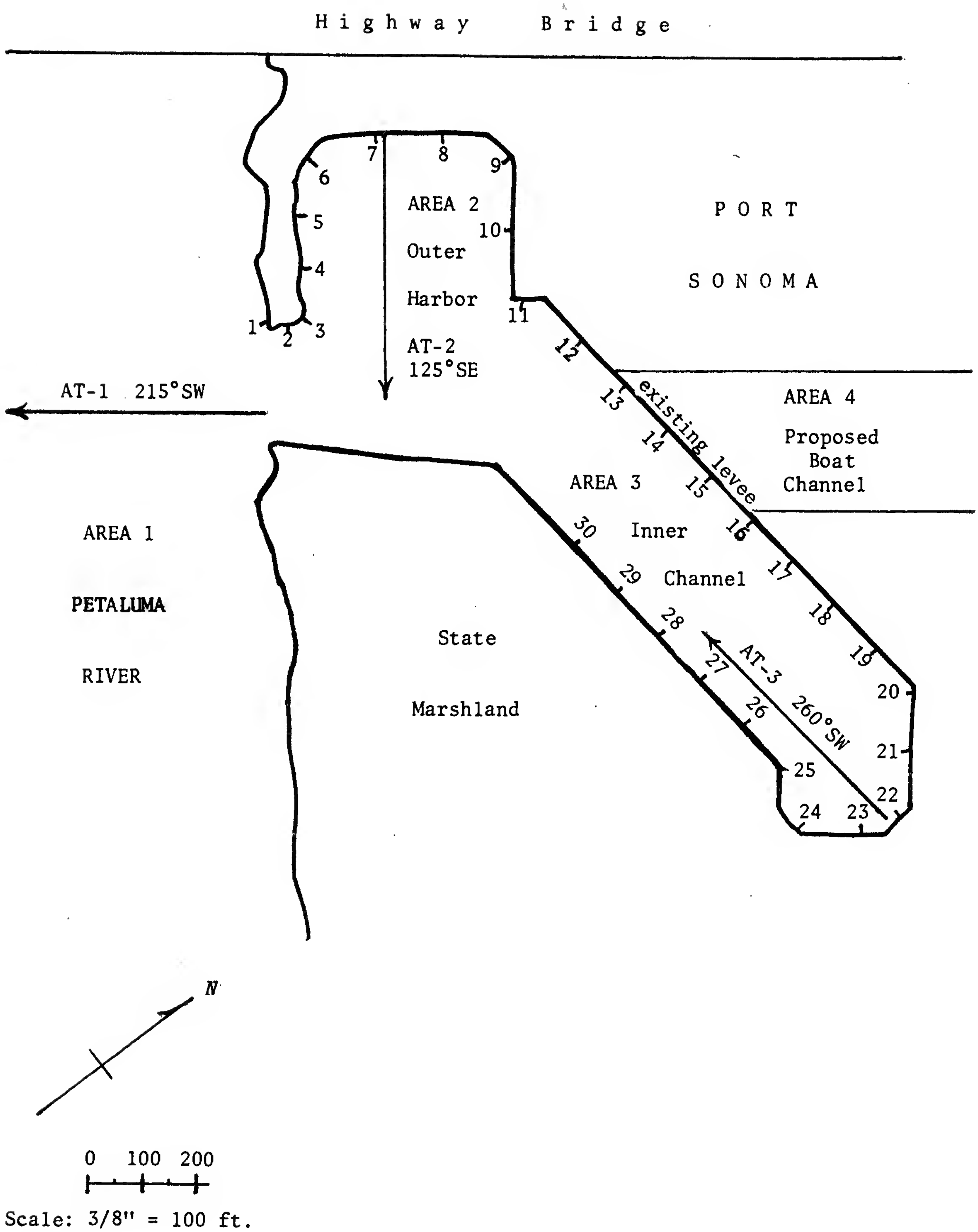


Figure 1. <u>Sampling Transects, Port Sonoma</u>

2. A small volume grab (Gemware-Kahl, mud snapper) of 250 cc. was used. Each sample was washed through three U.S. Standard sieve screens of 1000, 420, and 177 microns. All biotic samples were removed from each sieve to provide the benthic sample data. Such samples revealed only surface organisms and omitted the deeper burrowing benthic fauna (Light's 1954; Keen, 1963; Fitch, 1953).

C. Intertidal Sampling

1. Tidal dates which would expose the mud-bank areas of the *Salicornia sp.* zone were selected for investigations. A square meter quadrat sample was taken every 100 feet along the areas of AT-2, the outer harbor channel, and AT-3, the inner channel. A total of 30 samples was taken, 15 in each of the two dredged areas. Major fauna species were recorded (Hedgpeth, 1962; Light, 1954).

2. The marsh and nearby plants were also recorded for AT-2 and AT-3, the dredged portions of the area. Species observed were listed (Dawson, 1966).

D. Plankton and Fish Samples

1. Plankton tows, with a 12 mesh net, were taken in each of the three areas. The analysis of plankton counts was made with a Sedgewick-Rafter plankton slide and a AO Neubauer cell-counting slide. The density of major species was recorded.

2. By use of a 40 x 8 foot, ¼ inch mesh seine, fish samples were taken in areas 2 and 3. Total species were recorded (Bane, 1971; Miller, 1972; Roedel, 1953; Kimsey, 1960).

E. Birds and Mammals

1. The species and density of birds were recorded (Peterson, 1961) on four sampling days. No attempt was made to observe the feeding habits of the birds during these observations.

2. All mammals observed during the sampling days were recorded.

F. Physical Parameters

The physical parameters for each of the three transects were recorded, covering the surface and bottom waters. These measurements were:

Variables	Sampling Method
Temperatures Air, surface, water	Thermister
Salinity total dissolved solids (TDS), water tested at 70°F.	AO Goldberg T/C Refractometer
Dissolved Oxygen	Hach, DR-EL Winkler method
Others: Phosphates pH Nitrates Hydrogen sulfide Optical Density	Hach, DR-EL colorimetric tests
Rainfall	As recorded by the Novato Fire Department

G. Other Information

The search for literature from various Bay Area institutions revealed no previous biological investigative work in this exact location of the Port Sonoma Project. Literature for adjacent areas covered Lower Tubbs Island and Napa Slough, about two to five miles to the northeast. Other papers are listed in the cited references.

H. Statistics

From the random transect samples, sample means were obtained for each of the areas. To project the population mean, the 95%

confidence intervals were computed (Simpson, 1960).

I. Classification

All animals and plants were classified to the most feasible nomenclature. Time did not permit species verification; all specimens are presently stored at the College of Marin Biology Museum. Generic names were used in some cases, while simply the larger classification of order-phyla was sufficient for other cases. Cited references list the major taxonomic keys employed.

J. Basic Procedural Questions

After data was collated, some basic procedural questions were developed in order to determine the pattern of evaluation.

1. Were there any significant statistical differences between the population means of the benthic organisms found in the three area transects, and in the population means of the intertidal organisms? Any differences in the physical variables between the areas?
2. Were there some key or major organisms, fauna-plankton through fish, which are common in the winter habitats of this area?
3. From a comparison of the data in the three study sites, can I make any extrapolation about biotic conditions during other parts of the year?
4. From the data, can I predict or mitigate the outcome or possible effects on the biotic environment if the full or partial Port Sonoma harbor facilities--with 3,000 feet of estuarine channel, 400± boats, parking lots, restaurants, human population, and other contaminants--were all introduced?

III. PRESENTATION AND INTERPRETATION OF DATA

A. Physical Description and Variables of the Area

1. Overall view of the Shellmaker property

The Shellmaker Inc. property is on the edge of the Petaluma River at the intersection to San Pablo Bay, and is considered to be an estuarine environment. The original diked-off areas of the property have been converted to agricultural fields in the past . The general area bordering the dredged channels, Areas 1, 2, and 3, is all marsh-plant community. The Area 4 section is a heavily disrupted site of a large dredged ditch in preparation for the proposed harbor project. It is only the levee section, Figure 1, which is keeping the estuarine waters from flowing into this excavated ditch. The spoils from this 3,000+ foot ditch have been deposited on the old agricultural fields.

The original dredging of Areas 2 and 3 occurred in 1969-70. The most recent remedial dredging just occurred in January, 1974. It appears from soundings made by our benthic operations that there are many shallow sections in these area 1, 2, and 3 locations. This leads me to believe that much siltation from the tidal and current actions of the adjacent Petaluma River occurs here. Timing floating particles during our benthic sampling, we observed that the current flowed 1-3 feet per second in areas 2 and 3.

2. Physical Parameters (Appendix II)

a. Weather. Rain during the 22-day period provided much dilution. The nearby Novato Fire Station recorded 5 inches of rain in December, 1973, and 4.18 inches for January 1-16 inclusive, 1974. The nine inches of accumulated rain during this time accounted for the low salinity levels observed in the studies.

b. Salinity. The salinity in channel waters of areas 1, 2, and 3 was recorded at 0 to 1 parts per thousand. The surface and bottom salinities within area 2 and 3 channels were essentially the same. Apparently the freshwater flow of the flooding Petaluma River during these severe winter rain conditions dominates the entire water column within this dredged inlet. Delisle (1966) reported that the U.S. Army Corps of Engineers found little vertical stratification in the freshwater channels of the San Pablo area. Perhaps the Port Sonoma-Petaluma River area is similar in uniformity of waters.

I could find no recorded information on the salinities for this exact location during the spring and summer months, although Kohlhorst (1973) indicated salinities (TDS) of 13.4-14.5 ppt in the small sloughs of the nearby Napa Marsh for October, 1973. Such salinities do appear normal for these waters prior to the winter runoffs.

I have observed the following conditions which may indicate higher salnities in this Port Sonoma channel. On docks, pilings, floating barges, dredge pipes which appear to have been stationary in this area for some time, there are many dead and a few living barnacles, *Balanus glandula*, on these structures. The ratio of living to dead barnacles appear to be about 1 to 20. Also, during low tides, much Hydroid hydrorhiza material, probably *Obelia spp.*, is found in thick masses, with the polyps all missing; these organisms are all dead. In discussion with Filice (1974), the cause for both dead barnacles and hydroids can only be attributed to the changes in salinities, from high to the extreme low of 0 parts per thousand.

c. <u>Other Physical Parameters</u>. For surface water temperature (which was very cold, 46°F. on January 2, 1974), optical density, pH, phosphates, nitrates, and hydrogen sulfide (Appendix II), I find no significant cause for alarm. The levels for these physical parameters seem to be in the normal ranges for this winter condition of thoroughly mixed fresh water. Only the dissolved oxygen taken on January 2 and 16 showed some differences.

	Dissolved Oxygen		
Harbor transects	Jan 2	Jan 16	(1974)
AT-1	5 mg/1	10 mg/1	
AT-2	2	10	
AT-3	3	6	

Figure 2. Dissolved Oxygen, mg/1, Port Sonoma

On January 2, when water temperature was about 46°F., we detected low dissolved oxygen levels for all three areas. Thinking that the calculations might have been in error, we resampled the stations on January 16 when the water temperature was 52°F. and the dissolved oxygen levels were higher overall. However, in both instances, AT-3, the inner channel, illustrated lower dissolved oxygen levels than either of the other two areas at the Petaluma River and the outer dredged channel.

The lower limit of dissolved oxygen for most fish and invertebrates is generally set at 5.0 mg/1, SERL Report (1964).

The evaluation of the proposed Port Sonoma construction of a 3,000-foot dead-end channel could follow the pattern of Turner's (1966) study of the tidal waters of Sycamore Slough, a dead-end channel on the Sacramento-San Joaquin Delta. In my project of the effects of the harbor development during summer months, I sense that the physical parameters would increase--higher temperatures, phosphates, nitrates, salinity and hydrogen sulfide production. Dissolved oxygen might be reduced or fall below the minimum levels of 5.0 mg/1.

B. Marsh Plants Data

In the zonation of major marine plants, Figure 3, the following marsh plants were observed (after Hinde, 1954):

Low marsh: *Spartina sp.*, cord grass

Mid marsh: *Salicornia sp.*, pickleweed

Some of the thalli of this plant were covered with a dense growth of *Enteromorpha sp.*

High marsh: *Distichlis spicata*, salt grass
Grindelia sp., gum plant
Frankenia grandiflora, alkali heath
Atriplex californica, California saltbush

From an overview of the marsh plants bordering the entire harbor facilities, they appear to be normal in growth patterns. I did observe that the marsh plants closer to the Petaluma River were more dense than those in the back portions of area 3. In area 4, there were no marsh plants, simply some grasses and chapparral broom (Appendix XV). None of the plants observed were classified as rare or endangered species for this area.

If *Enteromorpha sp.* is found abundantly in these winter months, growing on *Salicornia sp.*, perhaps the summer growth would be grossly high--perhaps reaching dangerous levels of eutrophication.

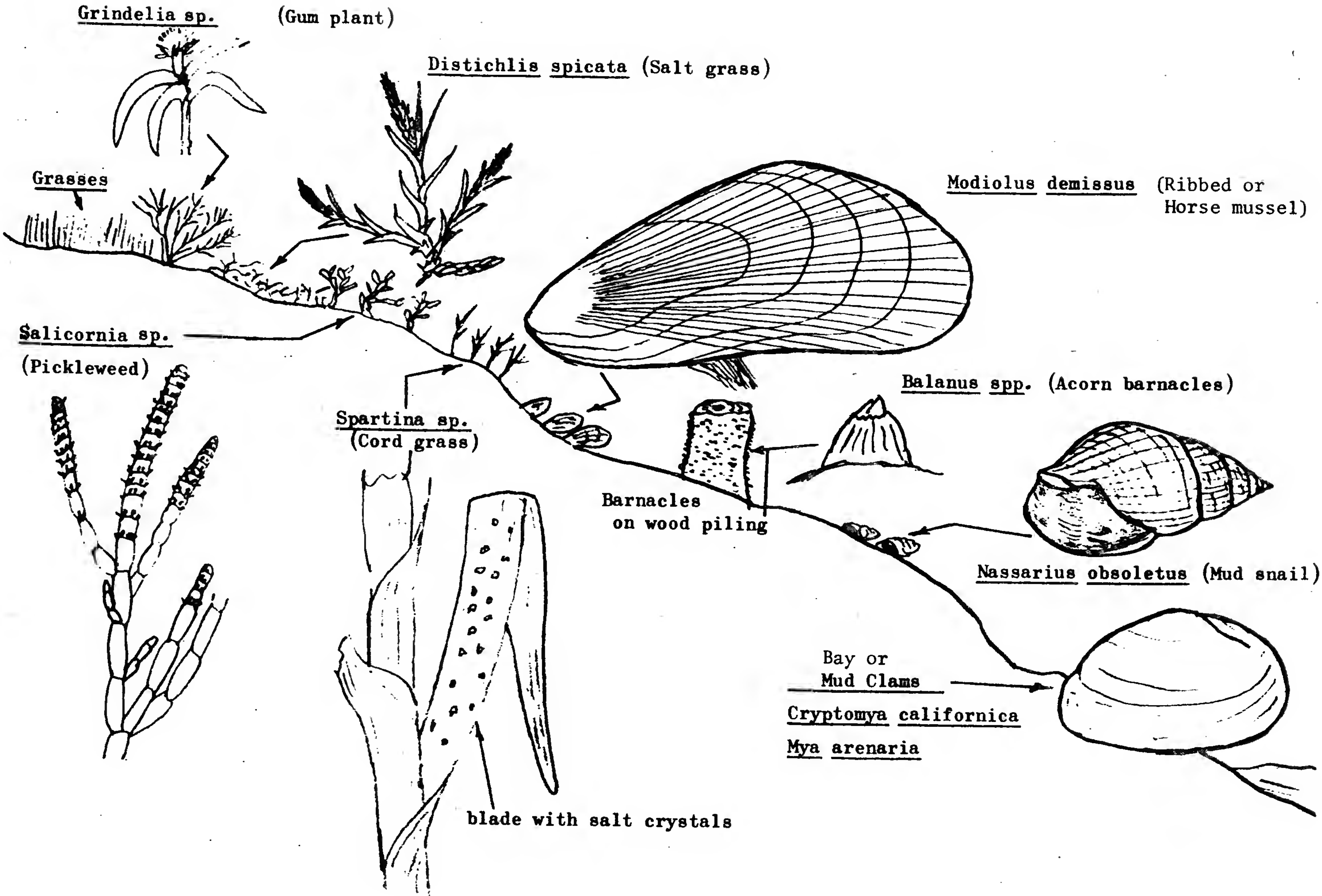


Figure 3 ZONATION OF MAJOR MARINE SPECIES, PORT SONOMA MUDFLATS (G. Chan 1/74)

C. Plankton and Fish Data

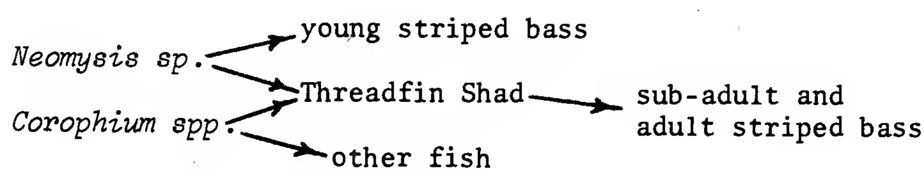
Two surface plankton tows and analyses were made, the first on January 2 when surface water temperatures were 46-47°F and the second on January 16 when water temperatures rose to 52°F. Salinities for both days were near 0 ppt, and the current about 2 feet per second. The first day's plankton results were almost nil, with a small count of diatoms. The second tow on January 16 yielded a larger density and variety of organisms (Appendix III):

Area	Phytoplankton density	Zooplankton Copepods	Zooplankton others
AT-2	$1.97 \times 10^5/m^3$	Sedgewick (1 ml count) 300	6 fish larvae 7 *Corophium sp.* 2 *Neomysis sp.*
AT-3	$2.9 \times 10^5/m^3$	84	2 fish larvae 2 Corixidae

Figure 4. Plankton Sample AT-2 vs. AT-3, January 16, 1974

The January 16 plankton samples indicated a good representation of organisms which occupy this area in the winter. Most all of the species listed are basically freshwater to euryhaline. The zooplankton which caught my interest were the amphipod, *Corophium sp.*, and *Neomysis sp.*, found in AT-2. The California Fish and Game studies on the striped bass *Roccus saxatilis* of the Sacramento and San Joaquin area indicated that this mysid shrimp is the predominant food of this important game fish. Stevens (1964) indicated that during the fall to spring in the Delta area, the *Neomysis sp.* constituted 84% of the young bass' diet. Although no striped bass was caught in our fish seine, a Threadfin shad, *Dorosoma petenense*, was obtained. The fish seine yielded mostly freshwater fish species (Appendix III), which also ingest the myriads of crustaceans as part of their food habits. In particular, *Corophium sp*. was reported as eaten in large numbers by young and juvenile bass, Stevens (1963-64) and Turner (1972). Stevens also reported that the Shad represented 36%-77% of the diet of sub-adult and adult bass in the Delta regions. Although no studies were found for the Petaluma River, I am assuming that this body of water is an important stream for striped bass fishery and salmon, Delisle (1966). Kohlhorst (1973) has also observed many such young bass in the Napa Slough, about 5 miles to the northeast of Port Sonoma.

A simple projected food chain for this area might look this way:



Hence, I value the observation of phytoplankton and zooplankton, particularly the young fish larvae and *Neomysis sp*. shrimp, which indicate the potentials of an active food web in this area. Chadwick (1972) has reported that Fish and Game studies of the Delta region of the Sacramento-San Joaquin area indicate water temperatures greater than 72°F. are lethal to *Neomysis spp*.; also, in salinities greater than 10.0 ppt, one would find that mysid shrimps are very scarce.

D. Benthic Sample Data

The benthic sampling was taken at transects AT-1, AT-2, and AT-3, (Figure 1). The 250 cc. grab sample provides but a small picture of the benthic surface and omits the deeper burrowing organisms. My intention was to observe the comparison of the benthic surfaces between the Petaluma River, the outer dredged channel and the inner dredged channel.

The benthic sampling basically illustrated that, by the 95% confidence intervals for population means, there were no significant differences between the population means of each area for the various benthic surface organisms.See Appendices IV through IX for summary listing of species and densities.

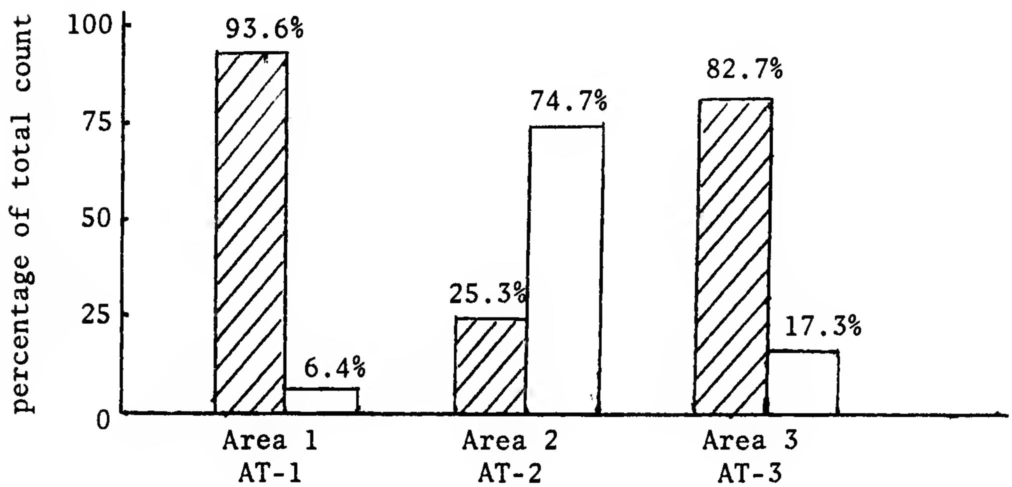


Figure 5. Comparison of Benthic Organisms (Foraminifera and Others), Port Sonoma (January 2, 1974)

Foraminifera   Other species

However, from the standpoint of population proportion, Figure 5 shows significant differences between the three areas for Foraminifera; the 95% confidence interval for population proportion differs by less than 1% above and below the sample proportion in each area. The higher percentage of other phyla in area 2 (74.7%) indicates this outer dredged channel contains more Nematodes, Oligochaetes, and Crustaceans (Appendix IV) than the other two areas.

The diversity index calculation of living species for the three areas combined was 2.17 overall, which compares favorably to the 2.44 diversity index of San Pablo Bay (SERL Report, 1960-64). Some biologists place much reliance on this index as a measure of biological health. I present the index here (Appendix VIII), but place very little value in such biological comparisons because the environments in which organisms live are different.

Another indication of much biological activity in these transects is the great abundance of minute fecal pellets which were examined in each of the transects -- AT-1, AT-2, and AT-3 (Appendices V,VI,VII). Such fecal pellets may be associated with the many small Oligochaetes which were abundant in the benthic samples, particularly AT-2, and with the Mollusks of the area (Filice and Nichols, 1974).

Likewise, the fragment samples from the benthic grabs in each of the areas revealed numerous fauna and flora particles, Appendix IX. Fragments of molluscan shells and crustacean parts were particularly abundant. All in all, the benthic samples do illustrate a very active food web with substantial trophic levels. Such a condition will exist until Shellmaker, Inc. deems it necessary to do remedial dredging; then this diverse benthic community will be disrupted or perhaps partially destroyed for a period of time.

E. Intertidal Sampling Data

Square meter quadrat sampling every 100 feet was taken at areas 2 and 3 along the *Spartina sp.*, cord grass intertidal zone. The dominant organisms sampled in these zones were the horse mussel, *Modiolus demissus*, and the mud snail, *Nassarius obsoletus*, Appendices X, XI.

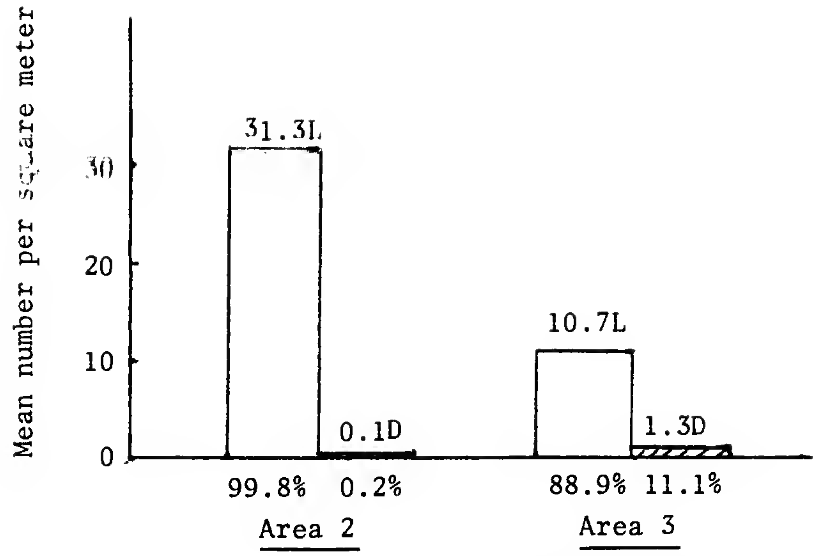


Figure 6. Intertidal Transect Sampling, Port Sonoma (January 4, 1974)

live dead

While there were no significant differences between the population means of live and dead organisms of areas 2 and 3, there was a significant difference between the population proportions of live organisms of the two areas by an interval of 6.3 to 15.5% difference.

Data in Figure 6 shows that Area 3, the inner dredged channel has fewer living intertidal organisms (mollusks) and more dead organisms (molluscan shells) than Area 2, the outer dredged channel. The reason for the differences is not exposed. Perhaps the Area 3 inner channel has more dead because it's a dead-end collection basin. On the other hand, if this dead-end basin is subjected to rising summer temperatures, eutrophication may occur, and resulting conditions could eventually produce lower number of living organisms and higher number of empty shells in this area.

Turner (1963) in his work in the Delta's Sycamore Slough, a dead-end basin, concluded:

1. There was an increase in retention time of the mass of water with increasing distance into the dead-end slough.
2. Water temperature was highest in the back portions of the slough, particularly in June.
3. Although he did not do benthic sampling, he found more Cladocerans and Copepods there in June than in December.
4. The higher dissolved solids, higher residence time of water, and higher water temperatures at the back end of the slough, all of these are important and influential factors in affecting zooplankton population.

If the Port Sonoma project were approved and the 3,000-foot dead-end channel constructed, I would also predict that this basin during summer months would have higher concentration of dissolved solids, higher temperatures, and higher residence time of water--all of which may contribute towards eutrophication problems, especially if sewage from this marina is dumped in this basin. Perhaps then, for Area 3, this small winter sample of more dead and fewer live organisms in comparison with Area 2 may give us a glimpse of the effect of the future boat project.

F. Birds and Mammals Data

Between the observations of Ballering and Silva (1970), Trudeau and Burns (1973), and Chan and assistants (January, 1974), there was a total of over 80 species of birds spotted in this Port Sonoma-Lower Tubbs Island area. My winter observations revealed some interesting sightings:

1. The canvasback, *Aythya valisineria*, numbered 36, 42, and 23 in the three days of counting in Area 3. Smith (1973) reported that the Suisan Marsh and adjacent area, including Port Sonoma, supports 70% of the wintering population in the state or some 35,000 *A. valisineria*. He also reports that the January Fish and Game counts for the past 14 years revealed a low of 185,013 to a high of 1,023,681 ducks of all types. Simply, the canvasback and other ducks represent a major bird in these winter quarters at Port Sonoma.

> "The Petaluma River estuarine habitats support a large population of canvasback ducks that winter among that river's marshlands and nearby San Pablo Bay...The 1970 inventory showed 28,400 canvasbacks in these areas."
> Smith (1973)

2. The white-tailed kite, *Elanus leucurus*, was observed over the Port Sonoma area. This bird is a protected species and is often seen in this San Francisco Bay Estuary region. This is a very important bird of prey, its food consisting mainly of rodents and large insects. This bird is described as a "threatened species", (U.S. Army Corps of Engineers, 1974). A significant number of other birds of prey were observed in this area, Appendix XIII.
3. The American egret, *Casmerodias albus*, was observed in large numbers, and on January 16, 1974, one was seen flying with a mouse (unidentified species) in its beak.
4. The only mammal observed during these winter days was a jack rabbit, *Lepus californicus*, and also the mouse in the egret's beak. However, many mouse burrows and trails could be easily observed in the grasslands surrounding the marsh borders in this area. Although not observed, the salt marsh harvest mouse, *Reithrodontomys raviventris*, may be an inhabitant of this area

and is classified as a "threatened species", (U.S. Army Corps of Engineers, 1974).

The birds and mammals (Appendix XIV) in this area illustrate that at the top of the trophic food pyramid and food web there are many birds vital to the balance of this habitat, Peterson (1961). Ducks are very important to these winter quarters. Obviously then, there must be an adequate supply of small mammals to keep the food web in a harmonious balance.

Finally, throughout this Port Sonoma-Lower Tubbs Island area, we have observed a large number of birds, some of which are classified as "endangered and protected"; these are--

Great Blue Heron, *Ardea herodias*

Common Egret, *Casmerodius albus*

Snowy Egret, *Leucopkoyx thula*

Burrowing Owl, *Speotyto cunicularia*

Clapper Rail, *Rallus longirostris*

White-tailed Kite, *Elanus leucurus*

To project a large boat harbor with boats, people, and contaminants to this area would certainly cause question as to how long the present biota would survive.

IV. IMPACT SUMMARY OF THE PORT SONOMA PROJECT

To evaluate the impact of the Port Sonoma Project on the biota based on a winter observation period of 22 days would be, as previously stated in the Introduction, a highly limited form of science. There is no question in my mind that a 8-12 month study would reveal much more data and significant information which would clarify the tenuous judgments concerning this project. However, I do have vibrations that are, in part, conditioned by my winter observations. The following summary statements reflect my projections of the Port Sonoma Project on the biota of the area.

A. Impact on the Physical Parameters

The 3,000-foot dead-end harbor channel would increase the residence time of water in the back parts of this basin, which may result in an accumulation of organic nutrients, influenced by the higher summer temperatures--all of which may produce an eutrophication effect. The degree of oxygen depletion and organic waste accumulation would be predicated on the numbers of boats, people, sewage from boats and the overall sewage system for the area. It was observed in my winter samples that changes in temperature and salinities would produce lethal effects on barnacles and hydroids, and such conditions would prevail throughout the 3,000-foot channel. Rainfall, such as the above-average recorded for December 1973-January 1974 (9 inches or more),will always cause low salinities and is a part of the atmospheric changes of our geographical location.

The extent to which all pollutants enter the marine-estuarine environment will vary according to the varieties and concentration of the pollutants, the flushing characteristics of the waters and the relative toxicity of these pollutants on the variety of species.

My winter observations did not reveal the presence of pollutants in toxic levels. A future hypothesis would be that toxic conditions would exist to some degree if the project were to be constructed in part or whole.

B. Impact on the Landscape

If the existing levee, Figure 1, were to be dismantled so as to allow tidal waters to enter the proposed 3,000-foot channel ditch, Area 4, then a potential marsh plant community would be established along the channel borders. The more dense concentration of marsh plants and organisms would probably be near the junction of the harbor at the Petaluma River, and the more sparse concentration towards the dead-end basin. Continual dredging and filling of the borders would eliminate the mammal-bird habitats of the present food web.

C. Impact on the Biological Organisms

If lethal concentration of pollutants is not present after the construction of the 3,000-foot channel, then phytoplankton and zooplankton production, particularly crustaceans such as Cladocerans and Copepods (after Turner, 1963) would form the basis of an intricate food web. In time, benthic and intertidal organisms would be established. Fish would enter and exit the area, perhaps even the sport-game fishes of striped bass and salmon. Ducks would come and feed on fauna and flora of the habitat during the winter, and other birds and mammals would interact with the myriad of insects and other land creatures. Conceivably, the diversity and productivity of organisms may even be quite high.

However, once the concentration of pollutants from human development increases towards the lethal levels, this 3,000-foot basin might then be compared to an estuarine cesspool affecting the Petaluma River and San Pablo Bay waters. As a result, long-lasting changes in the ecological conditions of the upper San Pablo area could be produced, affecting the speciation and density of the marine related organisms--the plankton, fish, invertebrates, ducks, other birds, and mammals.

Moreover, the siltation of the channel will undoubtedly take place, and remedial dredging and dumping of the spoils for safe boat passage would also be a continual devastation on marine biota and terrestrial organisms. The Port Sonoma project and operations would certainly benefit the owners of the property, the boats and boat owners, but what about the fisherman, duck hunter, bird watcher, educational student, and even the general public...? All have a stake in this proposed Port Sonoma development.

V. MITIGATION ALTERNATIVES

Mitigation for Habitat Improvement	Possible Results of Mitigation Measures
A. No development on the present site. Continue ecological monitoring of seasonal variations	The current populations of organisms and their trophic interactions would be maintained.
B. Open up the levee to restore the old agricultural fields into marsh lands.	Add new marsh habitats to the area.
C. Widen mouth of harbor to the Petaluma River. No development at present site. Continue ecological monitor of seasonal changes	Provide a larger tidal prism to enter the existing dredged channel areas. Allow more water circulation for marine biota.
D. Partial development in minute stages with ecological monitor stations developed for constant seasonal review, a one-third development.	Enable ecologist to record the effects of a partial development. Review would take place before justification of further construction. More marsh would occur.
E. Full development with ecological monitoring of the area	Record the actual impact of the total development on the areas of Port Sonoma, Petaluma Creek, Lower Tubbs Island, and San Pable Bay.
F. Dump dredged spoils elsewhere, not on the Shellmaker property.	Maintain current terrestrial biota.
G. Increase the planting of shrubs, trees, etc.	Increase habitats for wildlife.

H.	Slope the elevation of the channel banks, maintaining large sloping levels below 5.4' MLLW(Pestrong, 1972) for the Cord grass, *Spartina spp.*, 8.4' to 12.4' for the pickle-weed, *Salicornia spp.*	Produce a gradient growth of marsh plants; hence, increase plant productivity and habitats for marine animals, insects, birds.
I.	Allow natural succession of plants.	Increased shelter for nesting sites for birds and mice.
J.	Reduce the number of boat slips in proposed harbor.	Fewer boats and people mean more ducks and other wildlife.
K.	Require that all boats have sewage holding tanks which must be pumped into a pre-scribed land disposal system.	Prevent contaminants from entering the water column.
L.	Develop a sewage system for the boat harbor that will guarantee no or little contaminants to enter the water. A land disposal system seems to be most logical.	Prevent the buildup of contaminants in the dead-end basin.

Summary of Mitigation Alternatives

The biology of the Port Sonoma area is in constant change. Shellmaker, Inc.,continues to dredge the existing channels both to the east and west of the protective levee, Figure 1, and the spoils are dumped onto the old agricultural fields. If the area were to remain untouched, the biological estuarine conditions would prevail in their cyclical patterns conforming to seasonal changes. If the levee were opened to restore the old agricultural fields into new marshlands, this would cretainly be a bonanza to the estuarine inhabitants. Certainly, this position of "no development-open the levee" is reasonable from a purely biological-ecological view.

However, from my limited observations at Port Sonoma, a possible mitigation alternative would be to also add new marsh borders; that is, if partial development on about a one-third scale is allowed (a 1,000-foot channel instead), this could satisfy the recreational demand (to be determined) for Sonoma and Marin Counties. The harbor contaminants from such partial development must be strictly regulated. Certainly such construction should be monitored by a long-range (years) ecological plan, so that future decisions can be made wisely.

Full development, in my judgment, would constitute a costly experiment, with the entire biological communities of Port sonoma, Petaluma River, Lower Tubbs Island, and San Pablo Bay, emerging as the liability constituents. I don't believe the economic gain from such a project is worth the gamble.

Acknowledgements

To my colleagues, Maxine Chan and Carl Zeigler, go my deepest thanks for performing the arduous task of piecing together this little bit of science in such a short period of time.

VI. CITED REFERENCES

Ballering, Robert. 1970. A Report on Lower Tubbs Island, College of Marin, unpublished mineograph.

_______________. 1971. A Winter Population Census of Birds, Lower Tubbs Island, College of Marin, unpublished mineograph.

Bane, Gilbert; Bane, Anneka. 1971. Bay Fishes of Northern California, Mariscos Publications, N.Y.

Chadwich, Harold. 1972. Invertebrate Animals and Their Environmental Requirements Zooplankton., Calif. Fish & Game, "Ecological Studies of the Sacramento-San Joaquin Esturary," pp. 26-35.

Conradson, Diane. 1969. Exploring Our Baylands, Palo Alto Chamber of Commerce.

Curtis, Brian. 1949. The Warm-water Game Fishes of California, California Fish and Game, reprint, Vol 35, No.4, Oct.

Dawson, E. Yale. 1966. Seashore Plants of Northern California, University of California Press, Berkeley

Delisle, Glenn. 1966. Preliminary Fish and Wildlife Plan for San Francisco Bay Estuary, San Francisco Bay Conservation and Development Commission, pp. 66, 109.

Filice, Francis. 1974. University of San Francisco, Biology Department, telephone conversation, January 9.

Fitch, John E. 1953. Common Marine Bivalves of California, Calif. Dept. of Fish and Game, Fish Bulletin No. 90.

Gran, H.H.; Angst, E.C. 1931. Key to the Genera of Marine Diatoms, University of Washington, unpublished mineograph.

Hedgpeth, Joel W. 1962. Seashore Life of the San Francisco Bay Region and the Coast of Northern California, Univer. of California Press.

Hinde, Howard. 1954. The Vertical Distribution of Salt Marsh Phanerograms in Relation to Tide Levels, "Ecological Monographs", Vol 24, No. 2, pp. 209-225.

Hitchcock, A. S. 1972. Manual of the Grasses of the United States, Dover, N.Y.

Keen, A. Myra. 1963. Marine Molluscan Genera of Western North America, Stanford University Press.

Kimsey, J.B.; Fisk, L.O. 1960. Keys to the Freshwater and Anadromous Fishes of California, Calif. Fish and Game, Vol 46, No. 4, October.

Kohlhorst, David. 1973. Fish Fauna Survey of the Napa and Suisan Marshes, Calif. Department of Fish and Game, unpublished paper, p. 5.

Light's Manual, rev., various authors. 1954. Intertidal Invertebrates of the Central California Coast, Univer. of California Press.

Miller, D.J.; Lea, R.N. 1972. Guide to the Coastal Marine Fishes of California, Calif. Fish and Game, Fish Bulletin 157.

Nichols, Frederick. 1974. U.S. Geological Survey, Menlo Park, California, telephone conversation on Oligochaetes, January 8.

Pestrong, Raymond. 1972. San Francisco Bay Tidelands. California Geology, Vol 25, No. 2, pp. 27-40

Peterson, Roger. T. 1961. A Field Guide to Western Birds, Houghton Mifflin, Boston.

Ricketts, E.F.; Calvin, Jack., rev. by J.W. Hedgpeth. 1968. Between Pacific Tides, 4th Ed., Stanford University Press

Roedel, Phil M. 1953. Common Ocean Fishes of the California Coast, Calif. Dept. of Fish and Game, Fish Bulletin No. 91.

SERL Report. 1960-1964. A Comprehensive Study of San Francisco Bay, Vol V, No. 78-2, Table VI-2.

Simpson, George Gaylord; Roe, Anne; Lewontin, R.C. 1960. Quantitative Zoology, Harcourt Brace & World, N.Y. pp. 148-171.

Silva, Joseph. 1970. Bird S udy of Lower Tubbs Island, College of Marin, Kentfield, unpublished mimeograph.

Smith, Emil, Ed., 1973. Coastal County Fish and Wildlife Resources and their Utilization, California Dept. of Fish and Game, pp. 55, 87, 88.

Stevens, Donald. 1963-1964. Food Habits of Striped Bass, Roccus saxatilis, in the Sacramento- San Joaquin Delta, Calif. Dept. of Fish and Game, Bulletin 136, Part II, pp. 68-96.

Strudeau, Douglas; Burns, Aubrey. 1973. Birds Check List, Lower Tubbs Island, College of Marin, Kentfield, unpublished mimeograph.

Turner, Jerry. 1962. Seasonal Distribution of Crustacean Plankters in the Sacramento-San Joaquin Delta 1966, Calif. Dept. of Fish and Game, Fish Bulletin 133, pp. 95-104.

____________. 1972. Resident Freshwater Fishes of the Delta, "Ecological Studies of the Sac-San Joaquin Estuary," Calif. Fish & Game, 56-59.

U.S. Army Corps of Engineers. 1974. Environmental Impact Statement, Hahn Shopping Center, Marin County, San Francisco, pp. 26-28.

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Date	Weather	Location	Observations	Appendix
December 27, 1973	Overcast, light rain	Preliminary survey	birds, mammals	XIII, XIV, XV
December 28, 1973	Partly cloudy, calm 62°F.	General survey	birds	XIII,XIV
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January 2, 1974	clear, cool	Harbor transects		
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January 4, 1974	overcast heavy rains 46°F		birds	XIII,XIV
			algae	XV
		Area 2,3	fish seine	III
		Area 2,3	intertidal m^2 sampling	X, XI
January 16, 1974	overcast rain strong winds	AT-2,3	plankton tows	III
			physical parameters	II
			birds, mammals	XIII to XV

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APPENDIX II

PHYSICAL PARAMETERS, PORT SONOMA

Date Tide	Location	Weather, Air temp.	Water temp.	Surface Salinity	Optical Density	WATER SAMPLE ANALYSIS: d. O_2	pH	Phos-phates	Nitrates	H_2S
				(70°F)		mg/l		mg/l	mg/l	
Dec. 28, 1973	General Survey	partly cloudy, calm, 62°F.								
3.0 at 7:15 AM PST	South end of small dock		52°F.	2°/oo						
	South end of marsh pit		52°F.	2°/oo						
	South end AT-3		54°F.	1°/oo						
	near RR tracks		56°F.	4°/oo						
	intersection RR bridge and Petaluma River			1°/oo						
Jan. 2, 1974	Harbor Transects	clear, cool	ebbing tide 3 fps.							
1.0 at 12:34 PM PST	AT-1 (#4-9)	52°F.	47°F.	0°/oo		5	7.1	0.12	0.12	
	AT-2 (#10-8)	51°F.	46°F.	0°/oo		2	7.1	0.15	0.48	
	AT-3 (#19-3)	52°F.	46.5°F.	0°/oo	86.5%	3	7.4	0.3	0.08	
Jan. 16, 1974	AT-1 and 2	overcast, rain, strong winds	52°F.	0.1°/oo, 0.0°/oo at 2m d.	51.9%	10	7.4	0.39 to 0.57		∠0.1
0.5 at 1:09 PM PST	AT-3		51.8°F.	0.0°/oo, 0.0°/oo at 2m d.	30.2%	6	7.2	0.5 to 0.76		∠0.1

NOTE: RAINFALL recorded at Novato Fire Station for December: 5 inches
for January 1-16 inclusive: 4.18 inches

PLANKTON TOWS

Surface tows, one for each transect
Diameter of net opening = 25.4 cm.
Net micron mesh size 100

		Petaluma River Area 1 AT-1	Outer Harbor Area 2 AT-2	Inner Channel Area 3 AT-3
January 2, 1974	Length of tow =	100 meters	100 meters	100 meters
	Time of tow =	11-11:30 A.M.	1-1:30 P.M.	12-12:30 P.M.
	46–47°F water			
	Phytoplankton =	$3.95 \times 10^4/m^3$	0	0
January 16, 1974	Length of tow =	(no tow)	100 meters	100 meters
	Time of tow =		1-1:30 P.M.DST	1:30 P.M.DST
	52°F water			
	Phytoplankton =		$1.97 \times 10^5/m^3$	$2.9 \times 10^5/m^3$
	Zooplankton			
	Gross exam of tow:			
	Fish larvae		6	2
	Corophium sp.		7	0
	Neomysis sp.		2	0
	Corixidae, water boatmen		0	2
	1 ml of 100ml dilution, Sedgwick-Rafter count:			
	Copepods (Calanoid)		137	30
	(Harpacticoid)		0	2
	(Nauplius stage)		194	52

FISH SEINES

January 4, 1974	Area 2:	6 *Hypomesus transpacificus* Delta or Pond Smelt
		1 *Spirinchus thaleichthys* Longfin or Sacramento Smelt
		1 *Dorosoma petenense* Threadfin Shad
		1 *Pomoxis annularis* White Crappie
40'x8' ¼" mesh	Area 3:	1 *Cottus asper* Prickly Sculpin

APPENDIX IV SUMMARY LIST OF SPECIES FOR BENTHIC SAMPLING, PORT SONOMA

January 2, 1974

Total for all areas		Area 1 Petaluma River	Area 2 Outer Harbor	Area 3 Inner Channel	
10,263	=	2,533	1,532	6,198	Foraminifera
3,251	=	0	2,928	278	Nematoda
293	=	5	250	38	Annelida Oligochaeta
2,468 13 dead	= =	143 12 dead	1,342	983 1 dead	Arthropoda Crustacea Ostracods (2,126) Copepods (314) Harpacticoida (312) Calanoida (2) Amphipods (4) Gammaridea Corophiidae Cirripedia (24 live, 13 dead) *Balanus glandula*
27	=	23	4	0	Mollusca Gastropods (22) *Nassarius obsoletus* Pelecypods (5) 2 *Gemma gemma* 1 *Transennella tantilla* 1 *Modiolus demissus* 1 *Mya arenaria*
16,257	=	2,704	6,056	7,497	live organisms
13	=	12	0	1	dead organisms

APPENDIX V

DATA OF BENTHIC SAMPLING, PORT SONOMA

AREA 1
Petaluma River
at entrance to Port Sonoma

January 2, 1974: 10 samples of 250 cc. each

Transect sample	Washed sample volume	Foraminifera	Nematoda	Annelida Oligochaeta	Arthropoda Crustacea	Mollusca	Other phyla, Fragments (App.IX) &=plant fragments	Fecal pellets $* = \geq 10^3/cm.^2$
AT-1 Tr#4								
1	/1 ml	24	0	0	4 Ostracods	0	Fragments	*
2	15 ml	300 @ 20/ml	0	0	0	0	Fragments	*14 ml
3	/1 ml	3	0	0	0	0	-	*
4	/1 ml	4	0	0	0	0	-	*
5	/1 ml	3	0	0	0	0	-	*
6	14 ml	1316 @ 94/ml	0	0	0	2 Pelecypods	Fragments	*
7	/1 ml	14	0	0	3 Ostracods	0	Fragments	*
8	13 ml	351 @ 27/ml	0	2	78 Ostracods @ 6/ml	0	Fragments	*
9	6 ml	42 @ 7/ml	0	0	0	0	Fragments	*
10	39 ml	476 @ 28/ml 17 ml	0	3	34 Ostracods @ 2/ml, 17ml 24 live and 12 dead barnacles	19 Gastropods 2 Pelecypods	Fragments	*
AREA 1 Totals 2,704 live 12 dead		2533	0	5	143 live 12 dead	23	Fragments in 7 samples	more than $1,000/cm.^2$ in each sample *

* collated from sieves

APPENDIX VI — DATA OF BENTHIC SAMPLING, PORT SONOMA — AREA 2

Outer Harbor of Port Sonoma

January 2, 1974: 10 samples of 250 cc. each

Transect sample	Washed sample volume	Foraminifera	Nematoda	Annelida Oligochaeta	Arthropoda Crustacea	Mollusca	Other phyla, Fragments (App.IX) &=plant fragments	Fecal pellets $*=\geq 10^3/cm.^2$
AT-2 Tr#10								
1	13 ml	767 @ 59/ml	1378 @ 106/ml	154	4 Amphipods 91 Ostracods @ 7/ml 310 Copepods @ 24/ml	2 Gastropods	Fragments	* 10 ml
2	/1 ml	0	63	29	11 Ostracods 2 Copepods	0	Fragments	*
3	4 ml	172 @ 43/ml	124 @ 31/ml	18	56 Ostracods @ 14/ml	0	Fragments	* 3 ml
4	/1 ml	0	11	2	4 Ostracods	0	-	*
5	2 ml	77	49	3	0	0	Fragments	*
6	2 ml	19	3	0	10 Ostracods	0	Fragments	*
7	3 ml	28	47	12	10 Ostracods	1 Gastropod 1 Pelecypod	1 Pelecypod larva Fragments	* 2 ml
8	/1 ml	7	3	1	2 Ostracods	0	Fragments	*
9	8 ml	336 @ 42/ml	1112 @ 139/ml	22	656 Ostracods @ 82/ml	0	Fragments	*
10	6 ml	126 @ 21/ml	138 @ 23/ml	9	186 Ostracods @ 31/ml	0	Fragments, &, mica particles	* 2 ml
AREA 2 Totals 6,056 live		1532	2928	250	1342	4	Fragments in 9 samples 1 larva Plant fragments mica particles	more than $1,000/cm.^2$ in each sample*

* collated from sieves

APPENDIX VII — DATA OF BENTHIC SAMPLING, PORT SONOMA — AREA 3

January 2, 1974: 10 samples of 250 cc. each

Inner Channel of Port Sonoma

Tran-sect sample	Washed sample volume	Forami-nifera	Nematoda	Annelida Oligochaeta	Arthropoda Crustacea	Mollusca	Other phyla, Fragments(App.IX) &=plant fragments	Fecal pellets $*=\geq 10^3/cm.^2$
AT-3 Tr#19 1	75 ml	125 @ 5/ml, 25 ml 5620 @ 281/ml, 20 ml =5745	0	0	150 Ostracods @ 6/ml, 25ml 660 Ostracods @33/ml, 20ml =810 total 1 dead barnacle	0	Fragments &=abundant	*
2	<1 ml	35	0	0	18 Ostracods 1 Copepod	0	&=abundant	*
3	<1 ml	14	0	0	23 Ostracods	0	Fragments &=abundant	*
4	<1 ml	28	0	0	37 Ostracods	0	Fragments &=abundant	*
5	3 ml	164	0	0	25 Ostracods	0	Fragments &=abundant	*60% are charcoal color
6	<1 ml	61	0	0	9 Ostracods	0	-	*
7	<1 ml	7	4	0	5 Ostracods	0	-	*
8	1 ml	40	106	3	16 Ostracods	0	-	*
9	1 ml	26	61	2	9 Ostracods 1 Copepod	0	&=abundant	*
10	3 ml	78	107	33	29 Ostracods	0	Fragments	*
AREA 3 Totals 7,497 live 1 dead		6198	278	38	983 live 1 dead	0	Fragments in 5 samples Plant fragments in 6 samples	more than 1,000/cm.^{2} in each sample *

* collated from sieves

APPENDIX VIII — STATISTICAL ANALYSIS OF BENTHIC SAMPLING, PORT SONOMA — January 2, 1974

95% confidence interval
is used for population mean
L = live, D = dead

Ten samples of 250 cc. each
were examined for each area

Area 1 = Petaluma River at entrance
Area 2 = Outer Harbor
Area 3 = Inner Channel

Area Transect	Foraminifera	Nematoda	Annelida Oligochaeta	Arthropoda Crustacea	Mollusca	All phyla No Foram (live only)	ALL PHYLA
AT-1 total	2,533	0	5	143L, 12D	23	171	2,704L, 12D
sample mean	253.3		0.5	14.3L,1.2D	2.3	17.1	270.4L,1.2D
pop. mean	-41.9/548.5		-0.3/1.3	-6.2/34.8L -1.5/ 3.9D	-2.4/7.0	-7.0/41.2	-30.8/571.6L -1.5/3.9D
proportions:	93.7%					6.3%	
1.14 diversity index							
AT-2 total	1,532	2,928	250	1,342	4	4.524	6,056
sample mean	153.2	292.8	25.0	134.2	0.4	452.4	605.6
pop. mean	-18.9/325.0	-70.5/656.1	-8.2/58.2	-26.6/294.6	-0.2/1.0	-85.4/990.2	-92.1/1030.3
proportions:	25.3%					74.7%	
2.87 diversity index							
AT-3 total	6,198	278	38	983L, 1D	0	1,299	7,497L, 1D
sample mean	619.8	27.8	3.8	98.3L,0.1D		129.9	749.7L, 0.1D
pop. mean	-668.7/1908.3	-4.8/60.4	-3.6/11.2	-80.7/277.3L -0.1/0.3D		-45.3/305.1	-710.3L/2209.7L -0.1/0.3D
proportions:	82.7%					17.3%	
1.42 diversity index							
Overall totals:	10,263L	3,206L	293L	2,468L, 13D	27L	5,994L	16,257L, 13D

2.17 diversity index

APPENDIX IX

SUMMARY OF MARINE ORGANISM FRAGMENTS

Port Sonoma

(number) = number of samples containing fragments

Benthic Sampling, ten 250 cc. samples in each area, January 4, 1974

Area Transect	Annelida, Worm	Arthropoda Crustacea	Mollusca	Bryozoan	Other
Area 1, AT-1 Petaluma River at entrance, of Port Sonoma	tubeworm tubes in (3) oligochaeta in (1) nemertea in (1)	barnacle in (3)	pelecypod in (4) pelecypod valve (3) pelecypod siphon (3)	in (4) colony in (1)	radiolarian in (1) 1 insect in (1)
Area 2, AT-2 Outer Harbor	tubeworm tubes in (6) oligochaeta in (2) polychaeta in (1)	crustacea in (1) barnacle in (1)	pelecypod in (1) pelecypod valve (2) pelecypod siphon (4)	in (1)	none
Area 3, AT-3 Inner Channel	tubeworm tubes in (2)	barnacle in (1) barnacle plates (3)	pelecypod valve (2)	none	1 fish scale (1)
Total of 30 samples	tubeworm tubes in 11 of 30 oligochaeta in 3 of 30 nemertea in 1 of 30 polychaeta in 1 of 30	crustacea in 1 of 30 barnacle in 5 of 30 barnacle plates in 3 of 30	pelecypod, 5 of 30 pelecypod valve in 7 of 30 pelecypod siphon in 7 of 30	bryozoan, 5 of 30 bryozoan colony in 1 of 30	radiolarian in 1 of 30 1 insect in 1 of 30 1 fish scale in 1 of 30

Identifiable Benthic Sampling Species for Fragments: January 4, 1974

Mollusca =
- 1 *Modiolus demissus*
- 1 *Cryptomya californica*
- 1 *Macoma nasuta*
- 1 *Nassarius obsoletus*
- 3 *Mya arenaria*
- 6 *Macoma secta*

Intertidal Fragments from general survey of Port Sonoma: December 28, 1973

Arthropoda (Crustacea)
- *Hemigrapsus oregonensis*
- *Cancer magister*

APPENDIX X INTERTIDAL SQUARE METER SAMPLING OF INVERTEBRATES, PORT SONOMA

Total of 30 square meter samples, taken approximately every 100± feet; square meters # 1,2,3, every 50 feet.

January 4, 1974
-0.4 tide at 2:26 P.M. PST
46° F. water temperature
0/00 salinity
overcast weather, heavy rains

	m^2 #	*Modiolus demissus* ribbed mussel live	(dead)	*Nassarius obsoletus* mud snail live	*Hemigrapsus oregonensis* mud shore crab (dead) none live	*Mya arenaria* bay clam (dead shells) none live
AREA 2	1	0	none	0	0	0
Outer	2	0	dead	0	0	0
Harbor	3	16	in	0	0	0
	4	0	Area	0	0	0
	5	0	2	0	0	0
	6	45		0	0	0
	7	4		1	0	0
	8	6		0	0	0
	9	5		0	(1)	0
	10	170		0	0	0
	11	210		0	0	0
	12	12		0	0	0
	13	0		0	0	0
	14	0		0	0	0
	15	0		0	0	0
AREA 3	16	2	(6)	0	0	0
Inner	17	3	(0)	28	0	0
Channel	18	18	(0)	0	0	0
	19	8	(0)	18	0	0
	20	51	(0)	0	0	0
	21	2	(0)	0	0	0
	22	0	(0)	0	0	0
	23	2	(0)	0	0	0
	24	1	(1)	0	0	(1)
	25	0	(0)	0	0	(5)
	26	0	(0)	0	0	0
	27	4	(2)	0	0	0
	28	17	(1)	0	0	0
	29	2	(1)	0	0	0
	30	4	(3)	0	0	0
Total Count		582	(14)	47	(1)	(6)

APPENDIX XI STATISTICAL ANALYSIS OF INTERTIDAL M^2 SAMPLING DATA, PORT SONOMA

Comparison of Area 2 Outer Harbor sampling of 15 m^2
and Area 3 Inner Channel sampling of 15 m^2
Data taken on January 4, 1974, -0.4 tide at 2:26 P.M. PST

	Species	Area	Total Count	Sample Mean	95% confidence interval for population mean	Test hypothesis $H_0: \mu_2 = \mu_3$ $H_1: \mu_2 \neq \mu_3$
LIVE	*Modiolus*	2	468	31.2	-5.3 to 67.7	H_0 true
	demissus	3	114	7.6	0.2 to 15.0	
	Nassarius	2	1	0.1	-0.1 to 0.2	H_0 true
	obsoletus	3	46	3.1	-1.5 to 7.7	
	All Live	2	469	31.3	-5.2 to 67.8	H_0 true
		3	160	10.7	2.3 to 19.0	
DEAD	*Modiolus*	2	0	-	-	
	demissus	3	14	0.9	0.01 to 1.9	
	Hemigrapsus	2	1	0.1	-0.1 to 0.2	
	oregonensis	3	0	-	-	
	Mya	2	0	-	-	
	arenaria	3	6	0.4	-0.3 to 1.1	
	All Dead	2	1	0.1	-0.1 to 0.2	Reject H_0 0.2 to 2.3 interval of difference
		3	20	1.3	0.3 to 2.4	

	Area	live($\hat{p}$)	dead($\hat{q}$)	$H_0: p_2=p_3$; $H_1: p_2 \neq p_3$
All species counted	2	99.8%	0.2%	Reject H_0, 6.3% to 15.5% difference between population proportions
	3	88.9%	11.1%	

	Area	*M. demissus* ($\hat{p}$) $\hat{p}$	not *M. demissus* ($\hat{q}$) $\hat{q}$	$H_0: p_2=p_3$; $H_1: p_2 \neq p_3$
All live species	2	99.8%	0.2%	Reject H_0, 21.5% to 35.5% difference between population proportions
	3	71.3%	28.8%	

APPENDIX XII — OTHER OBSERVATIONS, PORT SONOMA

December 28, 1973 general survey	South end of marsh spit	*Modiolus demissus* along edge of cord grass *Orchestoidea sp.* along pickleweed
	South end of transect AT-3	styrofoam bored out by isopods *Sphaeroma sp.* dead *Obelia sp.* on dredge equipment
	Near railroad tracks	numerous aquatic insects, rabbit pellets
	Across railroad tracks	numerous *Hemigrapsus oregonensis* numerous *Modiolus demissus* deer trails and pellets
	Intersection railroad bridge and Petaluma River	Teredos in bridge piling, observed by diver
January 2, 1974	AT-3 boom of dredge	live barnacles, *Balanus glandula* , density of 15/linear decimeter, and *Modiolus demissus*
	barge, dredge side	one square decimeter count = 225 *Balanus glandula* 1 *Modiolus demissus* *B. glandula* had ratio of 20 dead to 1 live

APPENDIX XIII BIRD AND MAMMAL OBSERVATIONS, PORT SONOMA

(December 27,28, 1973; January 4,16, 1974)

Dec 27	Dec 28	Jan 4	Jan 16		
	1	6		*Aechmophorus occidentalis*	Grebe, Western
		1		*Aix sponsa*	Duck, Wood
	2			*Anas platyrhynchos*	Mallard
		1		*Aythya affinis*	Duck, Lesser Scaup
36	42	23		*A. valisineria*	Canvasback
	1			*Bucephala clangula*	Duck, Common Goldeneye
	1			*B. islandica*	Duck, Barrow's Goldeneye
5	3	7	1	*Casmerodius albus*	Egret
		2		*Charadrius vociferus*	Killdeer
4	4	6		*Fulica americana*	Coot
		20	2	*Larus sp.*	Seagull
	2			*Totanus melanoleucus*	Yellowlegs, Greater
	16			*Columba fasciata*	Pigeon
	7	6	6	*Corvus branchythynchos*	Crow
	1			*Junco oreganus*	Junco, Oregon
	30	20	30	*Sturnella neglecta*	Meadowlark, Western
	40			undetermined species	Dove
	60	60		undetermined species	Sparrow
	1	3		*Buteo lagopus*	Hawk, Rough-legged
	1			*B. lineatus*	Hawk, Red-shouldered
		1		*Elanus leucurus*	Kite, White-tailed
	1			*Falco sparverius*	Hawk, Sparrow
45	213	156	39	Total Birds = 453	(20 identified species)
1	1			*Lepus californicus*	Rabbit, Black-tailed
			1	undetermined species	Mouse, in mouth of flying egret

Total Mammals = 3

APPENDIX XIV BIRD OBSERVATIONS (Peterson, 1961)

LOWER TUBBS ISLAND, PORT SONOMA, PETALUMA RIVER AREAS

* = 1970 sightings by Joe Silva and Bob Ballering (October 24 to December 5)
Lower Tubbs Island
& = 1973 sightings by Douglas Trudeau and Aubrey Burns (October - December)
Lower Tubbs Island
+ = 1973-74 sightings by G. Chan and assistants (December 1973-January 1974)
Port Sonoma Harbor Project

& +	*Aechmorphus occidentalis*	Grebe, Western
+	*Aix sponsa*	Duck, wood
&	*Anas acuta*	Pintail
&	*A. carolinensis*	Teal, green-winged
&	*A. cyanoptera*	Teal, cinnamon
& +	*A. platyrhynchos*	Mallard
*	*A. strepera*	Pintail
* &	*Ardea herodias*	Heron, great blue
& +	*Aythya affinis*	Scaup, lesser
&	*A. marila*	Scaup, greater
* & +	*A. valisineria*	Canvasback
&	*Botaurus lentiginosus*	Bittern, American
* &	*Bucephala albeola*	Bufflehead
& +	*B. clangula*	Goldeneye, common
& +	*B. islandica*	Goldeneye, Barrow's
* & +	*Casmerodius albus*	Egret, common
* &	*Catoptrophorus semipalmatus*	Willet
&	*Charadrius semipalmatus*	Plover, semiplamated
* & +	*C. vociferus*	Killdeer
&	*Crocethia alba*	Sanderling
&	*Ereumetes mauri*	Sandpiper, Western
&	*Erolia alpina*	Dunlin
&	*E. minutilla*	Sandpiper, least
* & +	*Fulica americana*	Coot
&	*Hydroprogne caspia*	Tern, Caspian
+	*Larus sp.*	Gull
&	*L. argentatus*	Gull, herring
* &	*L. californicus*	Gull, California
&	*L. canus*	Gull, Mew
* &	*L. delawarensis*	Gull, ring-billed
* &	*L. occidentalis*	Gull, western
&	*L. philadelphia*	Gull, Bonaparte's
* &	*Leucopkoyx thula*	Egret, snowy
&	*Limnodromus griseus*	Dowitcher, short-billed
&	*L. scolopaceus*	Dowitcher, long-billed
&	*Limosa fedia*	Godwit, marbled
* &	*Mareca americana*	Widgeon, American
&	*Melanitta perspicillata*	Scoter, surf
* &	*Numenius americanus*	Curlew, long-billed
&	*N. phaeopus*	Whimbrel
*	*Nycticorax nycticarox*	Heron, black-crowned night
* &	*Oxyura jamaicensis*	Duck, ruddy
&	*Pelecanus erythrorhynchos*	Pelican, white
* &	*Phalacrocorax auritus*	Cormorant, double-crested
&	*Podiceps auritus*	Grebe, horned
&	*P. caspicus*	Grebe, eared
&	*Podilymbus podiceps*	Grebe, pied-billed

*	&		*Recurvirostra americana*	Avocet, American
	&		*Spatula clypteata*	Shoveler
	&		*Sterna forsteri*	Tern, Forster's
	&	+	*Totanus melanoleucus*	Yellowlegs, greater
*	&		*Agelaius phoeniceus*	Blackbird, redwinged
	&		*Aphelocoma coerulescens*	Jay, scrub
*			*Asio flammeus*	Owl, short-eared
*	&		*Bubo viriniarus*	Owl, great horned
	&		*Calypte anna*	Hummingbird, Anna's
	&		*Carpodacus purpureus*	Finch, purple
	&		*C. mexicanus*	Finch, house
	&		*Charmaea fasiata*	Wrentit
	&		*Colaptes cafer*	Flicker, red-shafted
	&		*Columba livia*	Dove, rock
		+	*C. fasciata*	Pigeon
	&	+	*Corvus brachyrhynchos*	Crow, common
*			*Dencroica auduboni*	Warbler, Audubon's
	&		*Euphagus cyanocephalus*	Blackbird, Brewer's
	&		*Geothlypis trichas*	Yellowthroat
	&		*Hirundo rustica*	Swallow, barn
	&		*Iridoprocne bicolor*	Swallow, tree
		+	*Junco oreganus*	Junco, Oregon
*			*Lanius ludovicianus*	Shrike, loggerhead
	&		*Megaceryle alcyon*	Kingfisher, belted
*	&		*Melospiza melodia*	Sparrow, song
	&		*Passerculus sandwichensis*	Sparrow, Savannah
	&		*Petrochelidon pyrrhonota*	Swallow, cliff
*			*Phasianus colchicus*	Pheasant, ring=necked
	&		*Pipilo erythrophthalmus*	Towhee, rufous-sided
	&		*Sayornis nicricans*	Phoebe, black
*			*S. saya*	Phoebe, Say's
	&		*Selasphorus sasin*	Hummingbird, Allen's
	&		*Speotyto cunicularia*	Owl, burrowing
	&		*Spinus psaltria*	Goldfinch, lesser
	&		*S. tristis*	Goldfinch, American
	&	+	*Sturnella neglecta*	Meadowlark, Western
	&		*Tachycineta thalassina*	Swallow, violet-green
*			*Telmatodytes palustries*	Wren, marsh
*	&		*Tyto alba*	Owl, barn
	&		*Zonotrichia albicollis*	Sparrow, white-throated
	&		*Aquila chrysaetos*	Eagle, Golden
*	&		*Buteo jamaicensis*	Hawk, Red-tailed
		+	*B. lagopus*	Hawk, Rough-legged
		+	*B. lineatus*	Hawk, Red-shouldered
*	&		*Cathartes aura*	Vulture, Turkey
*	&		*Circus sydneus*	Hawk, Marsh
*	&	+	*Elanus leucurus*	Kite, White-tailed
*	&	+	*Falco sparverius*	Hawk, Sparrow
	&		*Phasianus colchicus*	Pheasant, ring-necked
	&		*Rallus longirostris*	Rail, clapper
		+	undetermined species	doves
		+	undetermined species	sparrows

APPENDIX XV SPECIES OBSERVED AT PORT SONOMA

1973 December 27,28
1974 January 2,4,16
(5 days)

INVERTEBRATES

Foraminifera

Plankton (Gran, 1931)

Coscinodiscus sp.	*Synedra sp.*	*Rhaphoneis sp.*	*Nitzchia sp.*
Navicula sp.	*Ulothrix sp.*	*Rhyzosolenia sp.*	Fish larvae

Coelenterata
- *Obelia sp.*

Worms
- Nematoda
- Annelida
  - Oligochaeta

Arthropoda
- Crustacea
  - Ostracods
  - Copepods
    - Harpacticoida
    - Calanoida
  - Cirripedia
    - *Balanus glandula* — acorn barnacle
  - Isopods
    - *Sphaeroma sp.*
  - Amphipods
    - Gammaridea
      - *Corophium sp.*
      - *Orchestoidea sp.*
  - Malacostraca
    - *Neomysis sp.* — mysid bay shrimp
    - *Hemigrapsus oregonensis* — med crab
- Insecta
  - Corixidae — water boatmen

Mollusca
- Gastropods
  - *Nassarius obsoletus* — mud snail
- Pelecypods
  - *Cryptomya californica* — bay clam
  - *Gemma gemma* — bay clam
  - *Macoma nasuta* — bay clam
  - *Macoma secta* — bay clam
  - *Modiolus demissus* — ribbed mussel
  - *Mya arenaria* — bay clam
  - *Transennella tantilla* — bay clam

VERTEBRATES

Fish

Hypomesus transpacificus	Delta or pond smelt, freshwater-euryhaline
Spirinchus thaleichthys	Longfin or Sacramento smelt, marine-euryhaline
Dorosoma petenense	Threadfin shad, freshwater-euryhaline
Pomoxis annularis	White crappie, freshwater
Cottus asper	Prickly sculpin, freshwater

APPENDIX XV (continued) SPECIES OBSERVED

Birds

Aechmophorus occidentalis	western grebe
Aix sponsa	wood duck
Anas platyrhynchos	mallard
Aythya affinis	lesser scaup duck
Aythya valisineria	canvasback
Bucephala clangula	common goldeneye duck
Bucephala islandica	Barrows goldeneye
Casmerodius albus	egrets
Charadrius vociferus	killdeer
Fulica americana	coot
Larus sp.	seagull
Totanus melanoleucus	greater yellowlegs
Columba fasciata	pigeons
Corvus brachythynchos	crow
Junco oreganus	Oregon junco
Sturnella neglecta	western meadowlark
undetermined species	doves
undetermined species	sparrows
Buteo Lagopus	rough legged hawk
Buteo lineatus	red shouldered hawk
Elanus leucurus	white-tailed kite
Falco sparverius	sparrow hawk

Mammals

Lepus californicus	black-tailed rabbit
undetermined species	mouse, in egret's mouth

DOMINANT PLANTS

Marsh Plants

Spartina sp.	cord grass
Salicornia sp.	pickleweed with much marine algae Chlorophyta *Enteromorpha sp.* on outer thallus
Distichlis spicata	salt grass
Grindelia sp.	green plant
Frankenia grandiflora	alkali heath
Atriplex californica	California sal

Grasses

Avena spp.	oats
Festuca spp.	fescue