

Nature Photo #?

446041

FISHES OF BOLINAS LAGOON

by

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20 October 1967

BOLINAS MARINE STATION

ACKNOWLEDGEMENTS

To Mr. Gordon Chan, Dr. Joel Gustafson, Mr. Al Molina, Dr. W. I. Follet, Craig Hansen, Terry Maguire, and fellow students of Bolinas Marine Station, I sincerely extend my gratitude for service and guidance supplied during the project.

INTRODUCTION

Bolinas Lagoon is located approximately 20 miles north of San Francisco on the Bolinas Headland, directly over the San Andreas fault (Fig. 1). This area of Northern California is renowned for its abundance of intertidal and open water marine organisms, and is a center of marine sport and commercial fishing in the San Francisco Bay area. The richness of life is attributable to the upwelling of organically rich-oxygen laden, cold water that results from offshore winds blowing seaward to the surface waters. Fantastic plankton blooms form a life basis that supports this rich area of commercial fishing. King salmon, Oncorhynchus tshawytscha (Walbaum), silver salmon, Oncorhynchus kisutch (Walbaum), striped bass, Morone saxatilis (Walbaum), and California halibut, Paralichthys californicus (Ayres) are sought by both sport and commercial fishermen. Bolinas Bay offers refuge to baitfishes (surf smelt, Hypomesus pretiosus (Girard), white bait smelt, Alosmerus elongatus (Ayres) and northern anchovy, Engraulis mordax (Girard) which collect in areas of surf turbidity. Sporadically, the baitfishes seem to migrate from the San Francisco Bay region north, and temporarily reside in Bolinas Bay. Their arrival is accompanied by thousands of marine birds (gulls and pelicans) and by runs of striped bass. The runs of stripers are so rich and spectacular that the local Bolinas Rod and Boat club sponsors an annual bass derby.

The monetary value of Bolinas Lagoon may be increased by the expansion and development of a boat harbor. The Marin

County Harbour Commission requested the marine scientists of Bolinas Marine Station of the College of Marin. In consultation with Dr. Joel Gustafsson of San Francisco State College, to construct an ecological portrait of the lagoon. By incorporating past student projects and their own research, Mr. Gordon Chan and Mr. Al Molina of the College of Marin hope to make suggestions regarding the most efficient harbor planning. Their main concern will be the utmost conservation of ecologically important lagoon regions and their indigenous forms. By periodic collection and laboratory analysis it was hoped that I might gain some insight into the poorly little studied fishes of Bolinas Lagoon. This paper constitutes a report of an ichthyofaunal survey that I pursued throughout the summer of 1967 with the support of the College of Marin and San Francisco State College.

A lagoon is usually regarded as a body of water isolated from the sea periodically by a coral reef, shoal, kelp beds, or other obstruction. In Bolinas Lagoon, a sand spit (an extension of Stinson Beach) isolates the lagoon from the Pacific Ocean (Fig. 2&3). As can be seen from the map, the lagoon is closed except for the narrow channel of the lagoon map. This bottleneck would certainly be closed by the encroaching sands of Stinson spit if it were not for the scouring action of the tidal prism. Marin County presently is studying the scouring effects and is measuring discharge and siltation of this region. The dynamic nature of the lagoon results from the delicate balance of tremendous energy potentials in continuous opposition. During winter months, a

Water sandier is forced outside the channel mouth as waves
are broken, the ocean area and beach are sandier in
places. The contrary occurs during the summer when weather
surf allows beach deposition of sand.

This area is also dramatically effected by currents
and tides. North of Bolinas, Duxbury Reef extends seaward
over a mile into the Pacific and absorbs the main wave action.
According to Mr. Chan, this reef represents the most extensive
reef in California and at one time was geographically located
near Monterrey in Central California (it is composed of Mon-
terrey shale). The surf action along its northern border
slowly grinds the shale into gravel and sand grains which are
swept southward toward San Francisco Bay (Fig. 1). The sand
stream, however, is diverted by a circular littoral current
causing long shore drift and sand deposition along Stinson
Beach and spit. Geologically, the sand production system of
Duxbury Reef unceasingly tends to close the lagoon mouth.
The whole process is in such delicate balance that any drastic
alteration by man or nature could easily result in the for-
mation of a landlocked lagoon.

BOLINAS LAGOON

14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

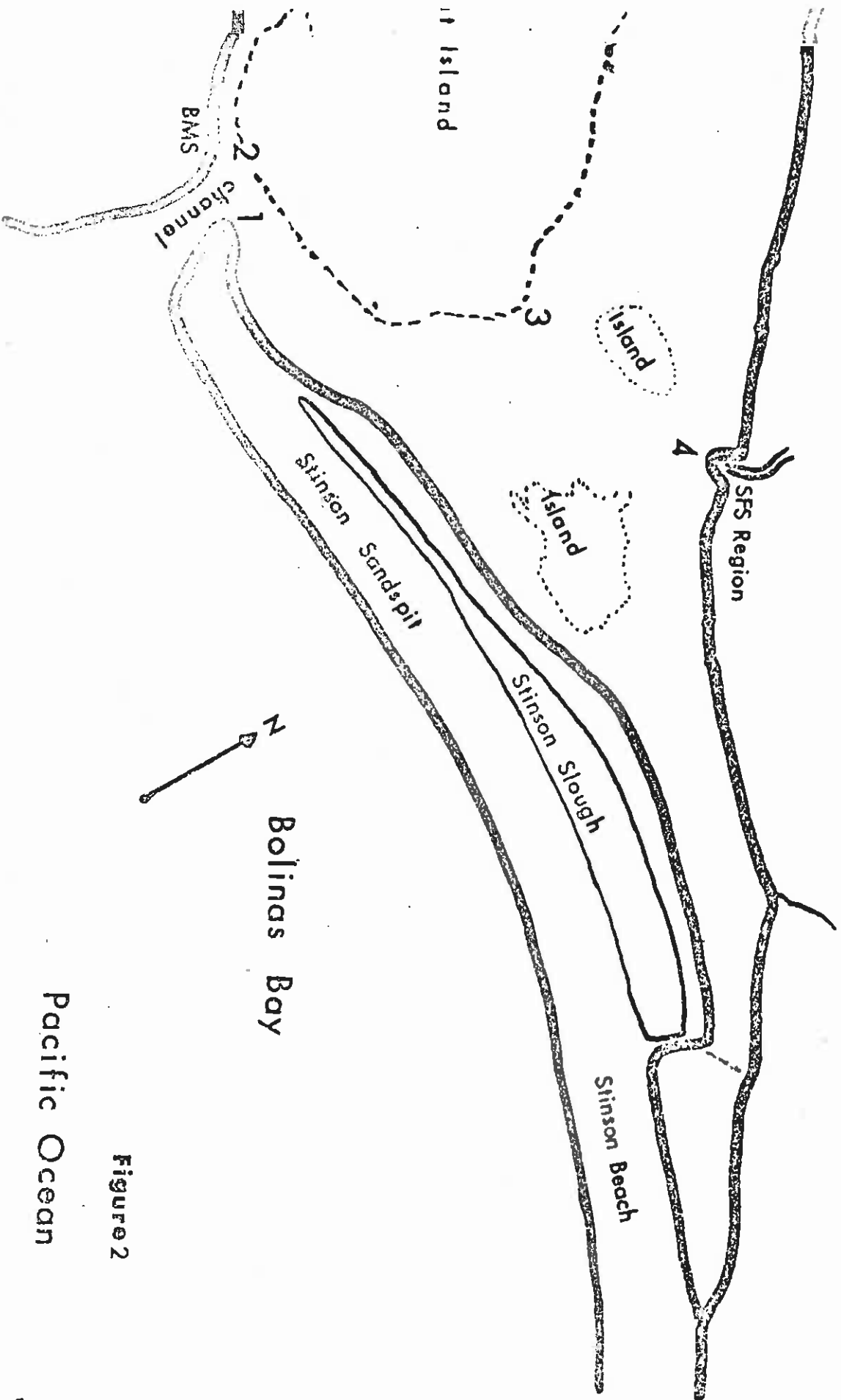


Figure 2

Pacific Ocean

Bolinas Bay

Stinson Beach

Stinson Slough

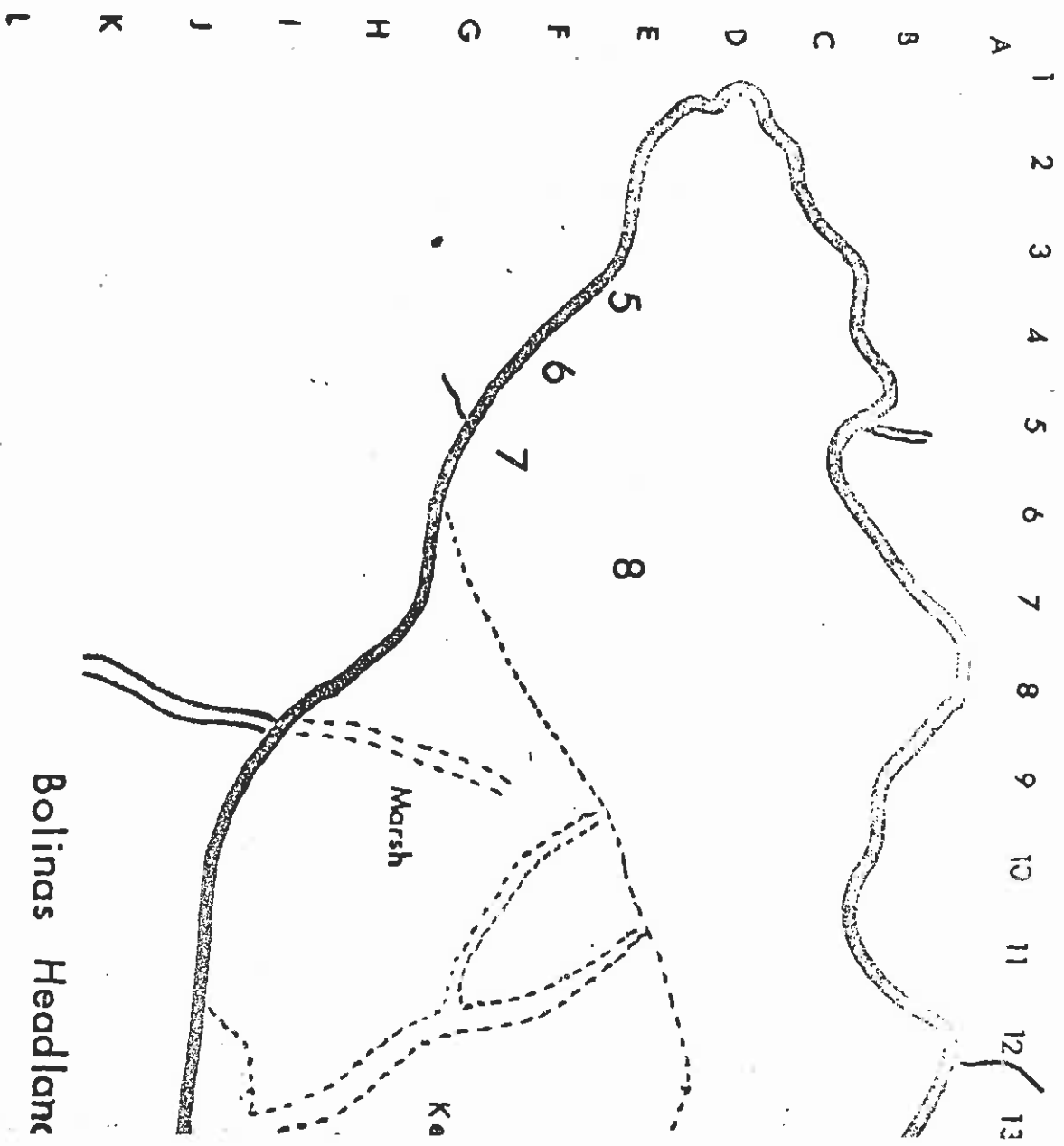
Stinson Sandspit

Island

Island

Island

BMS



Bolinas Headland

METHODS

Fishes were mostly collected with a cotton seine, 40 foot length - 10 foot depth, $\frac{1}{2}$ inch stretched mesh. In addition, many sharks and rays were caught by rod and line with bait. On one occasion, a large commercial seine (300 yard length - 10 foot depth, 3 inch stretched mesh leaders, $\frac{1}{2}$ inch stretched mesh bag) was fished at Station 1. This large net surprisingly yielded few fishes in relation to the effort required for operation, so later collections were made with the smaller more maneuverable seine. Most areas were reached by a 14 foot Boston Whaler and shallow waters were navigated with a 12 foot canoe.

Collected fishes were fixed in 10% formalin. In collections of fishes to be analyzed for gut contents, the visceral cavities were injected immediately in the field with 10% formalin. The fishes were then placed in 10% formalin. Plastic 15 gallon garbage cans with tight fitting lids were found to be excellent field containers for transporting preservative solutions with fishes and for protecting field notes and lanterns from salt spray and fog.

In the field, data sheets (Appendix) were incorporated to record physico-chemical and biological data. Water temperature, air temperature, water turbidity (rough estimate into grades), atmospheric clarity, tidal state (present tide level and time of high-high and low-low tides), water depth, number of seine hauls, species collected, number of fish preserved per species, number of fish released per species, and observed flora and fauna were noted.

In the laboratory, these specimens to be analyzed. All contents were immediately measured for standard lengths, sexed, and the alimentary tracts removed through a mid-ventral incision. Each specimen was labeled and a corresponding code was included in vials of 10% formalin into which the entire alimentary tract was placed. These tracts were then sent to Dr. Joel Gustafason of San Francisco State for identification of food items and volume of stomach contents.

Fishes were identified with the taxonomic keys of Tarp (1952), Stephens (1963), Phillips (1957), Roedel (1953), Barnhart (1936), Corrick and Schultz (1963), Clemens and Wilby (1961), and Light (1954). For each new species collected, a series of "type" specimens was preserved. The identities of these fishes were kindly confirmed by Dr. William Follet, ichthyologist of the California Academy of Science at the Steinhart Aquarium of San Francisco. This series of fishes remains as a complete collection at the Bolinas Marine Station, Bolinas, California, and is open for inspection.

PHYSICO-CHEMICAL PROPERTIES OF SOLINAS LAGOON

Solinas lagoon is a marine body of water roughly one mile long and $\frac{1}{2}$ mile wide. Extreme variations of physico-chemical conditions result from the great tidal prism operating in the lagoon. For example, summer water temperature may range from 12 degrees C. to 42 degrees C. These extremes are mostly dependent upon tidal dynamics as the lagoon is drained and filled twice daily. If a high tide occurs during diurnal hours of a clear day, the standing lagoon water receives tremendous radiant energy. Heated lagoon water of 42 degrees C. contrasts radically with normal open water temperatures of 13-15 degrees C. As a result of cool onshore breezes blowing over the lagoon, an inland fog often occurs to impenetrable densities. The mean air temperature for collecting Stations 5, 6, 7, 8, which occur in the shallow areas of the lagoon and are accessible only during high tide, is less than the mean water temperature of these regions. In some cases, the air temperature may be 18 degrees C. while the water temperature is 28 degrees C. (Fig. 4).

Tides affect lagoon salinity conditions in the same manner that they determine air and water temperature. Lagoon salinity ranges from nearly 0 ‰ at entrances of freshwater streams to 36 ‰ in isolated pools of Kent Island. It is interesting to note that in both extremes, specialized and restricted life forms occur. At certain freshwater stream mouths, an actual interface between the differing salinities can be demonstrated by placing a hydrometer in

The upper level of freshwater then plunging it past the interface into the saline water. The instrument will float at two different levels registering two different salinities.

Tides also affect the geography of the lagoon by their scouring effects. The channels of Bolinas Lagoon are extremely intricate and only through experience are they mastered. (Fig. 3) Certain tidal flats in the lagoon are actually completely exposed at low tides (twice daily). This is true of the area east of map coordinates E-F (Fig. 2). This includes study areas 5, 6, 7, 8. So not only do these stations have extreme variations of salinity and temperature, but they are often completely exposed. Tidal currents passing through channels have profound effects on other study areas also. At Stations 1, 2, 3, 4, the flow of water reverses twice daily from a slack to a full flood or ebb. At the channel mouth this means a terrific force of water flowing at roughly fifteen knots, slowing then traveling in reverse as the tide changes.

The organisms of Bolinas Lagoon are remarkably adapted behaviorally to cope with their dynamic environment. The fact that the lagoon constantly changes offers a variety of potential habitats and niches. This environmental variety supports a diverse and abundant invertebrate fauna which is paralleled by an equally varied ichthyofauna.

DESCRIPTION OF STATIONS

Summaries of the physico-chemical characteristics of each station are recorded in Fig. 4. Study areas were marked with stakes and red ties for consistent sampling.

For a study supported by San Francisco State, under Dr. Joel Gustafson, it was decided to make weekly collections in a particularly rich ichthyofaunal region. Stations 1, 2, 3, 4 represent collections made in surveying for a permanent station (Fig. 2). For this reason, Stations 1, 2, 3 were sampled few times in contrast to Station 4 which was selected as the permanent station and collected weekly.

Station 1. East edge of lagoon mouth in channel on Stinson spit (Fig. 2). One survey collection was made on 21 June 1967 at 1600. The tide was ebbing, three hours past a high-high tide of +4.7. This is an area of swift deep water flowing through the lagoon's deepest channel (5-15' deep). The bottom consists of actively moving fine sand and declines rapidly a few meters from shore. Collecting here is difficult due to the depth and current. Ten species of fishes were collected. This area serves as a bird sanctuary during runs of baitfish.

Station 2. South edge of channel immediately south of center-channel marker as channel bends south to lagoon mouth (Fig. 2). One survey collection was made on 21 June 1967 at 1630. The tide was ebbing 3.5 hours past a high-high tide of +4.7. Current flow was strong as this is one

Physico-Chemical Properties of Collecting Stations

# Station	# Collections	Air Temp. °C	Water Temp. °C	Tidal Range (Collected)	Depth, m (Collected)	Turbidity (4, 1, 2, 3)	Notes
1	3	15.6	20.6-22.8 mean 21.7	Ebb tide, 3 hours post high high of 4.7 feet.	1-1'	-	Sand
2	1	15.6	20.6-22.8 mean 21.7	"	1-5'	-	Gravel, sand
3	1	15.6	20.6-22.8 mean 21.7	"	1-2'	-	Gravel
4	7	13.2-20.8 mean 17.0	17.1-20.0 mean 18.5	Flood, 20 min. post low low	1-6'	+0,-	Rock, mud, sand
5	10	17.4-18.2 mean 17.8	20.0-26.3 mean 24.1	Entire tidal cycle -1.5 to 6.5 feet	2-3'	+0,-	Red coral rock & trid.
6	10	20.6	25.3	"	2-3'	+0,-	Red coral rock
7	10	18.3-22.2 mean 20.3	23.3-28.3 mean 25.8	"	2-3'	+0,-	Red coral rock
8	10	17.2	25.6	"	2-3'	+0,-	Red coral rock

* Rough turbidity: 4 clear, 3 moderate, - turbid

... the lagoon flood channels (100 - 150 feet in width).
... which is dominated by water flow. This is a
relatively easy area to collect by wading, the lagoon being
shallow (toward lagoon mouth) with the current, then sweeping
it into the gentle sloping shore. Seven species were col-
lected.

Station 3. Easternmost point of Kent Island (Fig. 2).
One survey collection was made on 21 June 1967 at 1700. The
tide was ebbing 4.0 hours past the high-high tide of +4.7.
Here there is virtually no measurable flow as this shallow
flat does not border any flood channels. Water depth is
shallow ranging from 1-2.5 feet as much as 500 feet away from
the island shore. Substrate mainly is soft, sticky mud which
makes the area difficult to collect because of seine clog-
ging and collector sinking. This area is markedly inhabited
by horseneck clam, Tresus nuttallii, blue ghost shrimp, Upogebia
pugetensis, and white ghost shrimp, Callinectes zinnii. On-
ly 3 species of fishes were collected.

Station 4. (SF3 region) North edge of lagoon di-
rectly northeast of Station 1 (Fig. 2). Collections were
made on the following dates, 17 June 1967, 21 June 1967,
27 June 1967, 12 July 1967, 19 July 1967, 25 July 1967, and
2 August 1967. Flow usually consisted of slight flooding,
and the water varied from 6 feet deep at the channel to 1
foot deep along the east side of the point. Station 4 is
unique in that it offers radical changes in environment in

channel (100 meters), (Fig. 5). To the west of station 4, two points form the substrate bottom of the channel (8 feet). Progressing eastward, the substrate becomes sandy and the channel still remains close to shore. At this point, a freshwater stream enters causing radical extremes in salinity. Further east the bottom changes to silty mud then to reducing mud and the channel diverges from the shore leaving a gradual slope of shallow water (1-2 feet deep).

One seine haul of 17 meters was made along each of three collecting areas (A, B, C) marked in Fig. 5. This was performed every 7 days, 20 minutes post slack tide between a low-low and a high-high tide (flooding). Due to changing tidal periods, collections were made diurnally and nocturnally.

Five of each species were taken from each collection and the number of released individuals recorded. These specimens were injected in the seine with 10% formalin and placed in 10% formalin. In the lab, standard lengths were measured, the body cavities opened, sex recorded, and the alimentary tracts removed and placed in 10% formalin.

This area abounds in invertebrates including horse-neck clams, Tresus nuttali, pink sea star, Pisaster brevispinis hermit crabs, Pagurus sp., octopus, Cetopus sp. A total of 26 species of fish were collected.

The ecological diversity of Station 4 is outstanding not only due to the differing substrates, tidal influences, but also due to the influx of freshwater from the active

STATION 4 - SFS REGION

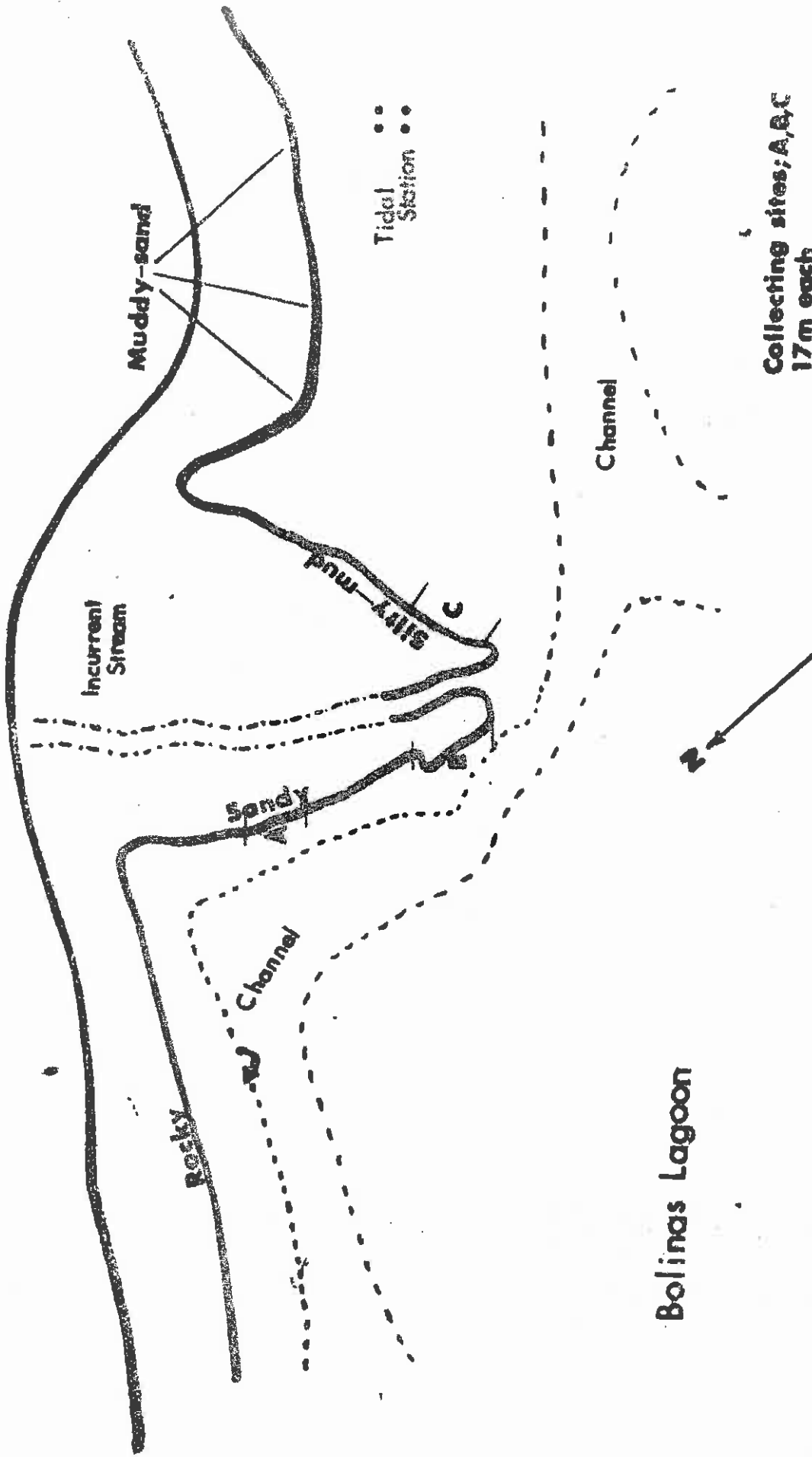


Figure 5

26 June 1967

1545 3.0, Flooding

lagoon (Fig. 5). These unique physico-chemical properties may explain the great species diversity and abundance in this area.

Collecting ease was great and seining was an ideal technique here. Although I usually reached Station 4 by boat, it is within 50 meters of California Highway 1.

Station 5, 6, 7, 8. Station 5, 30 meters northeast of trash dump in west end of lagoon (Fig. 2). Station 6, 100 meters southeast of Station 5 - about 30 meters from shore (Fig. 2). Station 7, 100 meters southeast of Station 6 - about 30 meters offshore (Fig. 2). Station 8, 200 meters northeast of Station 7 - 300 meters offshore (Fig. 2).

Twenty collections were made under varying day and night periods, tide levels, and water depths. Stations 5, 6, 7, 8 are exceptional, being completely exposed during normal low tides and beneath 3-5 feet of water during normal high tides.

The primary interest of collections at these stations was the periodic occurrence of leopard sharks, Triakis semifasciata, and bat rays, Holorhinus californicus. These animals were often extremely abundant in waters merely 1-3 feet deep. The substrate at all stations consisted of thick layers, of sticky reducing mud. The water surface frequently was choked by dense growths of algae, especially Ulva.

The stations typically were characterized by extremely warm water. Often times the water temperature exceeded that of the air by 76 degrees.

10

The presence of great numbers of leopard sharks and bat rays offered an outstanding opportunity to study feeding habits in relation with diurnal-nocturnal and tidal influenced movements. Both sharks and rays were tagged with helium balloons and followed throughout the tidal cycle. This information will be presented as an additional section of this paper.

SPECIES DIVERSITY

The following is a cumulative list of fish species that I collected in Bolinas Lagoon during the summer of 1967. The identity of representative specimens of each fish was verified by Dr. William Follet of the California Academy of Science.

1. Greenling sea trout, Hexagrammos decagrammus (Pallas)
2. Brown rockfish, Sebastes auriculatus (Girard)
3. Whitebelly rockfish, Sebastes vexillaris (Jordan & Gilbert)
4. Black rockfish, Sebastes melanops (Girard)
5. Grass rockfish, Sebastes rastrelliger (Jordan & Gilbert)
6. Walleye surfperch, Hyperprosopon argenteum Gibbons
7. Black perch, Embiotica jacksoni Aggasiz
8. Dwarf perch, Micrometrus minimus (Gibbons)
9. Shiner perch, Gymnogaster aggregata Gibbons
10. File perch, Damalichthys vacca Girard
11. Curlfin turbot, Pleuronichthys decurrens Jordan & Gilbert
12. Speckled sanddab, Citharichthys stigmaeus Jordan & Gilbert
13. Starry flounder, Platichthys stellatus (Pallas)
14. English sole, Parophrys vetulus Girard
15. Pacific tomcod, Microgadus proximus (Girard)
16. Topsmelt, Atherinops affinis (Ayres)
17. Jacksmelt, Atherinopsis californiensis Girard
18. Staghorn sculpin, Leptocottus armatus Girard
19. Arrow goby, Clevelandia ios (Jordan & Gilbert)
20. Saddleback gunnel, Pholis ornata (Girard)
21. Penpoint gunnel, Apodichthys flavivus Girard

22. Lingcod, Ophiodon elongatus Girard
23. Buffalo sculpin, Enophrys bison (Girard)
24. Cabezon, Scorpaenichthys marmoratus (Ayres)

The following fishes were identified by me and not verified by Dr. Follet, but I feel confident that no mis-identifications were made.

25. Surf smelt, Hypomesus pretiosus (Girard)
26. Striped bass, Morone saxatilis (Walbaum)
27. California halibut, Paralichthys californicus (Ayres)
28. Dogfish, Squalus acanthias Linnaeus
29. Leopard shark, Triakis semifasciata Girard
30. Bat ray, Holorhinus californicus (Gill)

In addition, various other species have reportedly been collected in the past, but I found no collections for verification. A past student paper by Bill Callister referred to the monkey-face eel, Cebidichthys violaceus (Girard) and Pacific electric ray, Torpedo californica Ayres as being lagoon inhabitants. I have heard reports about "eels" occurring under and around wharf pilings in the lagoon and this species probably does occur. However, I feel less certain of the occurrence of Torpedo californica. According to Barnhart, (1936) this electric ray is typically found in deep water, and I feel that it probably was mistaken for Holorhinus californicus by Callister. G. Chan has also collected the following fishes which I have not seen; Pacific sanddab, Citharus sordidus (Girard); California tonguefish,

Stenotomus argenteus, (Jordan & Gilbert), tidypool sculpin,
Clinocottus asellus (Girard); and brown smoothound shark,
Rhinotriacis henlei Gill.

Since there are probably many species not yet collected, it seems likely that these fish did and/or do now occur. To date then, 30 species of fishes are known to occur and four more reported.

A cumulative record of fishes was tabulated for each station.

Station 1

- | | |
|---------------------|-----------------------|
| 1. staghorn sculpin | 6. dogfish |
| 2. cabezon | 7. striped bass |
| 3. speckled sanddab | 8. california halibut |
| 4. penpoint gunnel | 9. surfsmelt |
| 5. English sole | 10. bat ray |

Station 2

- | | |
|---------------------|---------------------|
| 1. topemelt | 5. pile perch |
| 2. staghorn sculpin | 6. speckled sanddab |
| 3. English sole | 7. Pacific tomcod |
| 4. lingcod | |

Station 3

1. staghorn sculpin
2. Arrow goby
3. English sole

Station 4

- | | |
|------------------------|-----------------------|
| 1. greenling sea trout | 14. English sole |
| 2. brown rockfish | 15. Pacific tomcod |
| 3. whitebelly rockfish | 16. tomcote |
| 4. black rockfish | 17. jacksmelt |
| 5. grass rockfish | 18. staghorn sculpin |
| 6. walleye surfperch | 19. arrow goby |
| 7. black perch | 20. saddleback gunnel |
| 8. dwarf perch | 21. penpoint gunnel |
| 9. shiner perch | 22. lingcod |
| 10. pile perch | 23. buffalo sculpin |
| 11. curlfin turbot | 24. cabezon |
| 12. speckled sanddab | 25. leopard shark |
| 13. starry flounder | 26. bat ray |

Station 5,6,7,8

1. leopard shark
2. bat ray

WEEKLY VARIATIONS IN RELATIVE ABUNDANCE
SEX RATIO & SIZE RANGE AT STATION 4

Station 4, or the SFS region, was collected at 7 day intervals from 12 July to 2 August 1967. These collections were made using a standardized technique already described for Station 4 (description of stations). A total of 26 species was collected although the maximum number collected at one time was only 18 (19 July 1967), (Fig. 6). Figure 6 lists the species taken at each collection, the number of specimens collected, their percent composition of the specific collection, the cumulative percent composition of each species averaged for all collections, size range of standard lengths, and percent of population found to be male (sex ratio) and diversity index.* The range of sizes and ratio of sexes was determined from five representative specimens selected at random from the seine. The alimentary tracts of these fishes were removed for future study. Also included in Figure 6 are physical data, such as time of collection, height of high-high tide and low-low tide

*A diversity index described by Odum (1959: 281-283) was calculated for each collection and recorded in Fig. 6. This index seems to have dubious value primarily due to the bias introduced by differential collecting efforts. The index is calculated $\frac{\# \text{ species}}{\log \# \text{ specimens}}$

Actually, Odum says that the index is concerned with communities, "...and not with the biota of zoogeographical areas containing a variety of habitats and mixed communities." (Odum, 1959: 283).

Weekly Variation in Relative Abundance, Sex Ratio, Size Range at Station 4, April 12, 1966

Date	1952-12-12	1952-12-13	1952-12-14	1952-12-15	1952-12-16	1952-12-17	1952-12-18	1952-12-19	1952-12-20	1952-12-21	1952-12-22	1952-12-23	1952-12-24	1952-12-25	1952-12-26	1952-12-27	1952-12-28	1952-12-29	1952-12-30	1953-1-1	1953-1-2	1953-1-3	1953-1-4	1953-1-5	1953-1-6	1953-1-7	1953-1-8	1953-1-9	1953-1-10	1953-1-11	1953-1-12	1953-1-13	1953-1-14	1953-1-15	1953-1-16	1953-1-17	1953-1-18	1953-1-19	1953-1-20	1953-1-21	1953-1-22	1953-1-23	1953-1-24	1953-1-25	1953-1-26	1953-1-27	1953-1-28	1953-1-29	1953-1-30	1953-1-31	1953-2-1	1953-2-2	1953-2-3	1953-2-4	1953-2-5	1953-2-6	1953-2-7	1953-2-8	1953-2-9	1953-2-10	1953-2-11	1953-2-12	1953-2-13	1953-2-14	1953-2-15	1953-2-16	1953-2-17	1953-2-18	1953-2-19	1953-2-20	1953-2-21	1953-2-22	1953-2-23	1953-2-24	1953-2-25	1953-2-26	1953-2-27	1953-2-28	1953-2-29	1953-2-30	1953-3-1	1953-3-2	1953-3-3	1953-3-4	1953-3-5	1953-3-6	1953-3-7	1953-3-8	1953-3-9	1953-3-10	1953-3-11	1953-3-12	1953-3-13	1953-3-14	1953-3-15	1953-3-16	1953-3-17	1953-3-18	1953-3-19	1953-3-20	1953-3-21	1953-3-22	1953-3-23	1953-3-24	1953-3-25	1953-3-26	1953-3-27	1953-3-28	1953-3-29	1953-3-30	1953-3-31	1953-4-1	1953-4-2	1953-4-3	1953-4-4	1953-4-5	1953-4-6	1953-4-7	1953-4-8	1953-4-9	1953-4-10	1953-4-11	1953-4-12	1953-4-13	1953-4-14	1953-4-15	1953-4-16	1953-4-17	1953-4-18	1953-4-19	1953-4-20	1953-4-21	1953-4-22	1953-4-23	1953-4-24	1953-4-25	1953-4-26	1953-4-27	1953-4-28	1953-4-29	1953-4-30	1953-5-1	1953-5-2	1953-5-3	1953-5-4	1953-5-5	1953-5-6	1953-5-7	1953-5-8	1953-5-9	1953-5-10	1953-5-11	1953-5-12	1953-5-13	1953-5-14	1953-5-15	1953-5-16	1953-5-17	1953-5-18	1953-5-19	1953-5-20	1953-5-21	1953-5-22	1953-5-23	1953-5-24	1953-5-25	1953-5-26	1953-5-27	1953-5-28	1953-5-29	1953-5-30	1953-5-31	1953-6-1	1953-6-2	1953-6-3	1953-6-4	1953-6-5	1953-6-6	1953-6-7	1953-6-8	1953-6-9	1953-6-10	1953-6-11	1953-6-12	1953-6-13	1953-6-14	1953-6-15	1953-6-16	1953-6-17	1953-6-18	1953-6-19	1953-6-20	1953-6-21	1953-6-22	1953-6-23	1953-6-24	1953-6-25	1953-6-26	1953-6-27	1953-6-28	1953-6-29	1953-6-30	1953-7-1	1953-7-2	1953-7-3	1953-7-4	1953-7-5	1953-7-6	1953-7-7	1953-7-8	1953-7-9	1953-7-10	1953-7-11	1953-7-12	1953-7-13	1953-7-14	1953-7-15	1953-7-16	1953-7-17	1953-7-18	1953-7-19	1953-7-20	1953-7-21	1953-7-22	1953-7-23	1953-7-24	1953-7-25	1953-7-26	1953-7-27	1953-7-28	1953-7-29	1953-7-30	1953-7-31	1953-8-1	1953-8-2	1953-8-3	1953-8-4	1953-8-5	1953-8-6	1953-8-7	1953-8-8	1953-8-9	1953-8-10	1953-8-11	1953-8-12	1953-8-13	1953-8-14	1953-8-15	1953-8-16	1953-8-17	1953-8-18	1953-8-19	1953-8-20	1953-8-21	1953-8-22	1953-8-23	1953-8-24	1953-8-25	1953-8-26	1953-8-27	1953-8-28	1953-8-29	1953-8-30	1953-8-31	1953-9-1	1953-9-2	1953-9-3	1953-9-4	1953-9-5	1953-9-6	1953-9-7	1953-9-8	1953-9-9	1953-9-10	1953-9-11	1953-9-12
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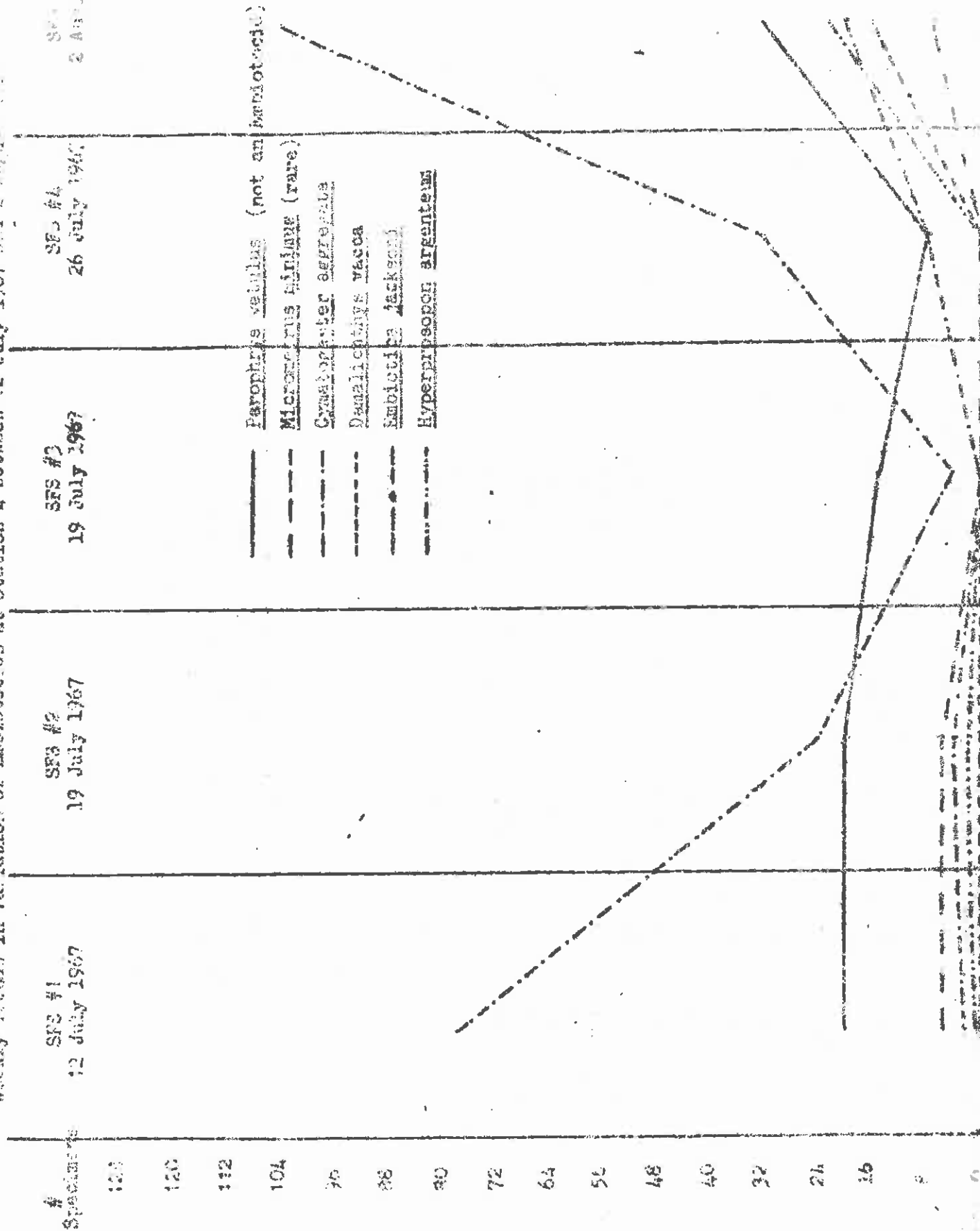
in feet + or - sea level, water clarity (roughly indicated by + for clear and - for turbid), water and air temperature.

The greatest number of species (18) per collection was taken on 19 July 1967 (SFS #2). This was also the third greatest number of individuals collected. The least number of species and individuals was collected on 19 July 1967 (SFS #3).

The relative abundance of fishes was determined by finding the mean percent composition of each species for all collections at Station 4 (Fig. 7). The most abundant fishes were shiner perch (32.7%), English sole (21.9%), Pacific sanddab (13.0%) and staghorn sculpin (8.3%). The least abundant fishes were jackmelt (0.5%), bat ray (0.3%), grass rockfish (0.3%), leopard shark (0.2%) and Pacific tomcod (0.2%).

Figure 8 is a plot of weekly trends in number of Embiotocids and the two most abundant fishes (shiner perch and English sole). During this relatively short period of time (4 weeks) there seems to be generally a constant level of population until 2 August 1967 - SFS #5. This rise may entail several explanations since the collection differed from others in physical conditions. SFS #5 was made at 0540 - before dawn. This is the only nocturnal collection made. The water temperature (16.5 degrees C) accordingly was 0.6 C degrees less than the prior recorded minimum and 1.8 degrees C less than the priorly recorded high. Each of these two factors may have contributed toward greater collection efficiency (2 August 1967 had the greatest number

Weekly Trends in Variation of Embiotocids at Station 4 between 12 July 1967 and 2 August 1967



SFS #5
2 August 1967

of *Embiotocids* collected). Surf perch, family *Paralichthyidae*, composed 66.4% of the total 2 August 1967 population (shiner perch 44.2%) compared to prior percentages of SFS #1 (11.7%), SFS #2 (36%), SFS #3 (17.4%), and SFS #4 (47.9%). The average percent composition for *Embiotocids* prior to SFS #5 was 38.3%. This mean contrasts with 66.4% composition of SFS #5. From this follow three possibilities:

1. greater percent composition merely due to random occurrence of fishes
2. surf perch were more susceptible to nocturnal seine collecting
3. surf perch were more abundant

It seems possible that surf perch were more abundant at this time, especially shiner perch. This might be correlated with reproduction in these viviparous fishes. W. A. Clemens states in *Fishes of the Pacific Coast of Canada* (1961: 214), "The breeding period for *C. aggregata* appears to extend from April to July and between 8 and 36 young are liberated 10 to 12 months later."

Possibly the rising curve for shiner perch and other *Embiotocids* indicates a new generation of offspring. Further evidence of this was found in the great abundance of apparently new born *C. aggregata* only about 3 cm. in length. This can also be seen in the ranges of standard lengths; previously the minimum length was 5.0 cm. (SFS #1) in SFS #5 it was 3.0 cm.

To determine between greater fish populations or greater collecting efficiency, more collections need to be

more under various conditions. Horizontal collections would
indicate collecting efficiency trends and seasonal collecting
would indicate reproductive trends. It is quite possible
that both factors are involved.

ASSOCIATED SPECIES LIST

Greenling seatrout, ~~XXXXXXXXXX~~ ~~XXXXXXXXXX~~ (Bell, 1967). This is the first report of seatrout in Bolinas Lagoon. It was collected only at Station 4 in the weekly series of collections. At Station 4, seatrout composed a mean 1.9% of the total population, (Fig. 7) - a total of 13 fish were collected. They were most abundant on SFS #2, 19 July 1967, when six specimens were taken. Of those specimens retained, the standard lengths ranged from 5.9-7.7 cm. and 20% were males. All were juveniles.

Seatrout are considered desirable sport fish by Roedel (1953) with a palatable flesh similar to certain rockfishes, (Clemens, 1961). Although not regarded as a commercial fish, it is preyed upon by steelhead and salmon (Clemens, 1961) and probably has economic importance in this respect. The annual commercial catch averaged 1,826 pounds in 1957 with a typical annual catch averaging around 1000 pounds (Baxter, 1960, 1963).

Mr. J.L. Baxter reported seatrout to feed upon "Various sea worms, crustaceans, and small fishes." (Baxter, 1960, 1963: 60).

In this case and many others to follow, only juvenile fishes were caught. This lends support to the idea that the lagoon acts as a nursery for oceanic fishes.

Grass rockfish, Serphoideus rastrelliger Jordan & Gilbert 1880).

This is the first report of grass rockfish in Bolinas Lagoon. It was collected only at Station 4, composing 0.7% of the total population of fishes collected at that station (Fig. 7). A total of 5 individuals were collected on SPS #5, 2 August 1967. No others were collected. Standard lengths ranged from 4.0 - 5.1 cm. and males composed 100% of the specimens examined. All were juveniles.

Nearly all rockfish may be of sport fishing interest depending upon their abundance, maximum size, and flesh palatability. S. rastrelliger is of minor importance both as a sport and commercial fish mainly because of small abundance, however, the flesh is tasteful (Baxter, 1958, 1960). It is interesting to note that the blackish-green color of S. rastrelliger may cause it to be neglected in the commercial market, being "unattractive" (Baxter, 1958, 1960).

Baxter reports brown rockfish feed upon crabs and small fishes - a 16 3/8 inch specimen contained a 5 inch white perch, Phanerodon furcatus (Baxter, 1958, 1960).

Brown rockfish, *Sebastes auriculatus* (Clemens, 1961)
This is a first record of brown rockfish occurring in Bolinao,
Luzon. It was collected at Station 4 on SFS #2, 19 July
1967, SFS #4, 26 July 1967, SFS #5, 2 August 1967).

The greatest abundance was recorded on SFS #1, 12
July 1967, and SFS #5, 2 August 1967, when four fish were
taken in each collection. A total of 9 specimens composed
1.2% of the Station 4 total population (Fig. 7). Standard
lengths ranged from 3.7 - 5.3 cm. with 24% of examined fishes
being males. All were juveniles.

Brown rockfish attain a maximum length of 18 inches
(Clemens, 1961), qualifying as a sport fish although of minor
importance.

Walleye surfperch, Hyporhamphus argenteus Vibbens 1954

This fish was collected at Station 4, although I have seen adults taken by pier fishermen in the channel directly northeast of Bolinas Marine Station. Walleye surfperch were collected on SFS #2, 19 July 1967, and SFS #5, 2 August 1967. SFS #5, 2 August 1967, had the greatest abundance when 20 fishes were collected. A total of 28 individuals composed 2.1% of the weekly Station 4 collections. Standard lengths ranged from 5.5 - 7.0 cm. and all examined specimens were juvenile males. Adults however, do occur in the lagoon.

H. argenteus is both an important sport and commercial species (Roedel, 1953), Baxter (1960, 1963). These fishes are widely sought and successfully collected by young fishermen in the bay area. In an unpublished study, I performed on the gut contents of Embiotocidae of Dillon Beach and Tomales Bay, it was found that H. argenteus fed upon annelids, arthropods, chlorophyta, and vertebrates (fish). Their diets varied with the abundance of prey species (Nolan, 1966). Baxter reports finding small crustaceans in the gut of H. argenteus (Baxter, 1960, 1963).

Black perch, Epiplatys jacksoni Agassiz.

This is the first report of black perch in Bolinas Lagoon. Occurring only at Station 4 on SFS #1, 12 July 1967, SFS #2, 19 July 1967, SFS #4, 26 July 1967, and SFS #5, 2 August 1967, it composed a total percent composition of 4.4% (Fig. 7). It was found in greatest abundance on SFS #5 when 22 specimens were collected. Standard lengths ranged from 2.8 - 5.4 cm. and males averages 38% of examined individuals. All were juveniles.

Roedel lists black perch as "A minor constituent of the 'perch' catch caught in moderate quantities in Central California." (Roedel, 1953: 109). Tarp also regards E. jacksoni as a minor constituent of the commercial "perch" catch and as a common fish taken by anglers (Tarp, 1952).

Dwarf perch, Micrometrus minimus (Gibbons)

This is the first report of dwarf perch in Bolinas Lagoon. Occurring at Station 2 on 21 June 1967 and Station 4 on SFS #1, 12 July 1967, SFS #2, 19 July 1967, and SFS #5, 2 Aug 1967, it composed a mean 4% of all species collected at Station 4 (Fig. 7). It was found in greatest abundance on SFS #1, 12 July 1967 when 7 specimens were collected. Standard lengths ranged from 5 - 9.8 cm. and 18% of examined fish averaged males. The largest specimen (9.8 cm.) collected on SFS #1, 12 July 1967 seems to be an exceptionally large individual. Roedel states that dwarf perch seldom reach 3 inches in length (Roedel, 1953) and Tarp's maximum record in standard length was 9.45 cm., and 50 specimens averaged 5.7 cm. (Tarp, 1952). Juveniles and adults were collected.

This surfperch has neither commercial nor sport value. They are unique in that they are herbivorous, feeding on algae. Adaptation to a plant diet can be seen in the multi-coiled, long intestine. Being herbivorous and small in size explains the small dwarf perch catch by anglers. It is to be noted that both Tarp (1952) and Roedel (1953) refer to M. minimus as a tide pool resident and makes no reference to occurrence in lagoons or bays.

Shiner perch, Gymnotus aggregata Gibbons 1864.

Shiner perch were collected at Station 4 on each weekly collection. They composed the greatest average composition of all fishes (32.7%), (Fig. 7), and occurred in greatest abundance on SFS #5, 2 August 1967 when 123 specimens were collected. Standard lengths ranged from 5.0 - 11.3 cm. and 68% of individuals examined were males.

Shiner perch have virtually no commercial importance in California although they may be used as bait (Roedel, 1953). (Baxter, 1960, 1963). However, Clemens and Wilby (1961) report C. aggregata of commercial importance in Canada where "considerable quantities are brought to the markets during the winter as a ready sale is found amongst the Chinese who consider this fish a delicacy." (Clemens and Wilby, 1961: 214). California shiner perch are rated highly as a sport fish due to flesh quality (Baxter 1960, 1963), (Roedel, 1953).

Shiner perch feed upon small crustaceans, and barnacles (nip off appendages) and are fed upon by marine birds and mammals (Baxter, 1960, 1963). In examining the stomach contents of shiner perch in Tomales Bay, California, I found chlorophyta, arthropods, nemerteans, and molluscs (Nolan, 1966).

July 1967

Curfin turbot was collected only at Station 4 on July 19, 1967, where it comprised 0.3% of the population or 0.4% of the total composition of all fishes collected at Station 4 (Fig. 7). The one individual collected had a standard length of 4.6 cm. and was a juvenile female.

Curfin turbot is regarded as most desirable and important of the turbot - extensively fished at San Francisco (Roedel, 1953). In Canada, this is not a commercial species (Clemens and Wilby, 1961).

P. decurrens feeds upon crustaceans, small molluscs and anchovies (Clemens and Wilby, 1961).

to 500,000 - 700,000 pounds (Fitch, 1958, 1965). In some
places it is a widely sought sport fish which is regarded as
a delicacy and often served whole like *G. mordax* (Hodder,
1957).

Starry flounder, Paralichthys stellatus, was collected during the summer of 1967, and this at Station 4 on SFS #4, 26 July 1967. The specimen measured 6.0 cm. in standard length, was a female, and composed only 0.2% of the final weekly census (Fig. 7). It was a juvenile.

Being abundant in the sea, large- to 3 feet, and delicious; starry flounder are rated highly as a commercial and sport fish. The commercial catch has been nearly 500,000 pounds since 1935 and was 450,000 pounds in 1957 (Baxter, 1960, 1962). Most starry flounders are landed in winter between December and March. Other than this, no explanation can be given for the lack of P. stellatus in Bolinas Lagoon. It typically inhabits shallow sand substrate bays, and Rosdel reports that they may enter brackish and even freshwater (Rosdel, 1953). All of the conditions seem to be favorable in Bolinas in addition to great potential food sources; which in Canada consists of crabs, shrimps, worms, clams and clam siphons, small molluscs and small fish (Clemens & Wilby, 1961).

English sole, *Parophrys reticulatus* (Pisces: Pleuronectidae). This species was abundant at Station 4, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100. It was found in every collection with the exception of SRS #5, 2 August 1967 (40 individuals). English sole ranked second only to shiner perch in abundance comprising 21.9% of all fishes collected at Station 4 (Fig. 7). Standard lengths ranged from 7.4 - 9.5 cm, and males composed 75% of individuals examined. All were juveniles.

Reaching 22 inches, this species forms 25% of the sole catch (second largest proportion of catch) in California (Reeser, 1963). In 1958, 2 million pounds of *P. reticulatus* were collected in the Hecate strait of British Columbia (Clemens & Wilby, 1961). English sole young typically inhabit shallow water and move to deeper water with increasing size. Food consists of crabs, worms, shrimp, brittle stars, clam siphons, and small molluscs (Clemens & Wilby, 1961).

...the record, *Platypharodon* ...
...a first record for ... It was collected
... on ... 19 July 1967, at station 4 and there-
fore composed only a small part of the total weekly popu-
lation - 0.2% (Fig. 7). The toad collected had a standard
length of 10.4 cm. and was a juvenile male.

Although reported fairly abundant, *M. ...* is
of no commercial importance. In 1951, 2,000 pounds were
landed in California (Roedel, 1953). It is also of minor
sport value although it is fished to some degree.

Topsmelt, *Atherinops affinis* (Anchoa)

Topsmelt were collected at Station 2 on 25 July 1967 and Station 4 on SFS #1, 12 July 1967 and SFS #1, 19 July 1967. They were most abundant on SFS #1, 12 July 1967 when 14 were collected. They composed a cumulative total of 2.2% at Station 4 (Fig. 7). Standard lengths ranged from 11.1 - 13.6 cm. which is about $\frac{1}{2}$ of the maximum attained length of 12 inches. Males composed 100% of those specimens examined.

Topsmelt form about 25% of California's "smelt" catch and are regarded of minor importance (Roedel, 1933). There is no sport fishing importance except when used as bait.

Topsmelt belong to the silverside family, Atherinidae and are not true smelts, family Osmeridae.

Atherinops affinis are relatively common fishes which are tolerant to brackish and freshwaters and spawn in shallow water (Schultz, 1933).

Jacksmelt (*Ammocetes californicus*) were collected on 12 August 1957 at Station 4, forming a good station 4 composition of 0.5%. They were most abundant on 2 August 1957 when 4 were collected. Standard lengths ranged from 2.5 - 5.3 cm. and all examined were juvenile males.

Being larger than topsmelt, *Ammocetes* affinis, Jacksmelt reach 22 inches and are of greater commercial importance. It forms from 2/3 - 3/4 of California's "smelt" catch and is also widely caught by fishermen (Boedel, 1953).

Jacksmelt, like topsmelt, are Atherinidae, and actually the "smelt" catch of California consists of only a small percent of true Osmeridae.

I feel that in the cases of both top and Jacksmelt the numbers collected misrepresent the true abundance. Both fishes are extensive schoolers and fast swimmers, and seem to avoid the current of Station 4.

Great schools of "smelts" were observed from frequent boat trips but were extremely elusive to our seining techniques. Often they jump clear of the water and dart rapidly away from disturbances.

Staghorn sculpin, *L. armatus*, is a common and abundant fish species present in every collection at Stations 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100. They were most abundant at SPS #1. 12 July 1957, at Station 1 when 12 were collected. Staghorn sculpin composed the fourth greatest total percent composition of Station 1 (8.2%). (Fig. 1). Great populations also exist at the coordinates C-13, C-17, E-15, and I-15 (Fig. 2). I fished these locations to obtain bait for shark studies by using small hooks and California mussels for bait. Within 30 minutes, it is easy to catch 20-40 fish especially at flooding tides. Standard lengths ranged from 6.5 - 15.4 cm. and males composed 73% of the specimens examined. Juveniles and adults were collected.

The only economic importance of *L. armatus* is as bait fish; however it is widely sought by young anglers in the Bolinas area. Clemens and Wilby (1961) report that in Canada, staghorn sculpin are fed upon by ducks and other waterfowl.

The small, slender, silvery fish, *P. laeta*, was collected at Station 4 on 10 July 1967, 12 July 1967, and 26 July 1967, and SFS #3, 2 August 1967 - being most abundant on SFS #2 when 3 were collected. Totally, they composed 1.4% of Station 4 collections (Fig. 7). Standard lengths ranged from 10.9 - 13.9 cm, and males composed 35% of specimens examined. These probably were juveniles.

No known economic nor commercial importance is attributed to saddle gunnels.

When first collected, I identified these as *Thalassoma laeta*, but Dr. Follet distinguished between them by the parenthesis shaped dorsal markings of *P. laeta* (). The dorsal markings of *P. ornata* are diagonal lines with a faint mid-dot.

LINGCOD *Ophiodon elongatus* (Walbaum, 1847)

Lingcod were collected at Station 3 on 21 June 1967 and Station 4 on SFS #1, 12 July 1967, SFS #2, 13 July 1967, SFS #4 (26 July 1967) and SFS #5, 2 August 1967. It occurred in greatest abundance on 12 July 1967 when 5 were collected. They composed a cumulative 2.2% of Station 4 collections. All were juveniles with standard lengths ranging from 9.1 - 12.7 cm. and 50% of those examined were males.

Lingcod are very important commercially attaining 50 pounds and ranking fourteenth in poundage and value in 1951 (Roesel, 1953). The average annual catch of lingcod is between 400,000 and 2,000,000 pounds. Lingcod are valued for their flesh, and in addition their liver oil is high in vitamin A & B. Of all fishes O. elongatus is regarded as one of the best sources for insulin (Clemens & Wilby, 1961).

In the Bolinas region, lingcod are heavily fished and many large specimens are caught in Bolinas Bay. Since 1951, the annual party boat catch has been roughly 70,000 pounds yearly indicating a high degree of sport fishing.

Juvenile lingcod feed upon copepods (Clemens & Wilby, 1961), shrimp and other crustaceans (Fitch, 1955, 1965). As adults, they consume flounder, hake, cod, whiting, sand-lance, and young lingcod (Clemens & Wilby, 1961).

Buffalo sculpin, *Salvelinus namaycush* (Wilson)
This is the first record for buffalo sculpin occurring in
Solinas Lagoon. Two buffalo sculpins were collected on
SFB #1, 2 August 1967 at Station 4 and 1 was collected on
SFB #5, 2 August 1967. Together they composed 0.6% of the
weekly population. All examined were juvenile males ranging
in standard length from 7.7 - 8.8 cm.

E. bison have no commercial importance and are fished
only by young anglers. Living in shallow water, they feed
upon shrimp, amphipods, crabs, mussels and small fishes
(herring, young salmon, sea perches, sandlances, and Myx).
(Clemens & Wilby, 1961).

There is a first record for cabezon in Polaris Bay. It was collected at Station 2 on 21 June 1957 and at Station 4 on SFS #1, 12 July 1957, SFS #2, 19 July 1957, and SFS #3, 2 August 1957. They were most abundant on the last collection when 12 were collected. S. harringtoni composed 2 1/3 of the Station 4 totals (Fig. 7). Standard lengths ranged from 1.2 - 7.3 cm. and males composed 75% of those examined. All were juveniles.

Cabezon is not regarded as a significant commercial fish, although its value as a sport fish is considerable. Baxter reports that cabezon are "...one of the most sought-after rocky shore inhabitants." (Baxter, 1960, 1963). The sport catch of cabezon usually exceeds the commercial catch, which amounted to 6,000 pounds in 1954 and 13,000 pounds in 1957.

Cabezon feed on crabs (50%) and molluscs and fishes (50%), (Baxter, 1960, 1963).

Surfsmelt, *Hypomesus transpacificus* (Pinnock) 1879.
Surfsmelt were collected on all dates 1967 at Station #1. Only
three individuals were collected and no specimen data were
recorded.

In California surfsmelt compose a small fraction of
the "smelt" catch and are regarded as a minor commercial
species - chiefly at San Francisco. Some fishermen dip net
H. pretiosus in surf regions of the Bay area.

Surfsmelt are widely fed upon by striped bass, Roculus
maxillius. Some fishermen say that smelt located in turbid,
surf agitated waters are hiding from the voracious striper.
By fishing in these turbid waters, I have caught stripers
using smelt for bait. At some times, bass can be seen feed-
ing upon chaotically fleeing smelt.

In Canada, surfsmelt apparently are more important
commercially than in California. Clemens and Wilby (1961)
report that the fish "...find a ready sale in the fresh-
fish market."

Smelt eat small crustaceans and worms and are in
turn fed upon by carnivorous fishes and birds. Local fisher-
men attest that smelt migrate from San Francisco Bay to
Bolinas Bay and are in turn followed by great flocks of
water birds and striped bass runs.

observed bass observed were all adults ranging from 10 to 37 pounds and were caught on rod and line.

Stripped bass have been restricted to sport fishing since 1935 and bass fishing is extremely popular from Cape Cod to Long Island. Possibly 250,000 anglers catch 1,500,000 strippers annually. The average annual catch previous to commercial restrictions was 650,000 pounds in 1935. However, strippers are economically important indirectly, the value of fishing was \$18,000,000 in 1953 (about \$9 per day of fishing times 2,000,000 days fished), (Baxter, 1960, 1963).

Stomach contents contained eel, anchovy (winter) and a variety of small fishes (summer), (Baxter, 1960, 1963).

The fish was found by the fishermen at the lagoon at 11:30. The fish measured 5.6 feet in total length and was a perfect female, giving birth upon capture to a matured egg. The still attached to a yolk sac. This is the only instance of dogfish occurring in the lagoon this summer.

In California and the United States, this shark is no longer regarded as being commercially important. During past times before the artificial synthesis of vitamin A, sharks in general, and dogfish specifically, were widely sought (Roesel, 1957).

In Europe, however, dogfish are highly valued. Olav Aasen, a Norwegian fishery biologist, calculated that Belgium, France, Germany, and Scotland land about 3.5 million pounds annually in addition to the 48 million pounds landed by Norwegian fishermen (Jensen, 1967). Albert C. Jensen of the Bureau of Marine Fisheries, New York, analyzed the disparity between dogfish landings in the U.S. and Europe (Jensen, 1967). Europeans apparently are accustomed to and relish dogfish as "fish and chips," "flake," "rock salmon," "shark sausage" and "fish meal." American commercial fishermen regard dogfish as a costly nuisance because they tear nets and prey upon desirable fish captured in the nets. Xarashuretti alone estimated the damage caused by dogfish to exceed \$100,000 annually (Jensen, 1967).

Dogfish feed upon herring and herring-like fishes, "trash" fish, squid, some crustaceans and Ctenophorans (Jensen, 1967).

REPERCUSSIONS OF ENVIRONMENTAL ALTERATION ON THE
BIOLOGY OF BOLINAS LAGOON

It is well known that lagoons and protected bays often serve as "nurseries" for open water fishes. Clearly this seems to be the case in Bolinas Lagoon. A great proportion (51%) of the species collected consisted entirely of juveniles; 14% consisted of juveniles and adults both. The abundance of juvenile fishes indicates that the lagoon is at least a nursery and probably a spawning grounds. Many fishes spawn in shallow water, then after foraging for a variable length of time, the juveniles leave their protected environment for open sea (eg. starry flounder, striped bass, California halibut). Therefore, careful consideration to complex food webs and fish interrelations must be given prior to any environmental alterations if these fishes are to be preserved in their abundance.

The conversion of Bolinas Lagoon into a harbor would have many effects, some of which are not at all obvious. The primary effect would be the physical alteration for boat harbors which would involve dredging and possible alteration of priorly consistent lagoon currents. The tidal prism might be subsequently altered. Next, the occurrence of human activity and noise probably will drive many fishes from the lagoon. A final aspect will be pollution by boat fuels and human littering. The effect of water pollution by toxic chemicals is of wide spread occurrence in the United States today. As of yet, the tolerances of lagoon marine fishes to these conditions have not been established.

To date, the fishes of Bolinao Lagoon have been studied and much remains to be done. It is my intention to analyze and write up my studies on the behavior and feeding habits of the lagoon's cartilaginous fishes, and second to continue periodic sampling of Bolinao Lagoon. The following is a list of topics which hopefully I will be able to study in the future.

1. Determination of total # of species related to season and other physical conditions, by extrapolating the actual # of species from randomly distributed sample plots (Evans, Clark, and Brand, 1955).
2. Determination of differences between population densities (different species - same area, and same species - different areas, - times).
3. Determination of densities figured by the capture - recapture method (Kendall, 1961).
4. Determination and relationship of fish abundances with variables (season, food conditions, physico-chemical conditions).
5. Determination of the exact relationship of daily movements of leopard sharks, and bat rays to tidal conditions, food conditions, physico-chemical conditions.
6. Determination of number of economically important fishes inhabiting and spawning in Bolinao Lagoon.
7. Determination of age composition of fishes of lagoon.
8. Determination of effects of boat fuels and harbor pollution of local fauna and flora.

REFERENCES

- Barnes, R.T. 1946. Marine Fishes of Southern California. Univ. of Calif. Press 1936.
- Saxter, J.L. 1960, 1963. Inshore Fishes of California. Calif. Fish and Game, Sacramento, Calif. Second revision 1963.
- Chan, Gordon. 1967. Personal relations. Bolinas Marine Station, College of Marin.
- Clemens, W.A. and Walby, G.V. 1961. Fishes of the Pacific Coast of Canada. Bulletin of Fisheries Research Board of Canada, Ottawa, Canada.
- Fitch, J.E. 1958, 1965. Offshore fishes of California. Calif. Resources Agency Dept. Fish & Game, Sacramento, Calif. Second revision 1965.
- Jensen, A.C. 1967. New uses for an old test. See Frontiers vol. 13, no. 5. International Oceanographic Foundation; Miami, Florida.
- Light, S.F. 1954. Intertidal Invertebrates of Central California Coast. Univ. Calif. Press, Berkeley and Los Angeles, Calif.
- Nolan, R.S. 1966. Gut contents of Eubiotocidae. Unpublished. Univ. of Pacific, Pacific Marine Station, Dillon Beach, Calif.
- Odum, E.P. 1959. Fundamentals of Ecology. W.B. Sanders Co., Philadelphia.
- Phillips, J.B. 1957. A review of the rockfishes of Calif. Calif. Fish & Game, Marine Fisheries Branch, Fish bulletin # 104.
- Ricketts, E.F. 1939. Between Pacific Tides, Stanford Univ. Press, Stanford 1965.

Reeder, P.H. 1933. Common Ocean Fishes of the California Coast. Calif. Fish & Game, Marine Fisheries Branch. Fish Bulletin # 91.

Schultz, L.P. 1933. The age and growth of Atherinops affinis Oregonia Jordan and Snyder and of other subspecies of bay-smelt along the Pacific coast of the United States. Univ. Wash. Publ. Biol., vol. 2, no. 3, p. 45-102.

Stephens, J.B. 1963. A revised classification of the blennioid fishes of the American family Chagnopsidae. Univ. Calif. Publ. in Zool. vol. 68.

Tarp, F.H. 1952. A revision of the family Embiotocidae. Calif. Fish & Game, Bureau of Marine Fisheries, fish bull. no. 88.

APPENDIX

Collection
date

BOLINAS MARINE STATION

Species

Food Item

Frequency

Food Item

Lagoon Habitat of it.

RON C. MOLAN
BOLINAS, Calif.
Summer 1967

BOLINAS MARINE STATION

Collection
Site

Index
of Fish

Species	Food Item	Frequency	Abundance	Food It.	Lagoon Habitat of It.

RON S. MOHAN
Bolinas, Calif.
Summer 1967