5.0 BENTHIC INFAUNA SURVEY

5.1 INTRODUCTION

One way to measure the recovery of Malibu Lagoon since the 1983 restoration is to examine the density and diversity of organisms colonizing the sediments, such as invertebrate worms and clams. It seems that these creatures are particularly sensitive to changes in their environment, and their presence or absence can be used to indicate the relative "health" of an estuary (Crippen and Reish 1969). In polluted habitats, large numbers of only a few species are common. Species diversity is often lower when salinities fall below 8-9 ppt. Also, size and composition of sediment particles produce strong limits, as well as the rate of deposition. These species tend to be tolerant of low levels of dissolved oxygen and are principally scavenger feeders (Crippen and Reish 1969).

One concern at Malibu Lagoon is the steep gradient of the banks along the inlets, which dramatically affects the distribution of sediments and the rate at which tidal inundation occurs. In less disturbed estuaries, the bank gradient rarely exceeds 0.7% (Zedler 1982) which allows a more gentle and extended tidal flushing, and there is a more definite pattern of zonation related to tidal inundation which effects the distribution of both plants and animals. With further modifications of the estuarine hydrology of Malibu Lagoon pending, it is important to begin understanding the current population status of sediment dependent organisms.

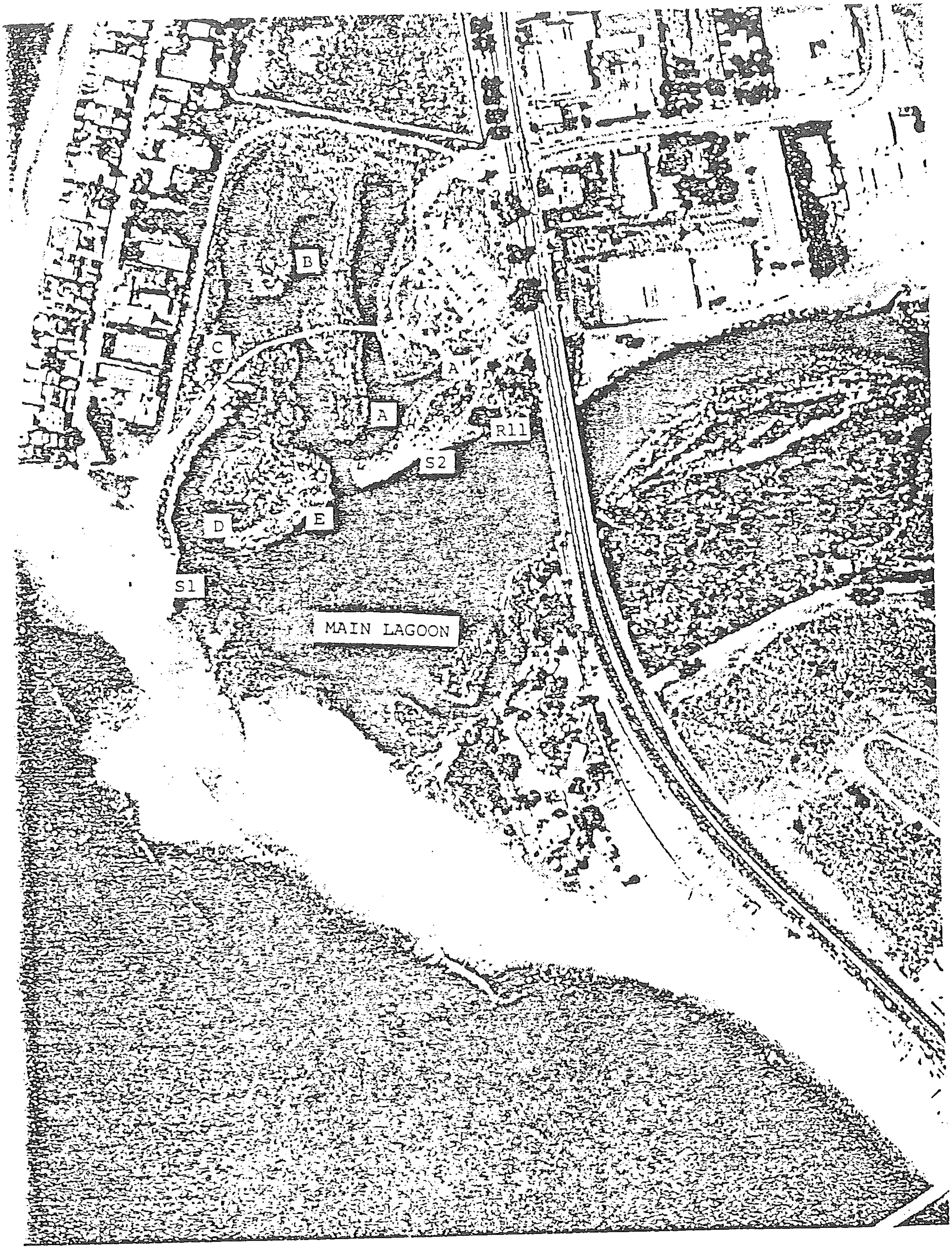
5.2 OBJECTIVES

The main objective of this study is to identify and quantify the population of benthic infauna found in the lagoon, and monitor both population distribution and density over time.

5.3 METHODOLOGY

Benthic infauna surveys are done bi-monthly in conjunction with the sediment profiles. These samples were collected at low tide, and the tidal range in the survey area is 4-5 feet. See map A for exact locations.

MAP A Study Stations at Malibu Lagoon



5.3.1. POLYCHAETE WORM SAMPLING

In order to randomize the sampling, a plastic lid is thrown into the channel. The place where it lands along the sediment profile is measured and distance from the North bank recorded. A total of three #1 cores (14 cm diameter x 13.9 cm depth) are then taken there, at 1 meter intervals parallel to the bank. Each core is examined for evidence of polychaete habitation, either worm tubes, worms, or both. In addition, the sediments are carefully described. A cross section of the core is taken and all worm tubes counted.

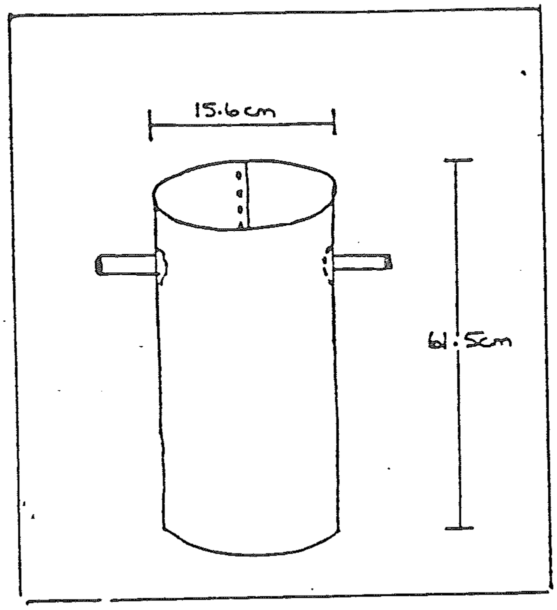
The standard methodology (according to Zedler and Nordby 1986) for determining density of worms requires the use of a "clam gun" which is equivalent to a #3 can (15.6 cm diameter x 17.0 cm depth). Three replicates of this size were unmanageable within the time framework, so only 1 core sample was taken along the sediment transect. After recording sediment description and depth of core, the sample is sieved through a fine 1 mm wire mesh screen. Worm tubes and worms are separated out and measured by volume displacement in a graduated cylinder. However, it appeared that the counting of worm tubes in the core cross section seemed to give a more accurate measurement of worm population than did the volumetric displacement which was biased due to the adherence of sediment particles to the tubes. As a result, cross-sectional counting was instituted as the standard measure in the September 1987 survey. Data from earlier surveys was not included in analysis.

5.3.2 CLAM SURVEY

The same core samples as those used for the polychaetes are also used for counting clams. Initially, the clams were escaping from the #3 cores, and on occasion this still occurs. However, the design and use of a new, large coring device (15.6 cm x 61.5 cm depth) has produced a better capture rate. This device was designed and made by Bob Jensen, Jr. specifically for our sediment samples (Figure 5.1). It is made of metal stovepipe, with pipe handles near the top, secured into fittings. By covering the top of the core with a #3 plastic coffee can lid, the enclosed sample can be removed for examination. The clam capture rate increased dramatically with the use of this tool, as it prevented the clams from escaping and allowed greater core depth.

Information collected includes: condition of clam (alive, dead), shell length, shell height at beak, diameter of any clam burrows. The burrow diameter is measured in the hope of being able to predict clam size from empty burrows in the future.

Fig. 5.1 Diagram of clam sampling device used at Malibu Lagoon for clam survey.



5.4 OBSERVATIONS

Repeated sampling at 5 locations in Malibu Lagoon revealed an infauna limited to two species of invertebrates; a spionid polychaete, Polydora nuchalis and a tellinid bivalve, Tagelus californianus. The two species will be discussed separately.

5.4.1 POLYCHAETE OBSERVATIONS

Only one species of Polychaete, Polydora nuchalis has been consistently identified in the sediments of Malibu Lagoon. Several different species are known to inhabit nearby waters (Smith 1975), but close examination of samples from Malibu Lagoon indicated a monoculture (Harris, pers. comm.). Polydora nuchalis is a species of segmented worm (Annelida) most frequently found in estuaries having the correct range of sediment sizes necessary for tube construction, feeding and burrowing, as well as a wide range of salinity (Woodwick 1953). In general, populations of polychaetes seem to peak during the spring and summer, with high adult mortality following reproduction and prior to resettlement of free floating larvae (Woodin 1974, Reish 1971).

Polydora nuchalis (Figure 5.2) found in Malibu Lagoon are segmented and transparent, ranging in length from 2-10 mm. The tubes they construct are a result of their burrowing into the sediment (Ricketts and Calvin 1985), and consist of consolidated fine silts. In some cases, the tubes can be extracted intact, but those at Malibu Lagoon were thin, somewhat flimsy and no greater than 15-20 mm long. It was very difficult to separate out the tubes and worms from the surrounding sediments. Methodology established by Zedler and Nordby, 1986 for other Southern California estuaries is based on separating out worms and tubes to be measured volumetrically. In order for this survey to be comparable to that of other estuaries, this methodology was initially followed. However, the displaced volume results (done only with the #3 sample) from Malibu Lagoon are biased due to the inclusion of inseparable sediments in volume measurement (Figure 5.3). In order to obtain more accurate results, a new methodology was instituted in September 1987 which allows comparison to data from other areas, but also reflected the characteristics of the species particular to Malibu Lagoon.

Taking a cross section of the core and counting the visible tubes seemed to be a more reliable indicator of population density for Polydora nuchalis. Therefore, the tubes found on the top of each core (both from the #3 and #1 cores) were counted, and then the core was cross-sectioned

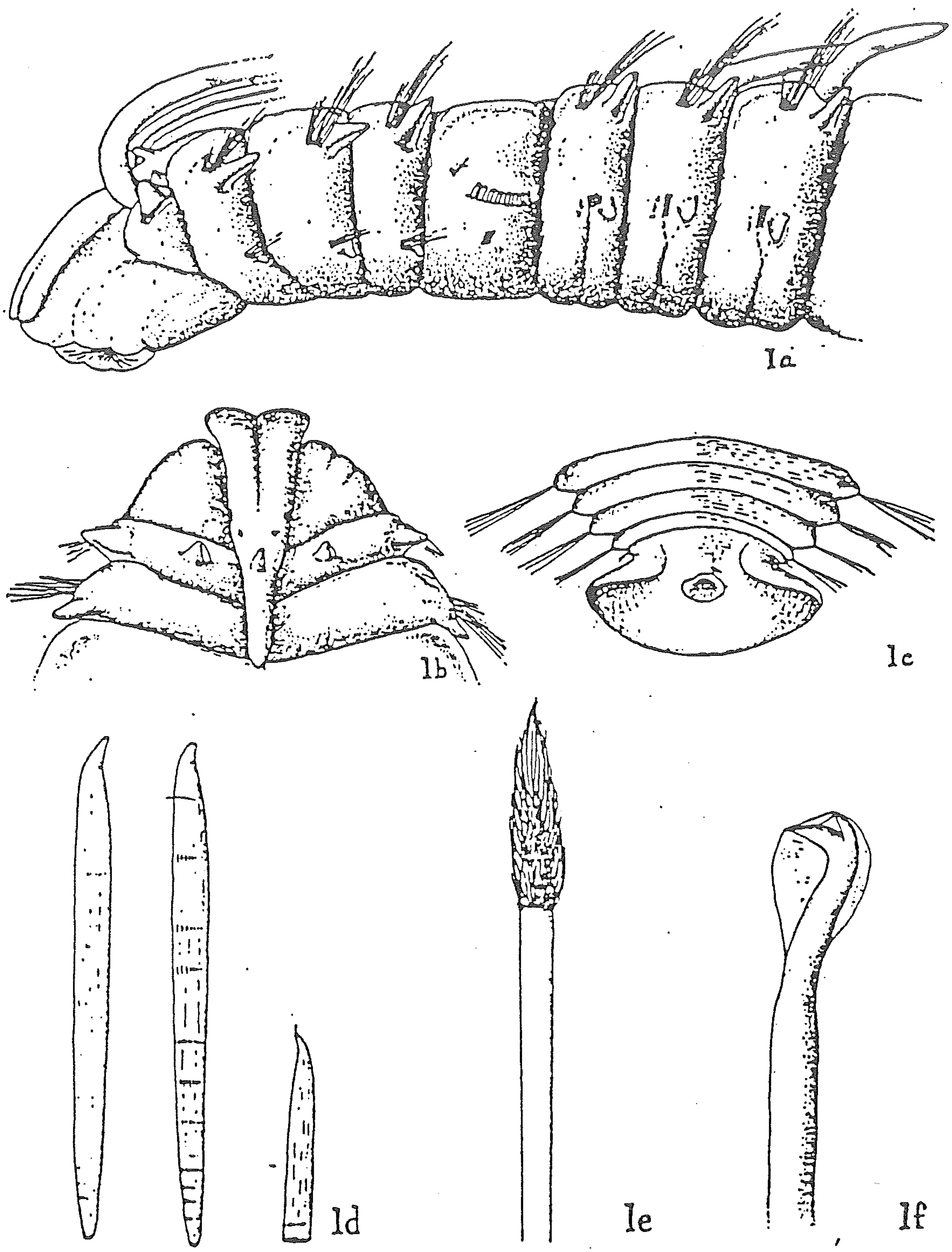
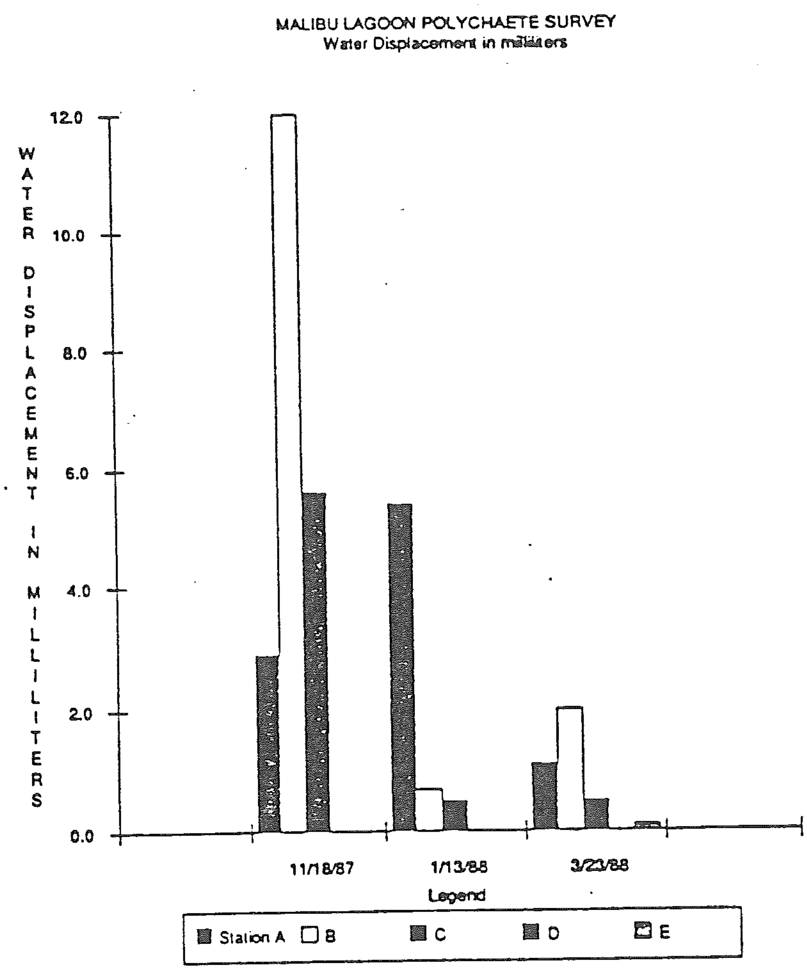


Fig. 1. Polydora nuchalis, n. sp.: a) Anterior end, in left lateral view, X53;
anterior end, in dorsal view, X53; c) pygidium, in posterior dorsal view, Xte; d) stout
ines of the modified fifth segment showing new, worn, and developing spines, X122;
companion seta of the modified fifth segment, X529; f) ventral hooded hook from the
venth segment, X710.

Fig. 5.2 Illustration of Polydora nuchalis, from Woodwick, 1953 (fig.1).

Fig. 5.3 Volume measurements of Polychaete worm survey, according to methodology of Zedler and Nordby, 1986, from 5 stations at Malibu Lagoon.



in 2-5 cm intervals to determine how far down into the core the burrows extended. Although individual tubes were quite short, clusters of tubes frequently extended down to depths of up to 36 cm. They extended down to 14 cm on the average. Often the tubes protruded slightly above the sediment surface making them readily visible for counting. Since only one worm per tube was observed, an accurate population density can be determined with this methodology. In future studies, fewer replicates per transect would be another way to reduce the impact of the study.

Density seems to be tied closely to habitat and sediment distribution. Greater numbers of worms were found at stations A, B, and C (Figure 5.4), all of which share common characteristics. The sediments are mostly composed of organic mud (rich in hydrogen sulfide), clay, and silt, with lots of decaying algae on the surface. The mud flats at station B are usually exposed at low tide, while those of stations A and C generally remained covered by a few centimeters of water. Higher concentrations of worms were found towards the center of the channels, rather than along the banks. By contrast, stations D and E are less muddy and composed mostly of sands and gravels. Data collected in early samples indicated that prior to the influx of sand, worms were abundant. This illustrates the direct relationship of sediment deposition and composition to the distribution of these organisms. These 2 stations are also closest to the influence of incoming ocean water, with potentially stronger currents capable of removing sediments and their worm inhabitants.

It is not clear how water quality parameters effect the population of <u>Polydora</u> <u>nuchalis</u> in Malibu Lagoon. In other areas, species of polychaetes seem to tolerate moderate to high levels of turbidity, extremes in water temperature (probably moderated by less variability in interstitial temperature), and variable salinity. The most significant limiting factor documented is dissolved oxygen, and no species of polychaetes are found in water having levels less than 0.3 mg/l (Crippen and Reish 1969). Malibu Lagoon has extremely variable ranges of salinity, temperature and dissolved oxygen (which only occasionally drops below 7 mg/l), due to the influx of water from the ocean and Malibu Creek. Extended periods of fresh water inundation from the Tapia Water Reclamation Facility, impounded due to the closure of the Lagoon ocean entrance, may also be a limiting factor, although no interstitial water samples were taken to see if the salinity, temperature and dissolved oxygen changes extended into the sediments. In other locations, random population fluctuations have been documented that are not explainable (Woodin 1974). No correlations were observed in this study between <u>Polydora</u> <u>nuchalis</u> density and the chemical parameters measured in the Lagoon.

Fig. 5.4 Average number of tubes found in cross section counts of #1 and #3 cores from 5 stations at malibu Lagoon.

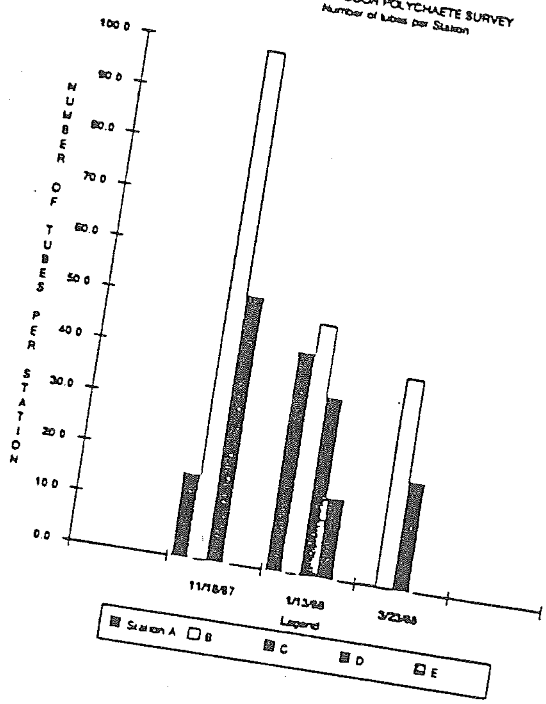
MALIBU LAGOON POLYCHAETE SURVEY
Average Number of Tubes per Station

#1 core

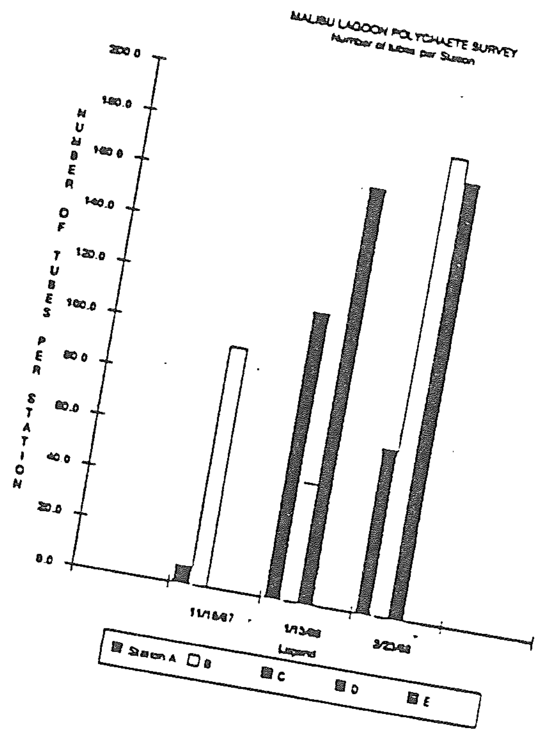
DATE	A	B	C	D	E
11/18/87	16.3	99.7	52.0	0.0	0.0
1/13/88	42.7	45.7	35.0	15.7	0.0
3/23/88	0.3	41.0	21.3	0.0	0.0

#3 core

DATE	A #	A Displ.	B #	B Displ.	C #	C Displ.	D #	D Displ.	E #	E Displ.
11/18/87	7.0	2.0	84.0	12.0		8.6	0.0	0.0	0.0	0.0
1/13/88	113.0	6.4	47.0	0.7	164.0	0.5	0.0	0.0	0.0	0.0
3/23/88	65.0	1.1	181.0	2.0	172.0	0.5	0.0	0.0	0.0	0.1



#1 Core



#3 Core

Station B had the largest population of polychaetes. It is the most shallow channel and the only area besides station D that is consistently exposed at low tide. It is also one of the preferred feeding sites for probing shorebirds. Station C also had a very high density, but always has a minimum water level of several centimeters, and fewer feeding shorebirds. The effects of predation by shorebirds is unknown. The dynamics of the population, seasonal differences, reproduction, response to changing environmental conditions, etc. require a larger database. Observations from the Fall 1988 school tours indicates an increase in population, indicating that late summer and early fall is a time of seasonal reproduction. This study should be extended for several years in order to document trends.

5.4.2. CLAM SURVEY OBSERVATIONS

Only one species of bivalve, the California Jacknife Clam (Tagelus californianus, Figure 5.5) was found in the Malibu Lagoon survey. These animals are common residents of intertidal mud flats that are somewhat sandy as well. They range from Monterey Bay, south to Panama. These clams can reach a length of 10 cm, and the shell is elongated with the hinge in the center. They are able to move quickly through the sediments, using a long, flexible and very strong foot which cannot be withdrawn totally into the shell, thus leaving gapes at each end of the clam where the shell doesn't completely close. This is one of its most characteristic features. Burrows extending down as far as 50 cm have been recorded, and the clam moves freely up and down within these permanent homes. It mostly resides near the surface, so as to be able to extend the 2 siphons used for filter feeding (Ricketts and Calvin 1985), but will descend into the burrow when threatened by predators.

Those specimens found at Malibu Lagoon ranged in length from 30.5 to 67.5 mm., with heights of 13.0 to 23.5 mm (Figure 5.6, 5.7). Although samples were collected in September, November, January and March, no seasonal difference in size class was noted. Thus the pattern of reproduction remains to be determined. A difference in distribution was very definite, and again seemed to correlate to sediment characteristic preferences. The greatest density of clams was found at station C, where the sediments are composed of organic mud, clay and silt, and there is a continuous covering of at least several centimeters of water. Stations B and A also had substantial populations, in contrast to stations D and E, where the only clams found were dead, empty shells following the covering of original muds with sands. These seemed to have been transported from other areas of the lagoon. It is interesting to note that although there were greater

Fig. 5.5 _Tagelus_ _californianus_ indicating standard measurements taken for clam survey from 5 stations at Malibu Lagoon. (Illustration from Reish 1972).

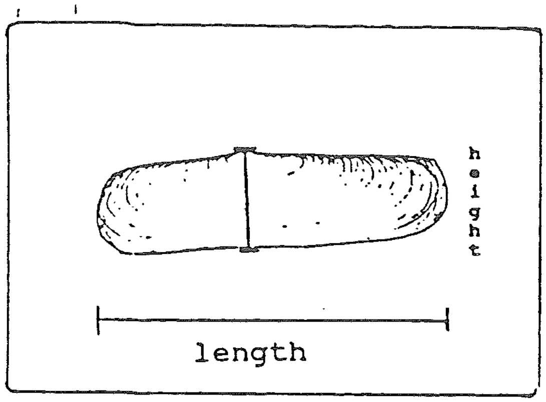


Fig. 5.6 Average length of Jacknife Clams (*Tagelus californianus*) from 5 stations at Malibu Lagoon.

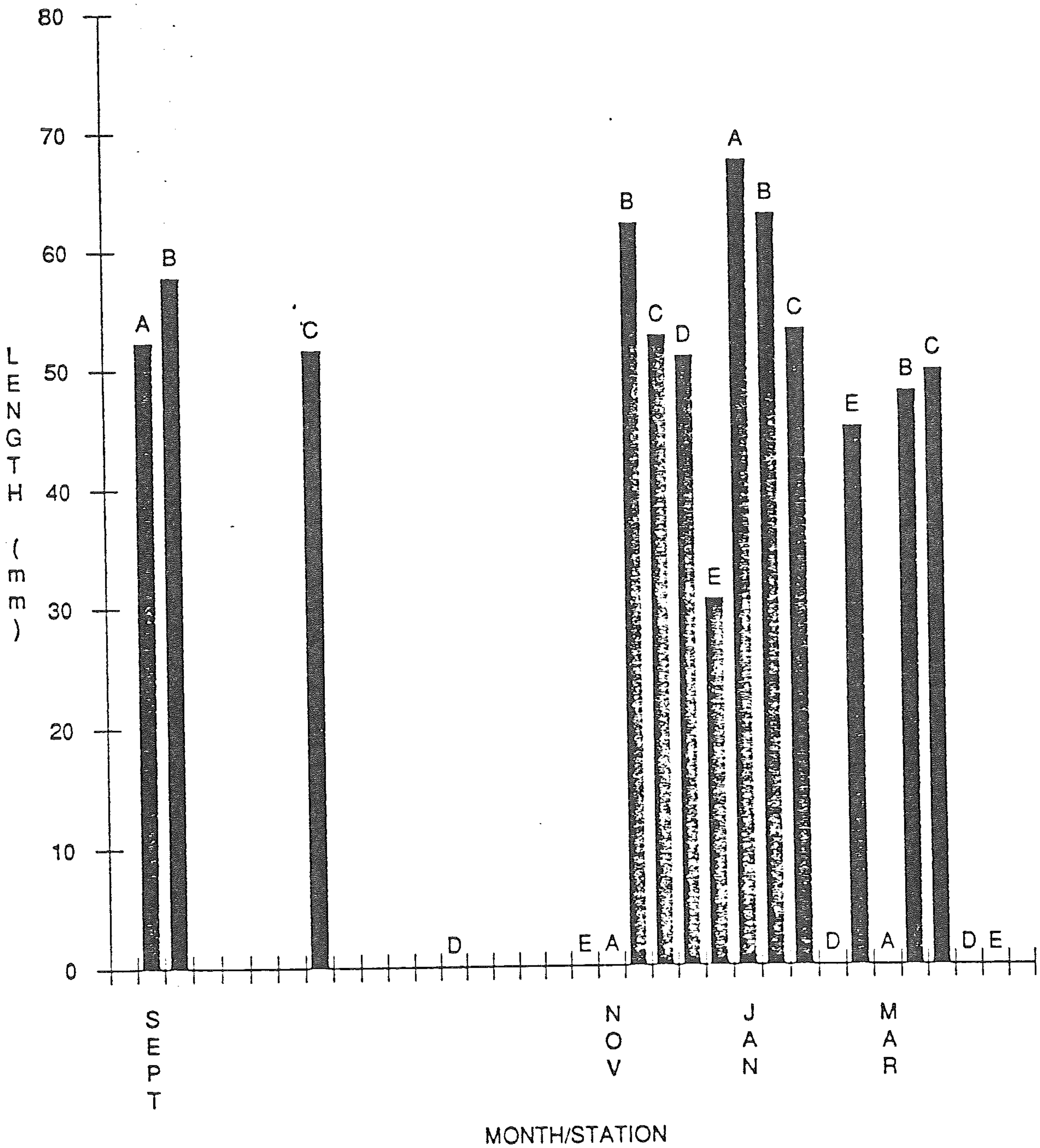
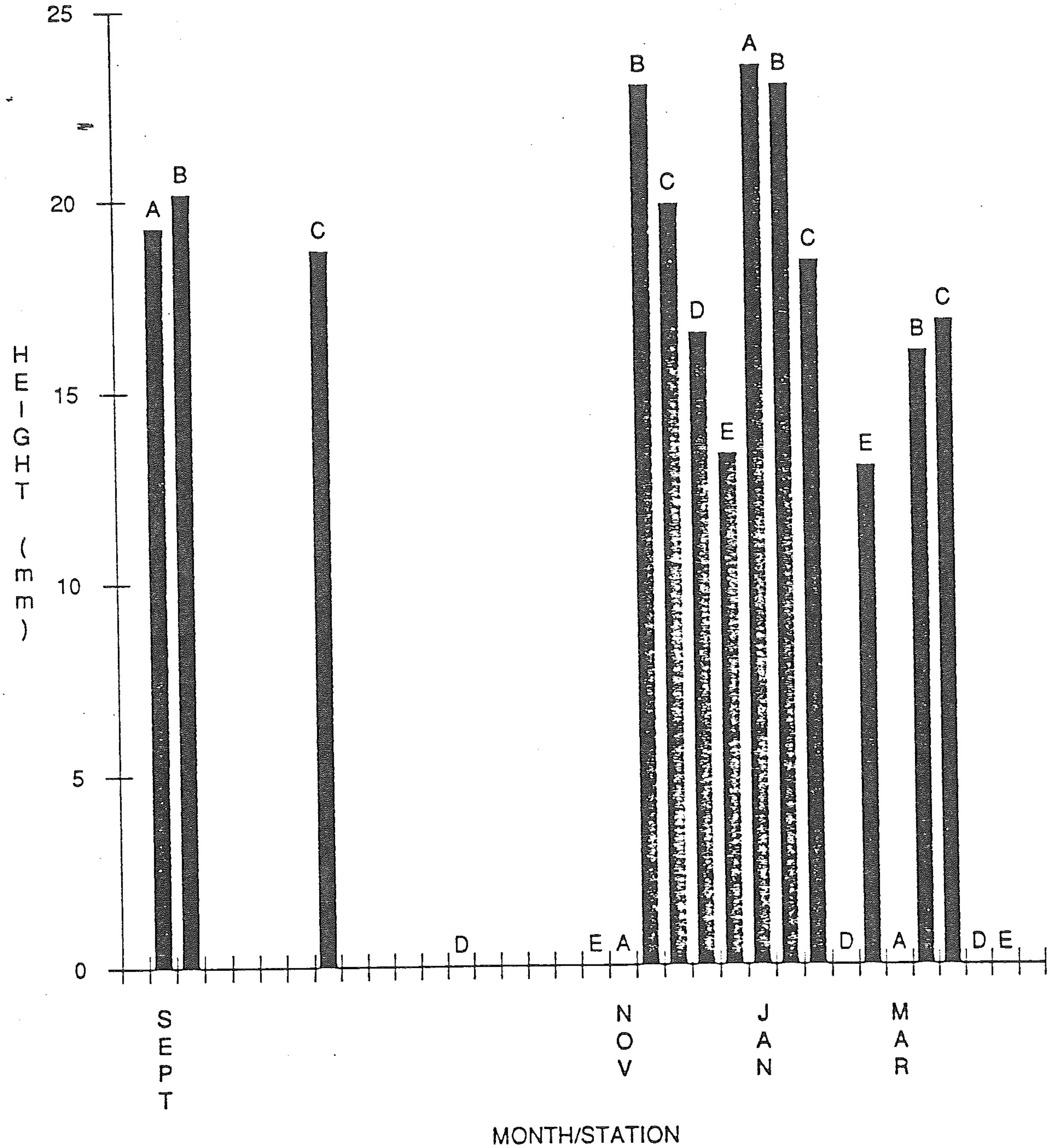


Fig. 5.7 Average height of Jacknife Clams (*Tagelus californianus*) from 5 stations at Malibu Lagoon.



of clams found at station C, they were of a slightly smaller average length than those found in A or B. This channel is where most observed pollution occurs. (Refer to Chapter 2.0). The potential relationship of this to clam size is not clear.

In trying to establish a consistent ratio between burrow width and clam width, all burrow diameters that were not distorted by the sample collection were measured. It appears that there is a strong correlation between shell height and burrow diameter (Figure 5.8), and with more data, it should be possible to construct a table allowing extrapolation of clam height, and potentially length as well, of those animals that escape collection. There seems to be a very strong correlation in our sample of length to height (Figure 5.9). Further data is needed in order to verify and establish such a table.

A potentially interesting fact that emerged from this study was that the clams were definitely concentrated at specific level in the sediments. Clumps of clams would be found at the exact same depth at all stations, with a maximum of 38 cm and average of 20.1 cm. This seemed to correspond to strata of mixed organic mud/clay and sand. It is not clear why they demonstrate this preference, but it could be related to optimal sediment composition, protection from predators, or inability to penetrate lower strata. Initially these layers appeared anaerobic, but became more aerobic in the spring.

A total of 96 clams were collected in the course of this survey, and of this 59 (61%) were alive (Figure 5.10). Empty shells buried in the sediment cores make up the difference. No live clams were ever found at stations D and E after September 1987. Many live clams were present there in the June sample (data not included in analysis due to changing methodology). The sand bar which formed in September at station D, also closed off the channel and allowed water to sit in C channel for extended periods of time. It is not clear which of these two factors played the dominant role in the population decline. Stations B and C showed similar percentages of live populations, with station C falling off consistently throughout the survey, and both having no live clams in the March sample. The cause of this is unclear. In contrast, the population at station A had a die-off in January (0% alive) and had recovered to 100% alive by March. No documented events occurred in the lagoon at that time which could be specifically tied to this observation. School tour records indicate that surveys from the bridges show large die-offs following major rainstorms. Although no data was collected, a large die-off (100+) of clams occurred in early October 1987. This seemed directly related to a film of soap bubbles and foam that was concentrated in C channel for several days during Lagoon

Fig. 5.8 Correlation between shell height and burrow diameter of Jacknife Clams (*Tagelus californianus*) at Malibu Lagoon.

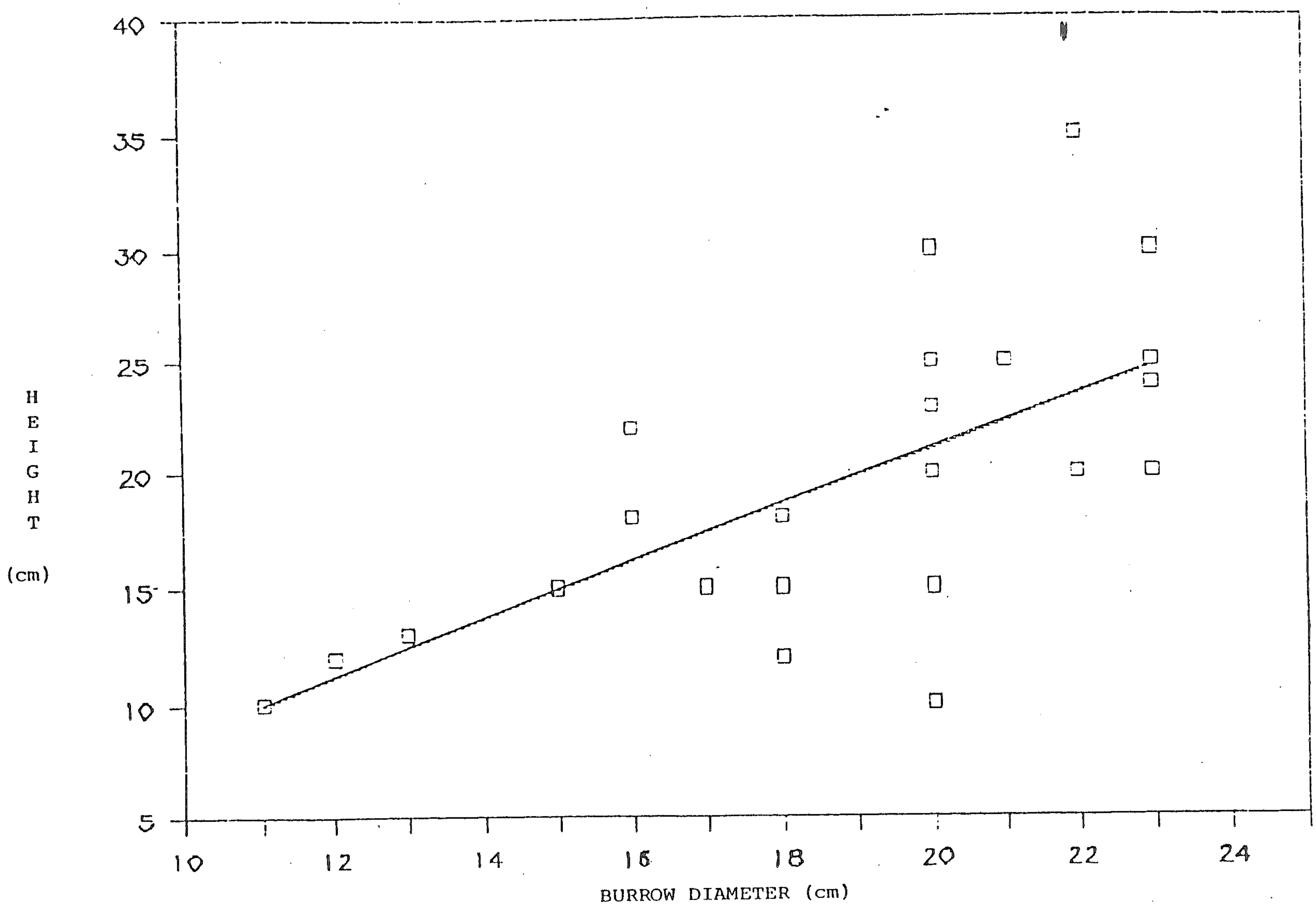


Fig. 5.9 Correlation between shell height and shell length of Jacknife Clams (<u>Tagelus</u> <u>californianus</u>) at Malibu Lagoon.

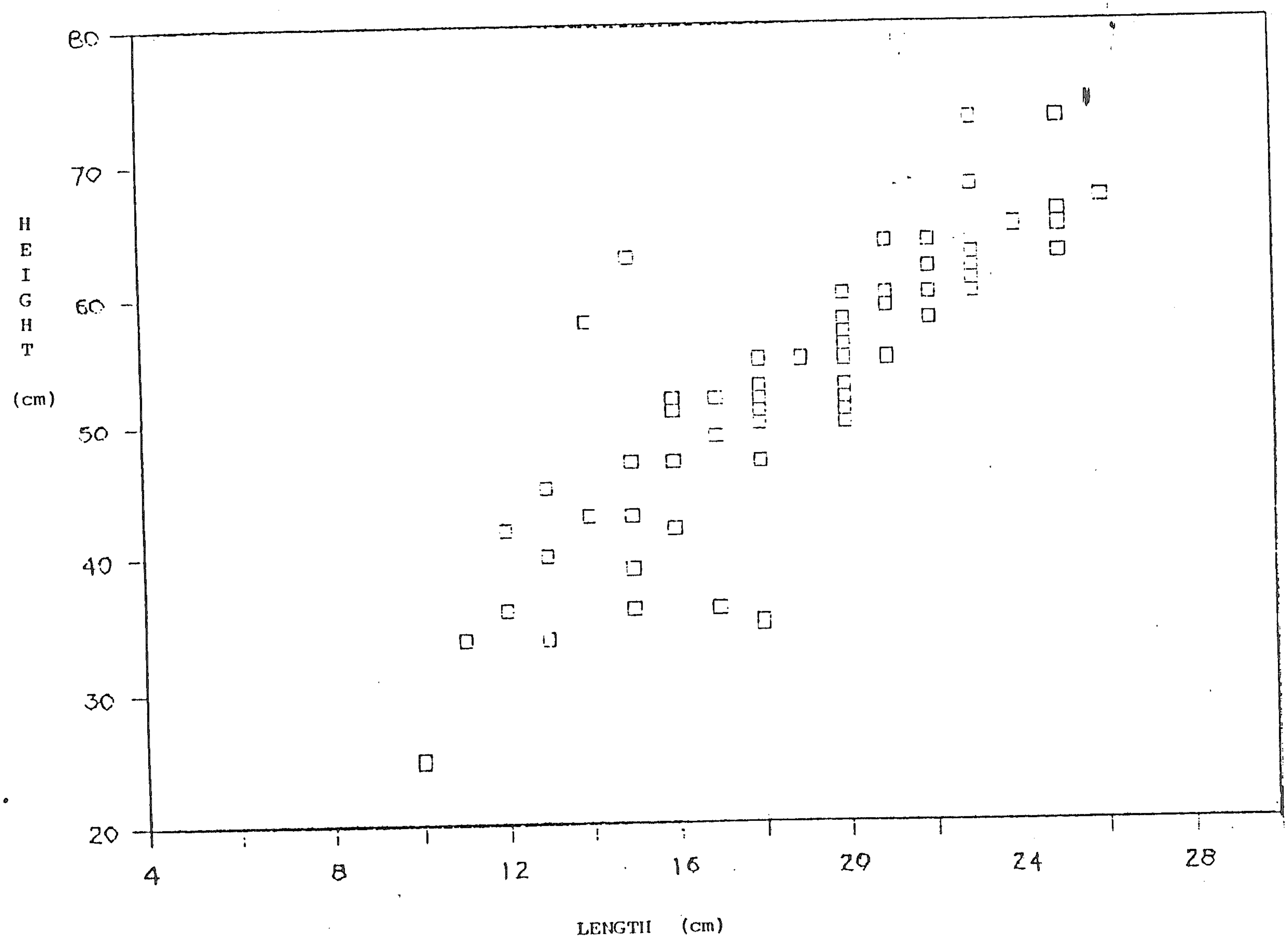
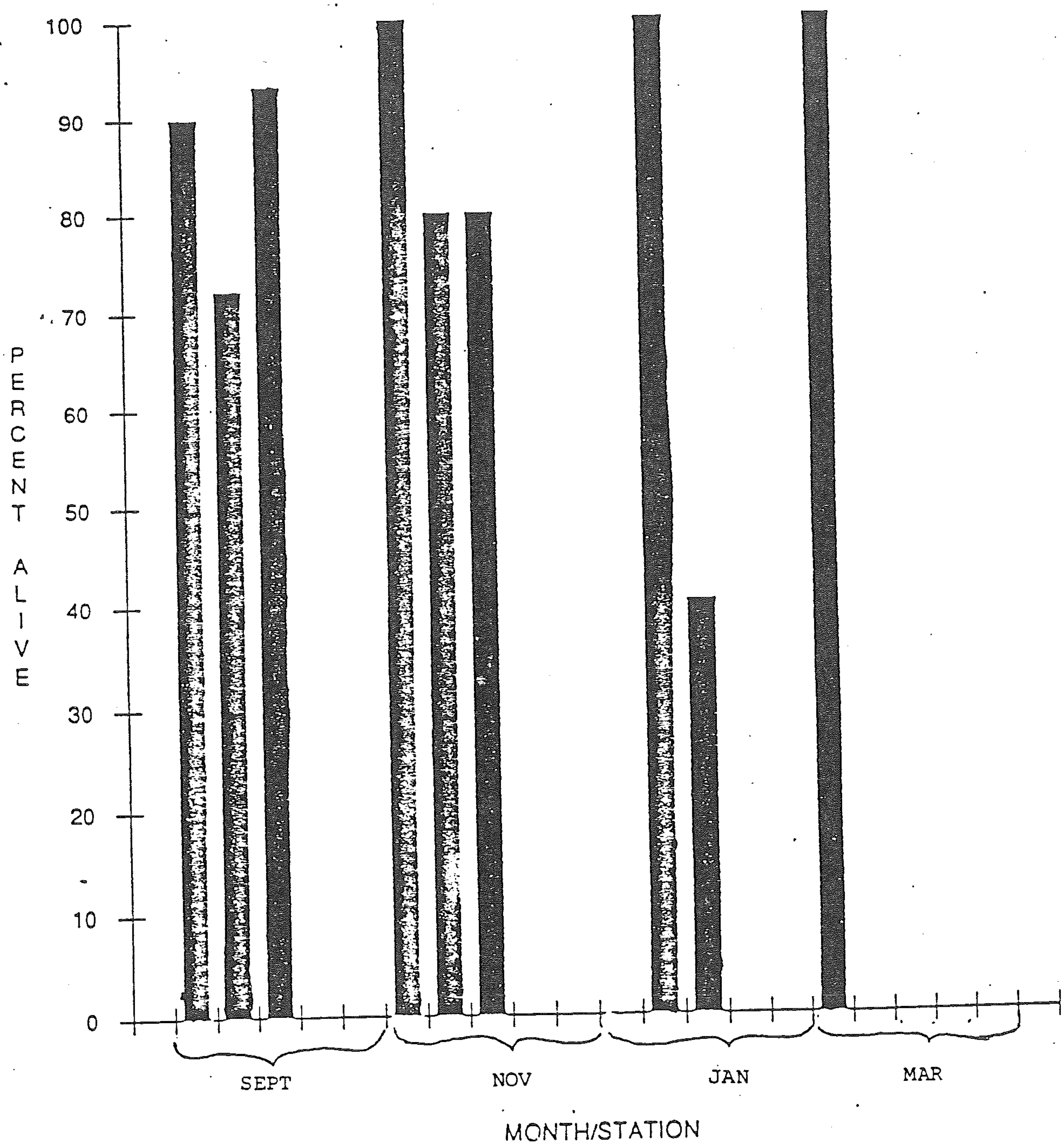


Fig. 5.10 Percent of live Jacknife Clams (*Tugelus*) *californianus* found at 5 stations at Malibu Lagoon.



impoundment, followed by an algal bloom. There was also another die-off in August 1987, following a sewage spill from the Pepperdine line connecting to Tapia.

5.5 DISCUSSION

This study provides an initial assessment of the benthic infauna of Malibu Lagoon. It took several months to revise the methodology so that greater accuracy could be assured, therefore only the last 4 samples were used in analyzing data. With further modifications, the sampling technique should better fit the specific needs of Malibu Lagoon, and thus provide more accurate information. An extension of this study for several years is needed in order to create a database sufficient for determining population trends.

Basic information concerning normal, seasonal population fluctuations of *Polydora nuchalis* is essential to the overall understanding of the role these organisms play in the Lagoon. How these animals respond to changes in water quality, especially extended periods of low salinity, fluctuations in water circulation, disturbance due to storms and predation, remain important questions that will provide essential pieces of the puzzle, allowing greater understanding of the role of these organisms in the overall food web of the Lagoon. It may be that the extended periods of non-seasonal fresh water inundation from the Tapia Water Reclamation Facility has prevented the expected colonization of other polychaete species which is characteristic of other estuaries (Nordby, pers. comm. to J. Dillingham).

Although some insight was gained into the distribution and population of Jacknife Clams (*Tagelus californianus*) it would still be of interest to determine: 1) at what season Malibu Lagoon serves as a nursery area, 2) the rate of growth at various locations within the Lagoon, as well as 3) basic information concerning their tolerance to changes in water quality. With the probability of non-point source pollutants entering the Lagoon in the channel near Malibu Colony, which is now somewhat restricted by the physiography of the inlets, this question is of great importance when considering the proposed connection of these fingers along a source of incoming pollution.

Malibu Lagoon has a limited diversity of benthic infauna which is consistent with other estuaries experiencing extended periods of brackish water conditions (Zedler, Koenigs and Magdych 1984). It has been 5 years since the restoration of the Lagoon, and the more usual development of a more diverse benthic infauna has yet to occur. *Polydora nuchalis* and *Tagelus californianus* may represent either an initial colonizing effort, re-establishment of a previous population, or could be a result of the physical and chemical parameters. Low salinity tolerances, and limiting factors such as temperature, pH, dissolved oxygen, turbidity and possible pollution may prevent the colonization by other, less flexible species. Continuation of this study, with a review of the impact of the sampling methodology, is recommended in order to determine which of the many variables outlined above may be the key to understanding the dynamics of these populations.

5.6 SUMMARY

1. Only two species of benthic infauna have been found in Malibu Lagoon, Polydora nuchalis and Tagelus californianus.

2. It is unusual to find a monoculture of Polydora nuchalis in an estuary. It may be that the influx of large volumes of fresh water coupled with inconsistent management of the ocean entrance are limiting factors. This warrants further investigation.

3. Both species prefer mud/silt organic sediments and disappear from areas inundated by sands.

4. Populations decreased overall during the survey. This could indicate disturbance due to sampling methodology, changes in water quality, the natural population cycle, or the influence of heavy predation by a large seasonal population of probing shorebirds.

5. It is not possible, based on current data, to determine how water quality factors such as salinity, large volume of fresh water, pH, turbidity, temperature and dissolved oxygen influence the population density and diversity of benthic infauna. Die-offs of Jacknife clams (Tagelus californianus) seem directly related to continued exposure to fresh water and possibly also to pollution (August 1987 Pepperdine spill). Continued study is needed to clarify these relationships.

6. Since benthic infauna are an important link in the food chain of Malibu Lagoon, further study is necessary to understand more fully the dynamics of the situation in order to foster continued growth and restoration of these populations.

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6.0 INVERTEBRATE EPIFAUNA

6.1 INTRODUCTION

Five years after restoration, it was expected that a more diverse assemblage of invertebrates would have recolonized Malibu Lagoon. Initial surveys of invertebrates have instead shown that only two benthic species occur here. Species diversity and abundance of invertebrates can provide an important measure of the recovery cycle in the Lagoon. As a measure of this recovery, invertebrate epifauna were investigated at the sediment and water column interface, and include studies of the mud crab, oriental shrimp, and small epifauna (ostracods, copepods, water boatmen, amphipods, nematodes, flatworms). The most conspicuous of this epifauna is the mud-flat crab (Hemigrapsus oregonensis).

Abundance and diversity of invertebrates are probably related to factors limiting the recovery process at Malibu Lagoon. Mud crabs, shrimp and small epifauna may therefore assume greater importance as food resources than would be expected in a more productive estuary.

Malibu Lagoon is typical of other southern California estuaries receiving large quantities of fresh water from wastewater treatment facilities, where invertebrate species diversity is significantly reduced due to prolonged brackish water conditions (Zedler 1984). Since there are clearly large numbers of crabs at Malibu Lagoon, studies which might provide insight into the biology and behavior of this species may become a significant factor in understanding the "health" of this estuary in the future.

6.2 PROJECT OBJECTIVES

Prior to making changes in the physical and morphologic characteristics of Malibu Lagoon during phase II of the restoration process, it is important to identify species and determine relative abundance of epifaunal invertebrates along habitat gradients and over time in order to understand the interrelationships which exist in this ecosystem. Of particular interest is the mud-flat crab, which appears to be thriving in this ecosystem. Understanding the factors limiting the distribution of these organisms will aid in the development of a sound management plan in the future.

6.3 METHODOLOGY

6.3.1 MACROSCOPIC EPIFAUNA: MUD CRABS AND SHRIMP

Mud-flat crabs and oriental shrimp (Palaemon macrodactylus) are surveyed in conjunction with the daytime monthly fish surveys. Data was collected from June 1987 to August 1988 and on blocking net surveys in January and September 1988.

Both species were collected during each of three replicate passes of the seine net at five stations along habitat gradients in the Lagoon (see map A for exact locations). After each replicate of the 6.1 m X 1.8 m X 3.1 mm ace-type mesh net within each 10 meter study site, all organisms were collected, identified, and numbers counted. Voucher specimens of shrimp were sent to the Los Angeles County Museum of Natural History Crustacea Lab for positive identification.

In addition, surveys of crabs and shrimp were made during January and September 1988 fish surveys for the California Dept. of Parks and Recreation (DPR). Surveys for DPR followed the methodology used by Nordby and Covin (1988) in other southern California estuaries, where a 10 m length of inlet channel is blocked by using two 15 m by 3.1 m by 3.1 mm ace-type mesh seine net. The area is fished repeatedly until fish numbers approach zero. Then blocking nets are drawn together to capture the remaining fish, crabs and shrimp.

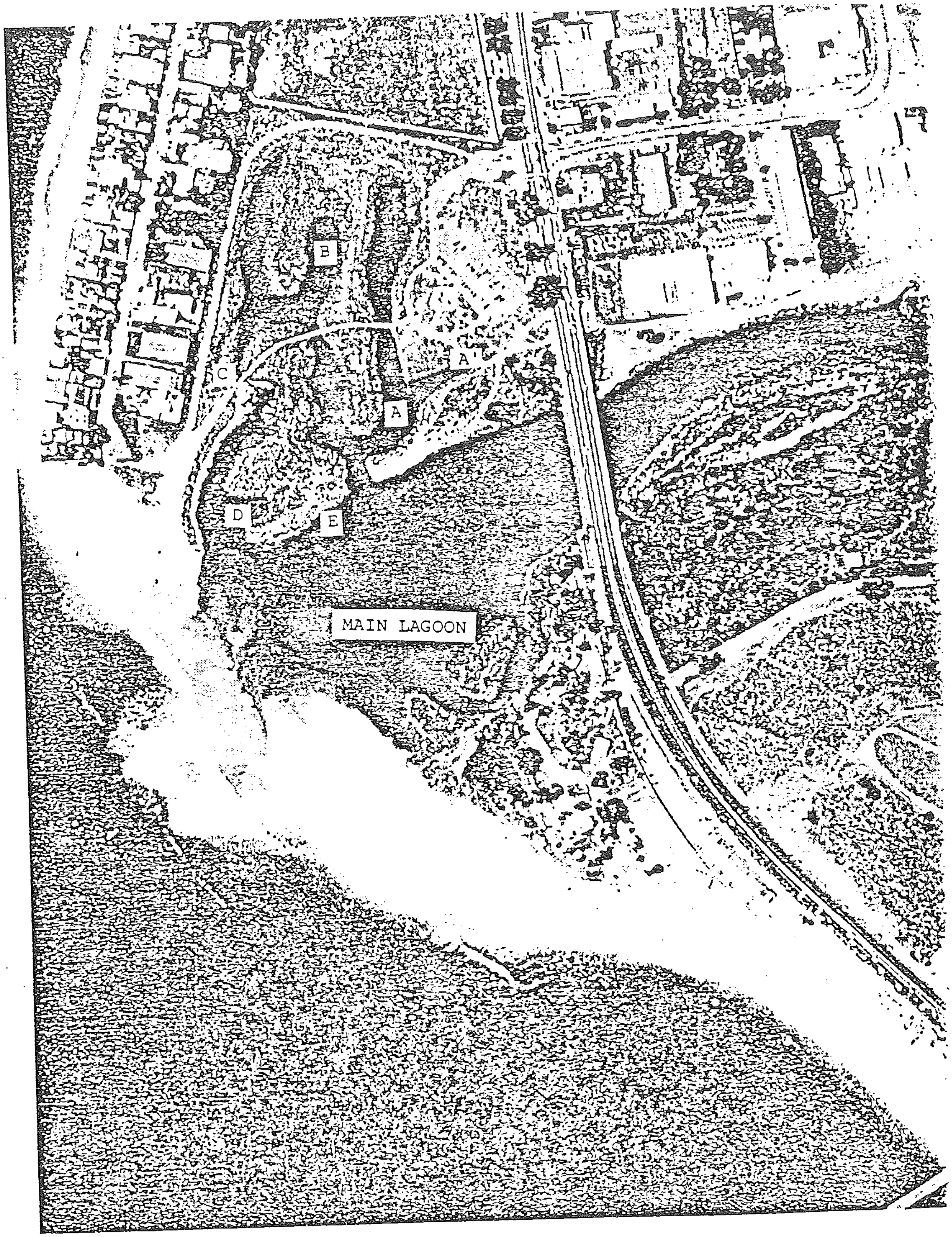
In both types of surveys, the carapace width of each mud crab is measured in mm at the second spine. Crabs are identified by sex and condition before being returned to the estuary. Crabs of other species are also identified, measured and counted.

Because of the fragile nature of this estuary, no attempt was made to excavate crabs from their burrows to determine crab populations, as did Willason (Zedler 1982) in his comparative studies of the mud crab and the lined shore crab (Pachygrapsus crassipes) at Goleta Slough.

6.3.2 SMALL EPIFAUNA: OSTRACODS, COPEPODS, WATER BOATMEN, NEMATODES, AND FLATWORMS

To identify small epifauna, random samples are collected at the interface between water and sediments by using a 13 cm by 15 cm fine aquarium dip net (1 mm mesh). Ten sweeps of the net are made within a meter square area during periods of low water in the Lagoon, where water depths are approximately 20 cm. The meter square area is marked with 1 m lengths of PVC pipe, which are joined at the corners with plastic elbows so that the meter square is floating in water. Epifauna collected in the aquarium net are then rinsed in the Lagoon to concentrate them in the bottom of the net. The net is

MAP A Study Stations at Malibu Lagoon



everted, and epifauna are added to a 5 cm diameter container holding 50 cc of surface water from the Lagoon. A 5 cc syringe with a 2 mm opening is used to collect a 2.5 cc subsample, which is placed in a 5 cm diameter watch glass.

Epifauna are identified and counted by using a 10-20 X widefield stereomicroscope. The relative abundance of each type of small epifauna are recorded by class, based on an average of the counts of three 10 X microscope fields. Individual organisms are first identified at 20 X magnification. Where classes overlap, a range is recorded.

RELATIVE ABUNDANCE BY CLASS:

Class 1:	fewer than 5	Class 3:	10-15
Class 2:	5-10	Class 4:	15 or above

AVERAGE NUMBER OF EPIFAUNA/ 10 X MICROSCOPE FIELD

This methodology was developed as a way of gaining needed information within the short time framework available for this study, and provides an idea of what organisms exist at Malibu Lagoon in this small size range.

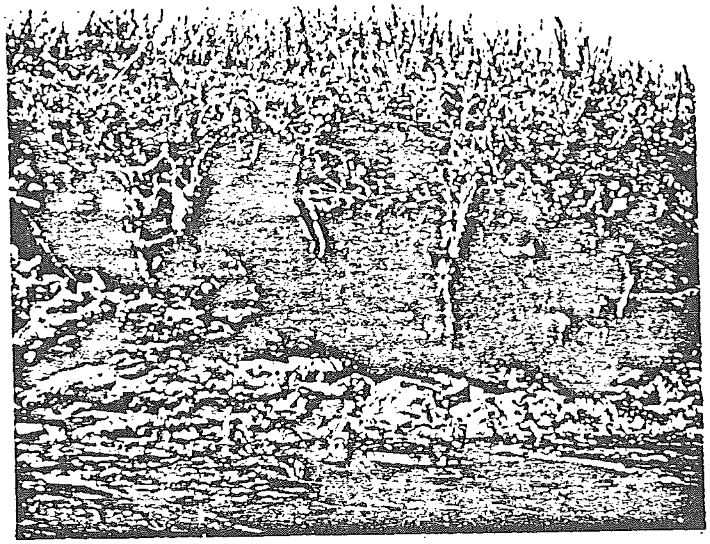
6.4 OBSERVATIONS

6.4.1 CRAB OBSERVATIONS

The mud(flat) or yellow shore crab (*Hemigrapsus oregonensis*) is the only crab regularly encountered in Malibu Lagoon. Mud crabs dig burrows along the banks of the Lagoon below the edges of vegetation to the 3-4 ft. tidal level (Fig. 6.1). Some burrows are encountered up to the level of the highest water in vegetated areas. Crabs often take advantage of the safety of cobble rocks occasionally found in the inlets, by establishing burrows beneath them. Holdfasts which drift into the Lagoon during extreme high tides and with storms also provide temporary habitat for these crabs. The mud crab is a major food resource for the western willet (Garth and Abbott, 1980), staghorn sculpins (Fitzgerald and Hasz 1983) and California killifish (Fritz 1975). At Malibu Lagoon, shorebirds are often seen feeding on or foraging for crabs.

Although many reference materials describe the mud crab as nocturnal in habit (Chace and Abbott 1980), (Ricketts and Calvin 1968), it is regularly observed in the daytime during fish surveys and programs for school groups at Malibu Lagoon. Although algae, mostly *Enteromorpha sp.*, appears to be the primary diet of the crabs, they are also observed feeding on dead razor clams, small organisms in the mud, probably diatoms (Garth and Abbott 1980) and an occasional dead fish. The

Fig. 6.1 Mudbank habitat of the mud(flat) or yellow shore crab (Hemigrapsus oregonensis). Photo by C. Nordby illustrations by J. DeWald (Zedler 1982).



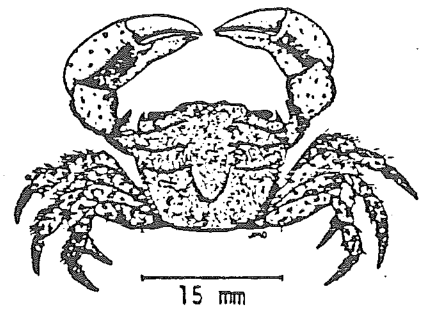
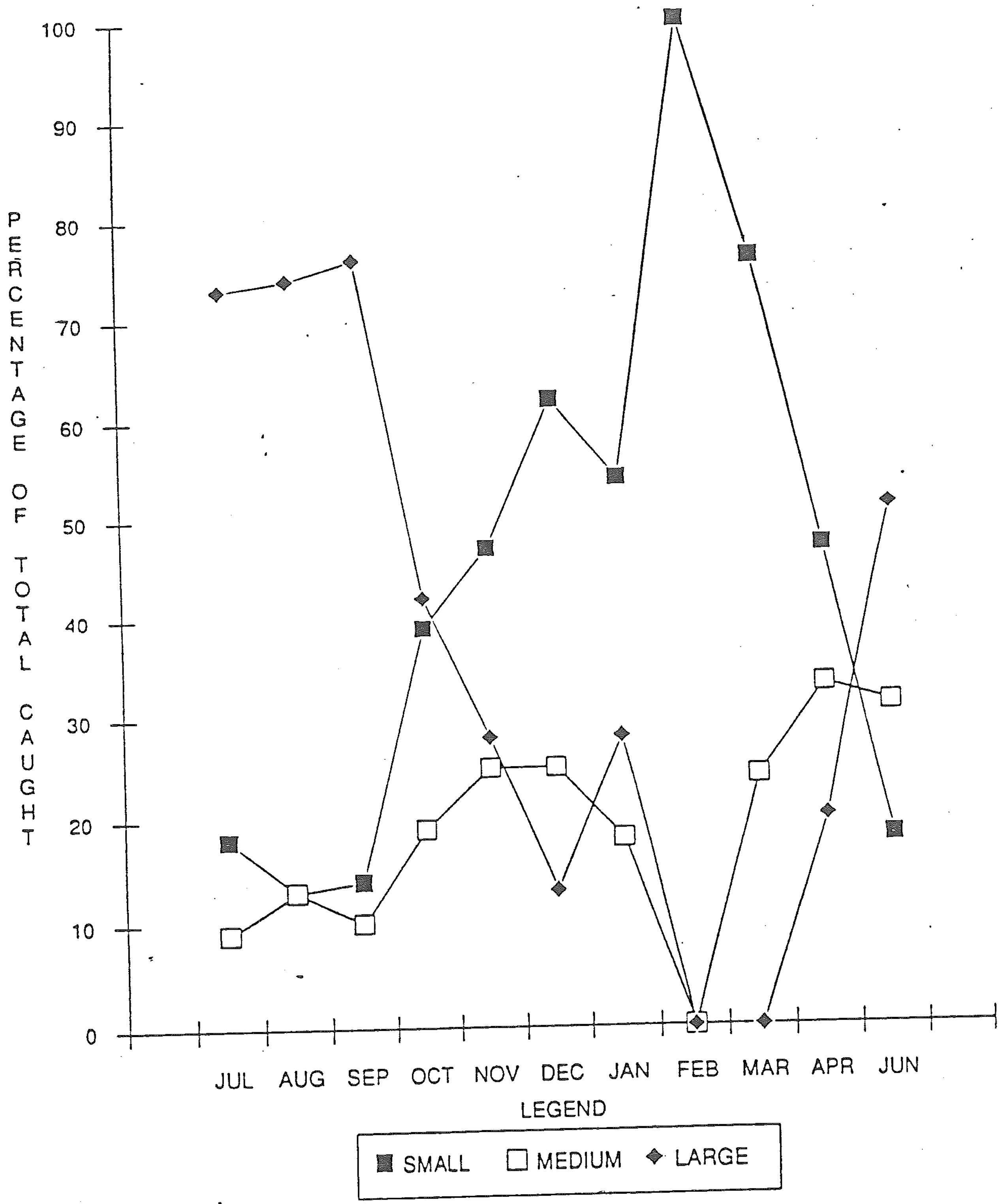


Fig. 6.4 Size classes of all mud crabs (*Hemigrapsus oregonensis*) observed at Malibu Lagoon, July 1987 - June 1988. small crabs: carapace width 9 mm or less; medium crabs: carapace width 10-13 mm; large crabs: carapace width 14-30 mm, includes size of smallest gravid female.



numbers when migratory birds are in residence at the Lagoon may indeed make them important as a food resource, since diversity and numbers of other invertebrate food resources are probably limited.

6.5 DISCUSSION

6.5.1 MUD-FLAT CRAB DISCUSSION

Seasonal population trends at Malibu Lagoon tend to reflect observations made of mud crabs in other areas along the Pacific Coast, although crab numbers remain higher here later in the year. This pattern possibly reflects the warmer water temperatures found in Southern California, and may be linked to the presence of algal mats as a food source and as cover from predators. Both sizes and numbers of crabs begin to increase in the spring, with peaks in summer and fall months following the period of greatest algae production. The observation that many crabs are present during the fall months when water temperatures might be expected to drop may be explained by a warm water inversion which is often present during this period of the year, and which may extend the period of algae production. Although the algae mats begin to die-off in late summer, an algal film covering the inlet bottoms and some coastal drift algae are usually present in most areas of the Lagoon to serve as a food source for the small crabs, whose numbers dominate winter surveys (Fig. 6.4). Further studies are indicated to determine if winter crab populations are diminished by cold water temperatures, the absence of algal mats, avian predation and/or sediment changes after storms. It may be during these periods that larger mud crabs remain dormant, and are in their burrows, where they are not collected during surveys.

Our methodology cannot be used to assess total crab numbers, since only crabs that are on the surface of the substrate can be captured with the seine net, with those residing in burrows evading capture. Since crabs were collected within similar physical and chemical parameters, the numbers observed at each study site probably give a good picture of the relative abundance of mud crabs along habitat gradients in the Lagoon.

Daytime seining may also affect our results, since other studies indicate that mud-flat crabs forage primarily on diatoms and green algae at night (Garth and Abbott 1980), and numbers of crabs caught during daytime may not relate to actual crab populations in the Lagoon.

Substrate appears to be important in the establishment of burrows. Not only does a susbstrate composed largely of consolidated muds seem to be preferred, a steep bank gradient also seems to be a factor in the distribution of crabs throughout the Lagoon. At stations A, C and D (map A), where banks are relatively steep, crab populations are highest. Although there is a mud substrate present at station B, inlet sediments are unconsolidated and no steep bank exists, and may explain why few crabs are collected on these surveys. It is possible that crabs also live in burrows underneath low-elevation vegetation at this site, where no surveys were conducted. Also, there are no cobble rocks and few holdfasts to serve as cover from predators at this site.

Gradual infilling of station D is a direct result of maintaining the present position of the Lagoon entrance by DPR. The covering of crab burrows with shifting sands probably explains why crab numbers have significantly dropped at this station.

Crabs appear to be more densely concentrated where there is additional protection from predators, such as under cobble rocks which exist above burrows, and in coastal algae holdfasts which are carried by tidal action into the Lagoon and inlet. The fluctuation in numbers which we noted on surveys during close periods of time probably reflect our survey techniques rather than any dramatic fluctuation in crab numbers. The fact that student tour groups regularly view large numbers of crabs from bridges over the Lagoon inlets from spring through fall months is probably a more visible measure of their success.

On all surveys conducted at the Lagoon, more males than females were present. Both small and large crabs exhibit these differences in sex ratios. During the summer reproductive period, two to three times as many males were collected on surveys as females. Possibly more males are produced during fertilization of eggs, or are the result after eggs are brooded and young are released. It has been noted in laboratory studies of crabs that several males may impregnate a single female (Garth and Abbott 1980). It is also possible that gravid females, with their increased vulnerability to predation, have retreated to burrows, where they are not collected during surveys. During blocking net surveys conducted for DPR, when the mud substrate was disturbed substantially during sampling, increased numbers of females were encountered during the final replicate seines (combined 6 and 7), but not in sufficient numbers to explain the great differences in numbers between male and female crabs.

Mud crabs at Malibu Lagoon show the resiliancy needed of a species which can survive here under constantly fluctuating physical conditions. In particular, these crabs seem to be able to adapt to a very wide ranges of salinities where other species cannot (Zedler and Nordby 1986), and to survive during extended periods where salinity levels remain low. The effects of fresh water discharge from the Tapia Water Reclamation Facility, which are compounded during periods when the entrance remains closed, clearly affects other biota in the Lagoon. Since mud crabs are highly tolerant of polluted conditions, present water quality in the Lagoon probably is not limiting. Factors relating to the success of this crab may aid in understanding how pollution and other physical factors may limit the success of other organisms in the Lagoon.

Both marine and fresh water crustaceans have been encountered on surveys, yet none have become established in the Lagoon. It is most likely that the long periods of brackish water conditions in the Lagoon prevent the lined shore crab (Pachygrapsus crassipes) from becoming established. Although it is a more aggressive species than the mud crab, it does not have the ability to osmoregulate over long periods of low salinities (Willason 1980). In contrast, the crayfish appears unable to tolerate brackish water conditions, and is found in the Lagoon only when salinity levels are very low.

6.5.2 ORIENTAL SHRIMP DISCUSSION

The presence of oriental shrimp in Malibu Lagoon appears to be associated primarily with the presence of coastal drift algae in the Lagoon, since the greatest numbers of shrimp were observed after algal mats had diminished in size, but not yet completely disappeared. The only factor consistent in the distribution of shrimp in the Lagoon appears to be the presence of drift algae, for shrimp may be present in large numbers at one site, and absent or in small numbers at others.

In the laboratory, these shrimp survive well at temperatures between 14-26 C, and tolerate wide ranges of salinities (Chace and Abbott 1980). At Malibu Lagoon, there appears to be no correlation between water temperature and the presence of shrimp. Shrimp appeared on surveys where temperatures extended well beyond this range, with temperatures varying from 10.5-27.5 C.

6.5.3 SMALL EPIFAUNA DISCUSSION

Observations made of the small epifauna only give a small indication of the potential of this resource, as samples were extremely small. Of particular interest is the little-described ostracod, which appears throughout the Lagoon in both fine and coarse sediments in relatively large numbers. Future studies might look into the changes in distribution patterns in the Lagoon, which appear to alter with season.

Copepods are an important resource at the beginning of the food chain. Sampling was so limited, that only the presence of this resource can be noted. Further study may confirm an observed trend of increased numbers during fall and winter months, when other food resources may be limiting. Many copepod females were observed carrying eggs during these surveys, and it is probable that they reproduce successfully here.

Although quantities of organic material are present in the Lagoon, unsegmented worm (nematodes and flatworms) numbers appear to be small during this study. Sampling techniques should have provided for ample collection of worms, as specimens were collected from the substrate of each study area. Worms are often used as indicators of pollution. Future studies in this area may assist in determining the "health" of the Lagoon.

The speed and the relatively large size of the brackish water boatmen made subsampling of this species difficult. These fast swimmers were almost always present during student surveys, and during these limited studies. In the future, counts will need to be made of this population on the basis of the entire sample if the relative abundance of water boatmen is to be understood. This extremely visible insect may be an important food resource for birds and fish, and warrants further study.

Never studied, but also of possible importance as a food resource are the large numbers of amphipods (Orchestoidea sp.) which appear in the Lagoon when coastal drift algae is present and when algal mats decompose in late summer.

6.6 SUMMARY

1. Mud crabs appear to be able to withstand the long periods of unseasonal fresh water inundation which occurs throughout much of the year at Malibu Lagoon as a result of discharge of wastewater from the Tapia Water Reclamation Facility. Infrequent opening of the Lagoon entrance by DPR and a natural closure of the entrance from April until the first major winter storms extends the effects of this additional fresh water.

2. Crab burrows are most numerous where bank gradients are steep, and sediments are composed of consolidated muds. Where sediments are unstable, few crabs are found. The presence of drift coastal algae holdfasts and cobble rock appears to provide temporary cover from predation for crabs along the bottoms of inlet channels.

3. Mud crabs clearly utilize algae mats as a major food resource, and are also observed feeding on organisms in the mud. In turn, shorebirds such as willets, whimbrels, and snowy egrets are often seen feeding upon the crabs. Mud crabs are also an important food resource of the staghorn sculpin and California killifish.

4. Greatest numbers of mud crabs (Fig. 6.2) have been observed during summer and fall months, when water temperatures are warm and algae mats are present. Large sized crabs (carapace width greater than 14 mm.) dominate in the summer and fall months, and small crabs (carapace width less than 12 mm) predominate in winter and spring. Almost no large crabs are found during winter months. The smallest gravid female collected during the survey had a carapace width of 14 mm.

5. Of particular interest is the ratio of males to females during this survey. Throughout the year, males are more numerous than females, with a hugh increase in the number of males caught at all sites during summer and fall months. The numbers of males are often two to three times that of females during this period, with the greatest difference being noted in October 1987. The ratios observed may be biased by our sampling methods.

6. Oriental shrimp most likely have entered Malibu Laoon on drift coastal algae as a result of shipping along the coast, and have appeared periodically throughout the Lagoon during these studies. Additional studies might add more insight into the role this shrimp plays in the Lagoon ecosystem.

7. The small epifauna probably represent a greater potential food resource than this small study indicates, since ostracods, copepods, brackish water boatmen, amphipods, nematodes, and flatworms are present in the Lagoon throughout the year. Clearly, more needs to be learned about these small organisms and their distribution patterns in the surface sediments and throughout the seasons. Future studies should also include the plankton.

8. Two other crustaceans found on surveys of the Lagoon serve as indicators of the extremes in the salinities noted throughout these studies. Freshwater crayfish were found on one fish survey, where salinities were very low. The lined shore crab, and other marine crabs, have been collected on other surveys. Neither fresh water nor marine species have become established in the brackish waters at Malibu Lagoon.

9. It is important to continue studies of the mud crab, for it appears to be thriving in the Lagoon, where only a few other species of invertebrates have colonized five years after restoration. Clearly the mud crab is extremely tolerant of the changing physical conditions noted during these studies at Malibu Lagoon. A continued monitoring of crab populations and water quality may give further insight into factors affecting the "health" of this estuary.

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7.0 THE FISHES OF MALIBU LAGOON

7.1 INTRODUCTION

Estuarine saltmarshes, such as Malibu Lagoon, have long been recognized as an important natural resource in the marine environment. They are among the most productive environments on earth. The estuary has been identified as a nursery ground for the juveniles of several species of marine fish, one of which is the California halibut. In fact, five of our six most important commercial fish species are dependent in some way on estuaries (Haedrich and Hall 1976).

An estuary simply defined is the transitional area between freshwater and saltwater environments (Moyle and Cech 1982). An estuary is typically a very stressful environment in which to live. The fishes found in this transitional environment are presented with some very real problems. Many physical factors are constantly changing in the estuarine environment, such as salinity, temperature, and dissolved oxygen. The fishes here have evolved either metabolically or behaviorally to deal with these changing situations.

Once the problems have been overcome, the estuarine environment offers a great many seasonal advantages to the fishes living here. In the summer and fall, the fishes find lots of food, warmer temperatures, and reduced competition and predation from other fishes that have not adapted to the estuarine environment. The seasonal availability of these resources are reflected in the seasonal changes of the fish communities. There are relatively few resident fishes in the estuarine community (Moyle and Cech 1982).

Malibu Lagoon is typical of a very small saltmarsh. The Lagoon is now a semi-natural marsh, due to the great degree of reclamation that has gone on here (Long and Mason 1983). Malibu Lagoon, historically, was typical of other small coastal lagoons found in southern California in that during the summer and fall months when rainfall is scarce the influx of freshwater into the Lagoon was virtually nonexistent (Soltz 1979; Swift and Frantz 1982). The lack of rainfall would allow a sand bar to build up at the mouth of the Lagoon and isolate the Lagoon from the ocean. When the Lagoon is cut off, the waters can become very brackish. These brackish conditions would persist until the winter rains came and washed the sand bar away. These natural conditions do not generally persist in Malibu Lagoon today. The mouth of the Lagoon is opened whenever it closes for any length of time.

In the past, the Lagoon has been dependent on the drainage of Malibu Creek to add freshwater to the system. The Malibu drainage has always been subject to periods of drought, where little or no freshwater has flowed into the Lagoon system via Malibu Creek. Now, with the development of

Malibu Canyon and the year-round runoff from man's activities via the Tapia Water Reclamation Facility, the Lagoon may, for the first time, have a year-round influx of freshwater into the Lagoon system.

Malibu Lagoon is an important and functioning estuarine saltmarsh. There are fishes here that are very dependent on the Lagoon for their survival, and the survival of any coastal wetland or estuary is of great importance to all of us both economically and ecologically.

7.2 OBJECTIVES

The purpose of this study is to develop a post-restoration baseline survey of the fishes found in the various habitats of the Lagoon. A species list reflecting relative abundance will be produced, along with estimations of the diversity of the fish communities in Malibu Lagoon. This study will establish some post-restoration baseline data on the fish populations of Malibu Lagoon.

7.3 DESCRIPTION OF STUDY AREA

It is of great importance to look at the study sites (stations) in relation to their ability to support fish communities. There are several different types of fishes found in this lagoon system that use very different habitats. The arrow goby and the Pacific staghorn sculpin use the bottom for their homes and burrows. California killifish, topsmelt, and striped mullet are found in the water column.

Many important factors, besides the physical and chemical characteristics of the water, determine where a species of fish can live. Two of these are: 1) the type of bottom, i.e. sandy, silty, or muddy and 2) the presence or absence of rocks, cobbles, plants, or algae that provide shelter or food resources. Refer to the map (figure 7.1) in order to see the physical locations of the various stations. Refer to temperature, and salinity, respectively.

Station A - This station was located in one of the channels of the developed Lagoon. It is most like station D in its proximity to the main body of the Lagoon, but is very different because of its distance from the mouth of the Lagoon. It has a very soft bottom composed of fine silts. Many organic materials are apparently being broken down in the anaerobic mud, due to the overpowering odors of hydrogen sulfide gas. The mean sediment depth has been measured to be 40 cm. This station also had the largest bloom of the algae *Ulva sp.* and *Enteromorpha sp.*. The water was typically very still and did not reveal any real currents or flows throughout the sampling period. This station was always deep enough to have standing water and never went dry.

Station B - This station is located on one of the innermost arms of the restored Lagoon. It is most like station C in its proximity to the main Lagoon body, but differs in that it is furthest from the Lagoon mouth. It has a soft, silty bottom type without the odor of hydrogen sulfide gas. The mean sediment depth here was measured to be 43 cm. This station would exhibit wide fluctuations in water depth and water currents. During one sampling period, the station was drained of free-standing water by the outgoing tide. This left only the mud bottom. This station does have a seasonal algal mat (Ulva sp./Enteromorpha sp.), but it is not as thick as that at station A.

Station C - This station is located in one of the back channels of the developed Lagoon. It is most like station B in its proximity to the main body of the Lagoon, but is different due to the shorter distance to the Lagoon mouth. It is more ocean-influenced than station B. It generally has a much firmer bottom than A or B. The mean sediment depth here was measured to be 36 cm. There appeared to be a current moving through this station most of the time, however slight. This station was not as subject to the algal mats (Ulva sp./Enteromorpha sp.) as were the other stations. The presence of drift coastal algae was noted here as a regular occurrence, i.e. Macrocystis sp. holdfasts, Eisenia sp. (the whole plants), and various assorted red and brown algae with the occasional occurrence of the flowering plant Phyllospadix sp..

Station D - This station is located fairly close to both the main body of the Lagoon and the mouth of the Lagoon. The bottom here is very sandy, with small pockets of silts. It has the most spatially heterogeneous bottom of all the stations. The sediment depth here ranged from 18 to 33 cm. There was an infilling of the channel with sand as a result of winter storms and also its proximity to the managed entrance channel. It generally had drift materials: algae, flotsam, and trash. It also had many pockets of rocks/ cobbles that represent the major differences between the stations. At times of water influx or outflux this station had very rapid water movement whenever water covered the sandbar. This station did not have algal mats of Ulva sp./Enteromorpha sp..

Station E - This station was located along the shore of the Lagoon proper. It has a very sandy bottom with little or no silt. It is always subjected to the inflow and outflow of the main Lagoon system. There were no algal mats produced by Ulva sp./Enteromorpha sp. at this station. The only algae found here were those that had been brought in by the tidal influx. This tidal influx did leave many larger-sized

Macrocystis sp. holdfasts. There were many other types of drift algae observed at this station, i.e. *Corallina sp.*, *Colpomela sp.*, *Sargassum sp.*, *Elsenia sp.*.

7.4 MATERIALS AND METHODS

The Lagoon was sampled at five stations every month. A seine, measuring 6.1 x 1.8 meters of 3.1 mm mesh ace style netting, was used for this survey. Three seine hauls were made at each station.

The fishes caught were measured to the nearest millimeter (mm) standard length (S.L.). When the catches were large and the measurement of all individuals could not be done because of time constraints, sub-sampling was employed. A sub-sample of the most numerous species would be measured and all individuals would be counted for each replicate. The fishes were then returned to the area between replicate hauls (sampling with replacement). Most fishes were returned alive, but topsmelt (*Atherinops affinis*) did suffer a high degree of mortality.

In order to visualize what size class of a certain species of fish is using the Lagoon at any one time, the standard length of the four most numerous fish was broken into 10 mm size classes and graphed.

Representatives of the different species of fishes were compared to Miller and Lea (1972) for their proper identification.

The volumes of water fished were calculated from the measurements of: 1) channel depth, 2) channel width, and 3) the width of the net.

Gear efficiency was measured by blocking off a section of the Lagoon with blocking nets. The blocked-off section was made to resemble the typical fishing conditions of our study areas. The blocking nets were set far enough apart (10 meters) to allow for escape around the sides of the nets, again modeling typical conditions. The area between the nets was then fished. One seine haul was made and the number and S.L. of the fish were recorded. The blocked-off area was then fished several more times until the number of fish caught approached 0. The blocking nets were then drawn together and brought up on shore, capturing the rest of the fish. A comparison between the first net haul catch and the total number of fish caught could then be performed.

The calculations for Shannon-Weiner and Simpson diversity indices, Simpson dominance, and community similarity were performed by software by J. Eckblad (1984).

7.5 RESULTS

Gear efficiency for the seine haul method was determined to be 17.27%. Volume of water fished (cubic meters) has been calculated and graphed in figure 7.2.

Mean monthly temperatures (Celsius) were calculated and graphed in figure 7.3.

Mean monthly salinities (parts/thousand) were calculated and graphed in figure 7.4.

Table 7.1 A species list of the fish caught and their relative abundance over the entire Lagoon during the one-year period is as follows:

SPECIES	NUMBER
California killifish (Fundulus parvipinnis)	5864
Topsmelt (Atherinops affinis)	2271
Arrow goby (Clevelandia ios)	1034
Staghorn sculpin (Leptocottus armatus)	370
Opaleye (Girella nigricans)	44
Striped mullet (Mugil cephalus)	25
Long-jaw mudsucker (Gillichthys mirabilis)	17
Mosquito fish (Gambusia affinis)	16
Spotted turbot (Pleuronichthys ritteri)	2
California halibut (Paralichthys californicus)	2
Northern anchovy (Engraulis mordax)	1
Crevice kelpfish (Gibbonsia monterivensis)	1
Serranid juv. (Paralabrax sp.)	1
TOTAL	9648

Table 7.2 Percent of total catch of all species found in the Lagoon during the one-year sampling period.

SPECIES	% CATCH
California killifish (Fundulus parvipinnis)	60.78
Topsmelt (Atherinops affinis)	23.54
Arrow goby (Clevelandia ios)	10.72
Staghorn sculpin (Leptocottus armatus)	3.83
Opaleye (Girella nigricans)	.46
Striped mullet (Mugil cephalus)	.23
Long-jaw mudsucker (Gillichthys mirabilis)	.18
Mosquito fish (Gambusia affinis)	.17
Spotted turbot (Pleuronichthys ritteri)	.02
California halibut (Paralichthys californicus)	.02
Northern anchovy (Engraulis mordax)	.01
Crevice kelpfish (Gibbonsia monterivensis)	.01
Serranid juv. (Paralabrax sp.)	.01
TOTAL	99.98

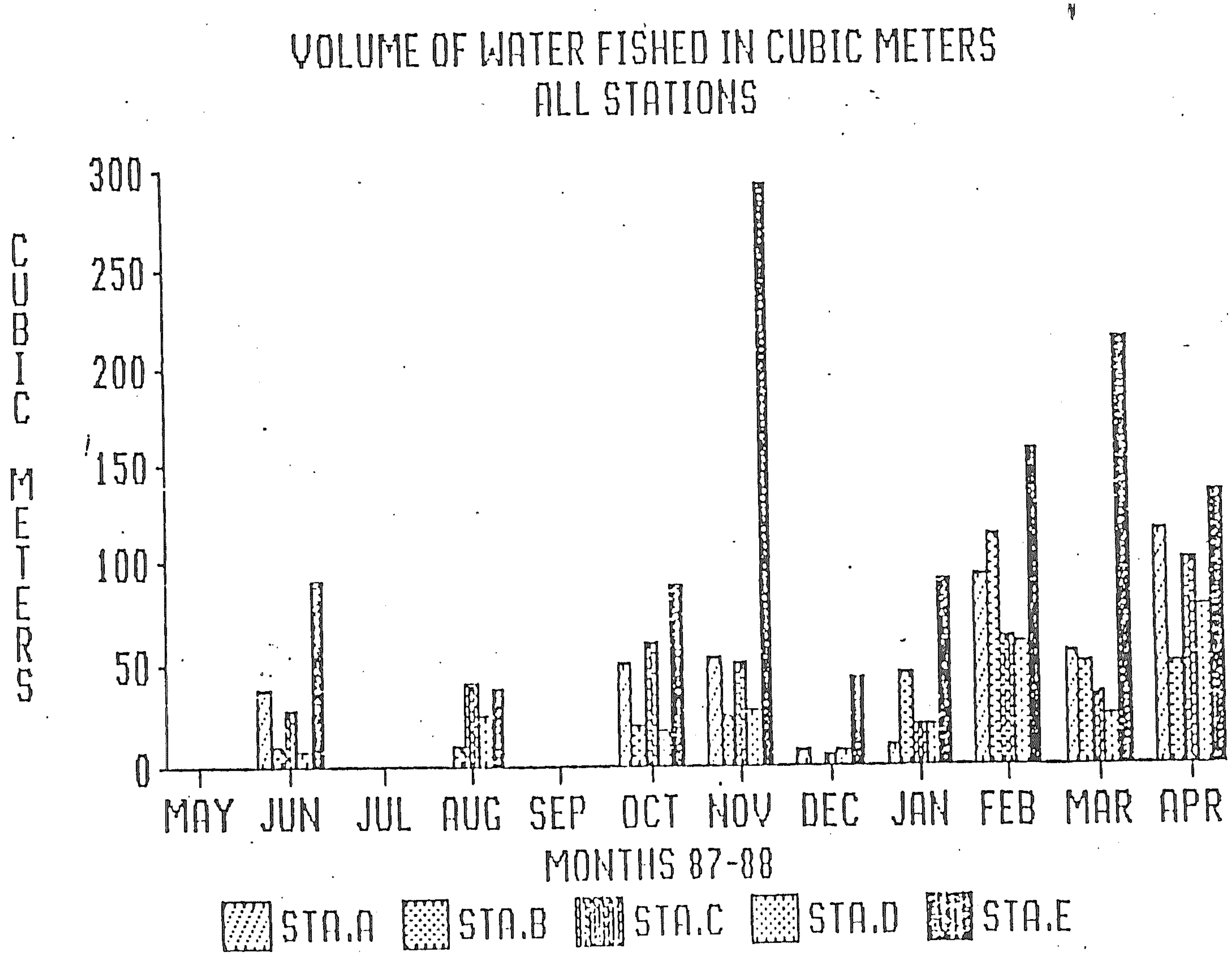


Figure 7.2 The volumes of water fished at each station per month, over the one year study period. (* Note missing data for the months of May, July, and September 1987).

Table 7.3 A species list and total numbers of each species per station. Ranked in order of most abundant.

SPECIES	STATION A	B	C	D	E
Fundulus parvipinnis	1541	1927	1515	300	581
Atherinops affinis	850	104	290	371	656
Clevelandia ios	63	148	382	341	100
Leptocottus armatus	73	0	15	38	90
Girella nigricans	10	11	11	10	2
Mugil cephalus	4	0	10	11	0
Gillichthys mirabilis	1	1	15	0	0
Gambusia affinis	8	2	6	0	0
Pleuronichthys ritteri	0	0	0	0	2
Paralichthys californicus	0	1	0	0	1
Engraulis mordax	0	0	1	0	0
Gibbonsia monterivensis	0	0	0	0	1
Paralabrax sp.	0	0	0	1	0
	2550	2194	2399	1072	1433

Table 7.4 The percentage of the total catch per station

STATION	# Individuals	% CATCH
A	2550	26.43 %
B	2194	22.74 %
C	2399	24.87 %
D	1072	11.11 %
E	1433	14.85 %
TOTAL	9648	100.00 %

Table 7.5 Percent (%) similarity of the various stations in regards to the fish fauna over the year. This is a measure of how similar the various stations are with one another.

STATIONS	B	C	D	E
A	68%	78%	67%	79%
B	*	75%	40%	52%
C	*	*	60%	66%
D	*	*	*	73%

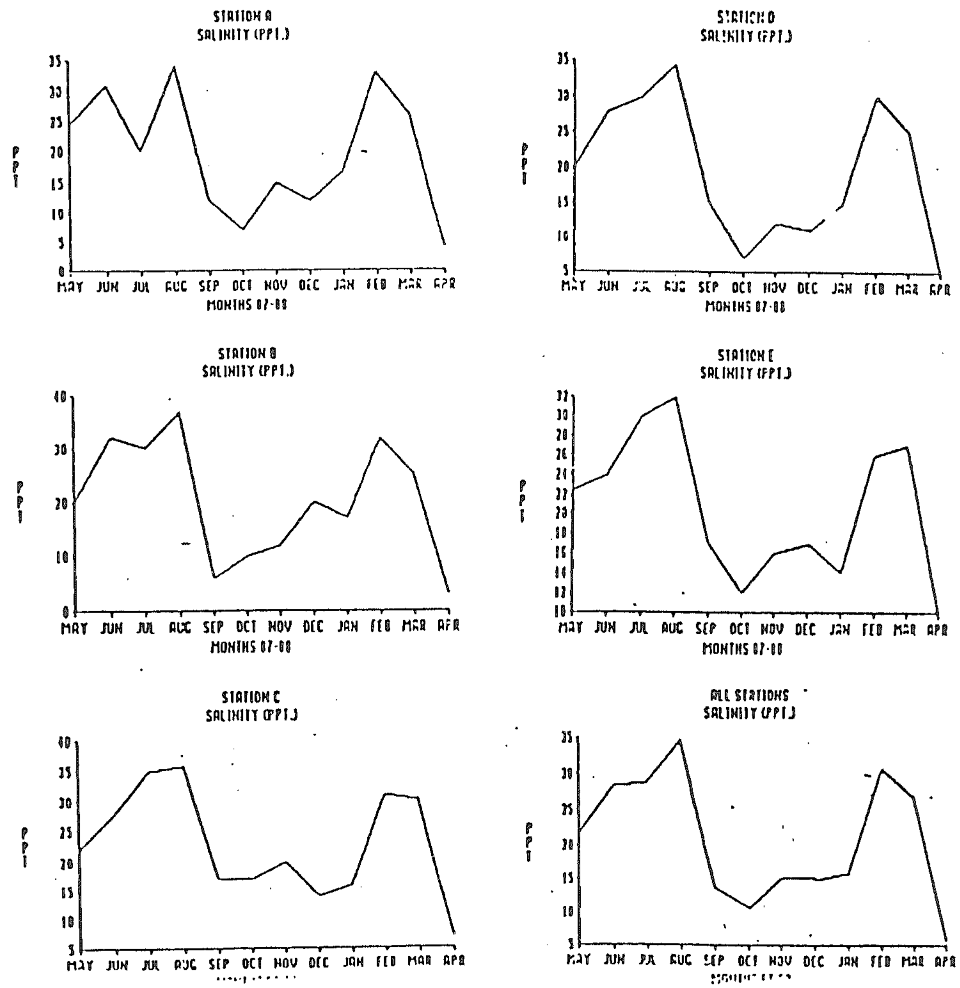


Figure 7.4 Water salinity measurements (ppt) at each station by month and mean salinity profile, of the lagoon, for all stations, over the one year study period.

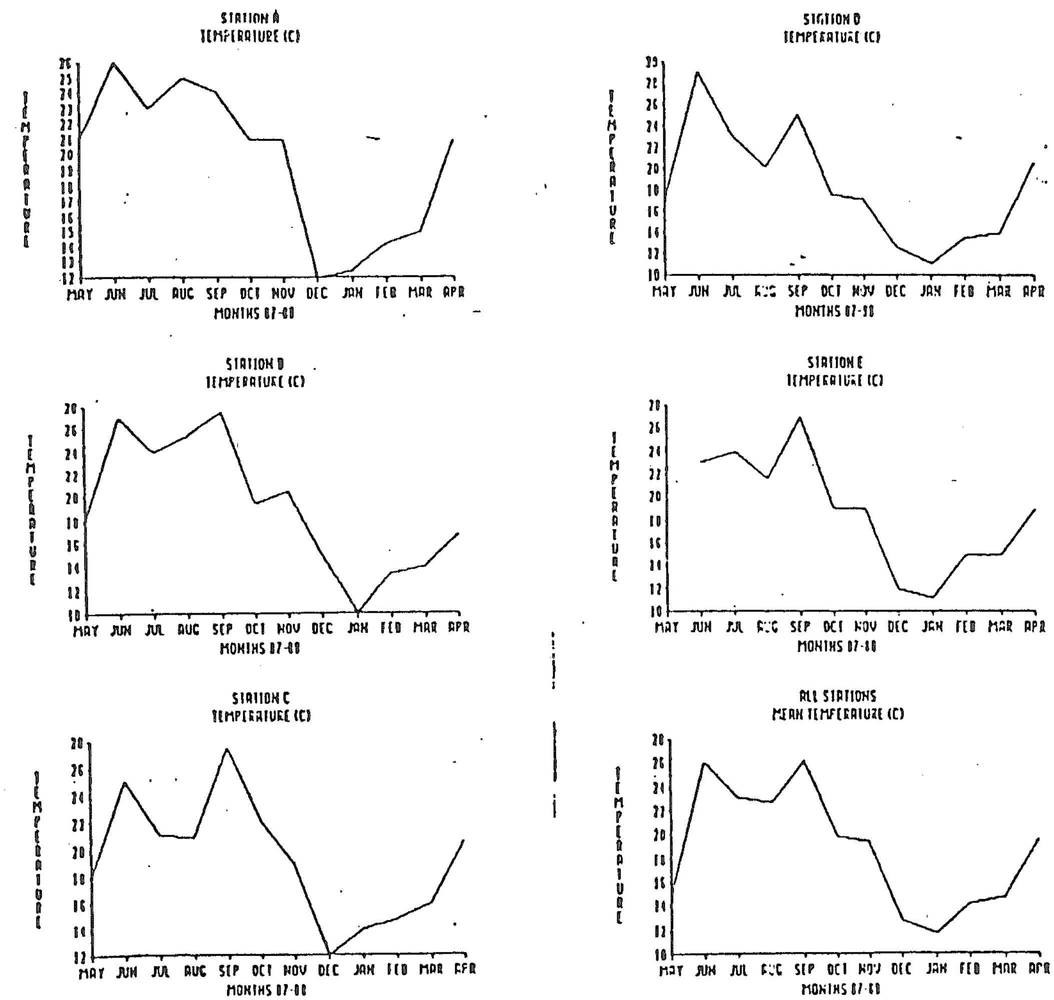


Figure 7.3 Water temperature (C) at each station by month and mean temperature profile, of the lagoon, for all stations, over the one year study period.

Figure 7.5 Mean Shannon-Weiner diversity values (logs to the base 2) per month over the one year study period.

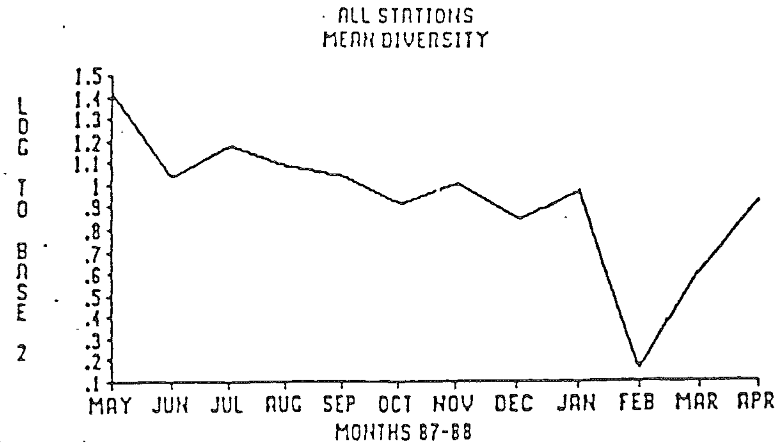


Figure 7.6 Shannon-Weiner diversity values (logs to the base 2) by station per month for the one year study period.

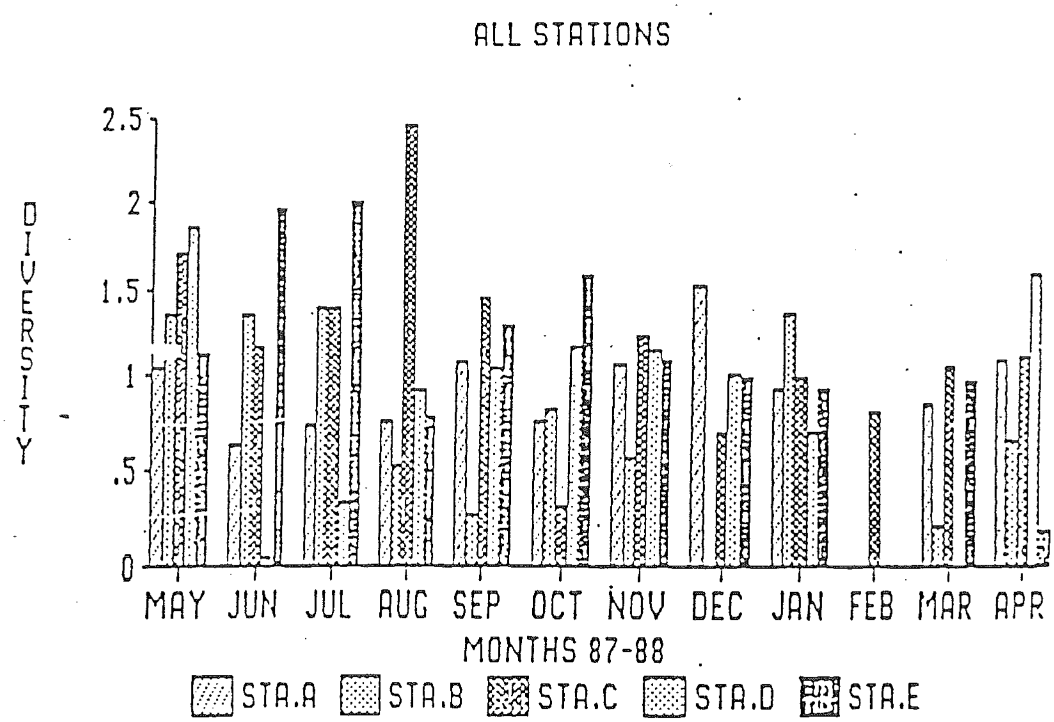


Table 7.6 A measure of diversity and dominance of the the total catch of all stations over the one-year period (Simpson and Shannon indices, *logs to base 2).

STATION	SIMPSON DIVERSITY	SIMPSON DOMINANCE	SHANNON DIVERSITY
A	.522	.478	1.322*
B	.221	.779	.692*
C	.556	.444	1.619*
D	.699	.301	1.880*
E	.617	.383	1.604*

Mean monthly Shannon-Weiner diversity values for all stations over the one-year period were calculated and graphed in figure 7.5. It should be noted that the high of 1.416 was in May and the low of .1582 was in February.

Shannon-Weiner diversity values for each station are graphed over a one-year period in figure 7.6. The number of species (S) has been graphed for each station over the one-year period in figure 7.7.

The monthly Shannon-Weiner diversity values for each station over a one-year period were calculated and graphed in figure 7.8.

The total of all fishes caught per month is graphed in figure 7.9. The mean monthly abundance of the four most numerous species has been graphed in figure 7.10.

Standard lengths of the four most abundant fishes were sorted into 10mm size classes and graphed. Figure 7.11 California killifish (*Fundulus parvipinnis*), figure 7.12 Topsmelt (*Atherinops affinis*), figure 7.13 Arrow goby (*Clevelandia ios*), figure 7.14 Pacific staghorn sculpin (*Leptocottus armatus*).

7.6 OBSERVATIONS

The surface areas of both the Malibu Lagoon State Beach and its waters have been measured to be 14.7 hectares (36.1 acres) and 5.2 hectares (13 acres) respectively. Malibu Lagoon is a very small coastal wetland that supports a fish population that is characterized by low diversity and fairly low productivity, which is typical for a lagoon of this size. The Lagoon is subject to sedimentation. It does not have any established *Zostera sp.* as do many other bay and estuarine systems in California (Onuf 1987). Due to the lack of plants and the effects of sedimentation, the Lagoon does not have much spatial heterogeneity, which may allow for more diversity.

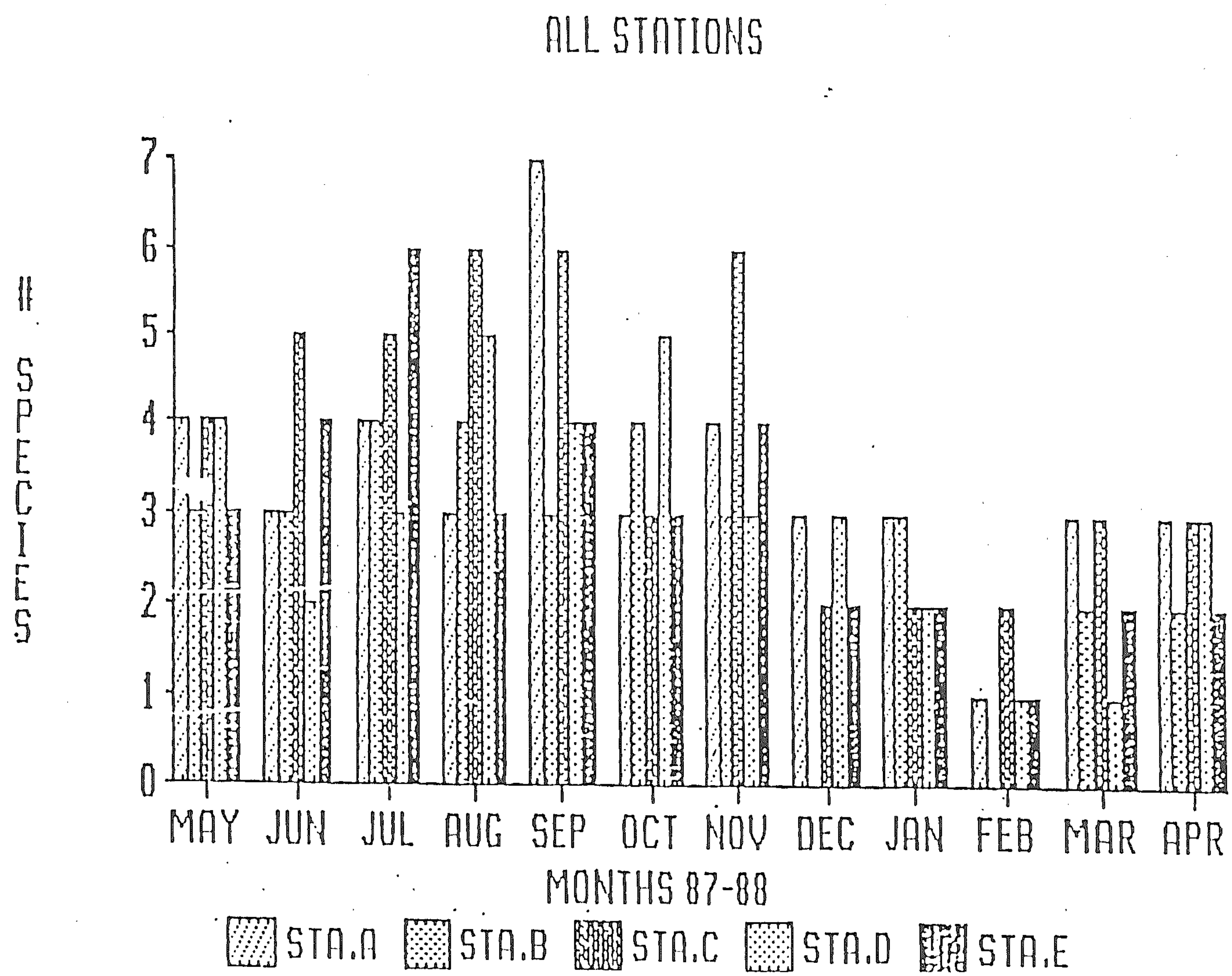


Figure 7.7 Number of species (S) present at Station per month, over the one year study period.

Figure 7.8 Shannon-Weiner diversity values (logs to the base 2) per month, and by station, over the one year study period.

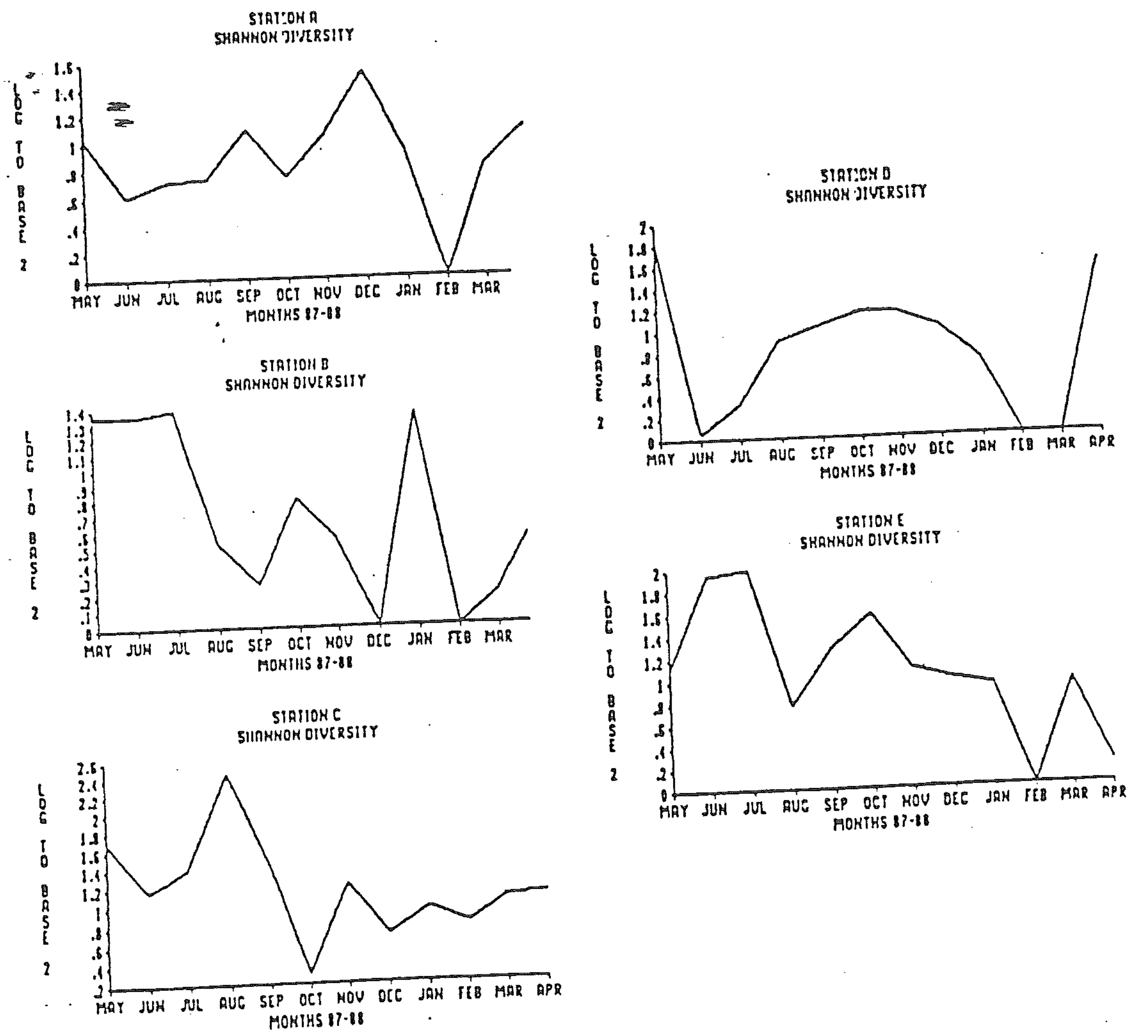


Figure 7.9 Total numbers of fish caught, per month, at all stations throughout the one year study period.

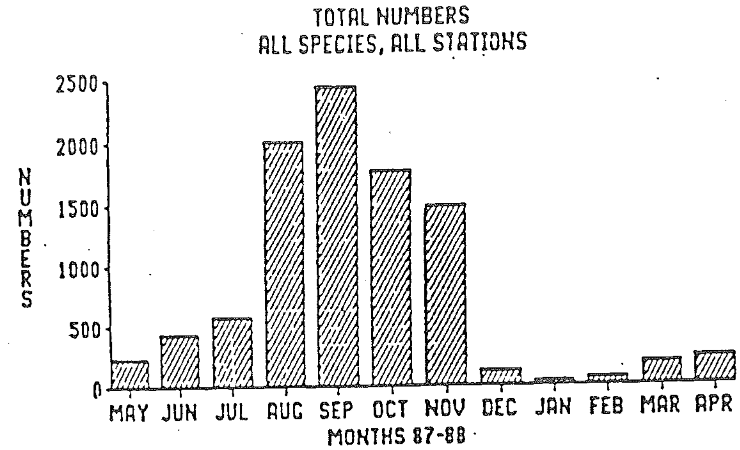
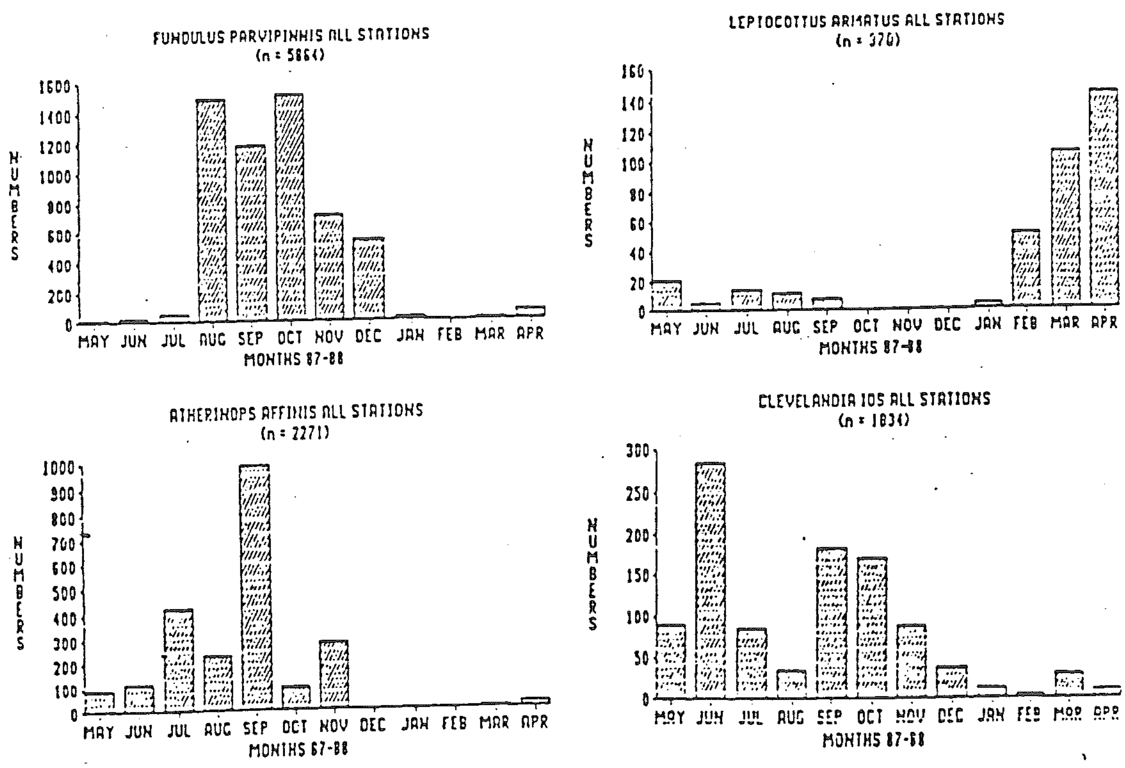


Figure 7.10 Relative abundances per month of the four most numerous species over the one year study period.



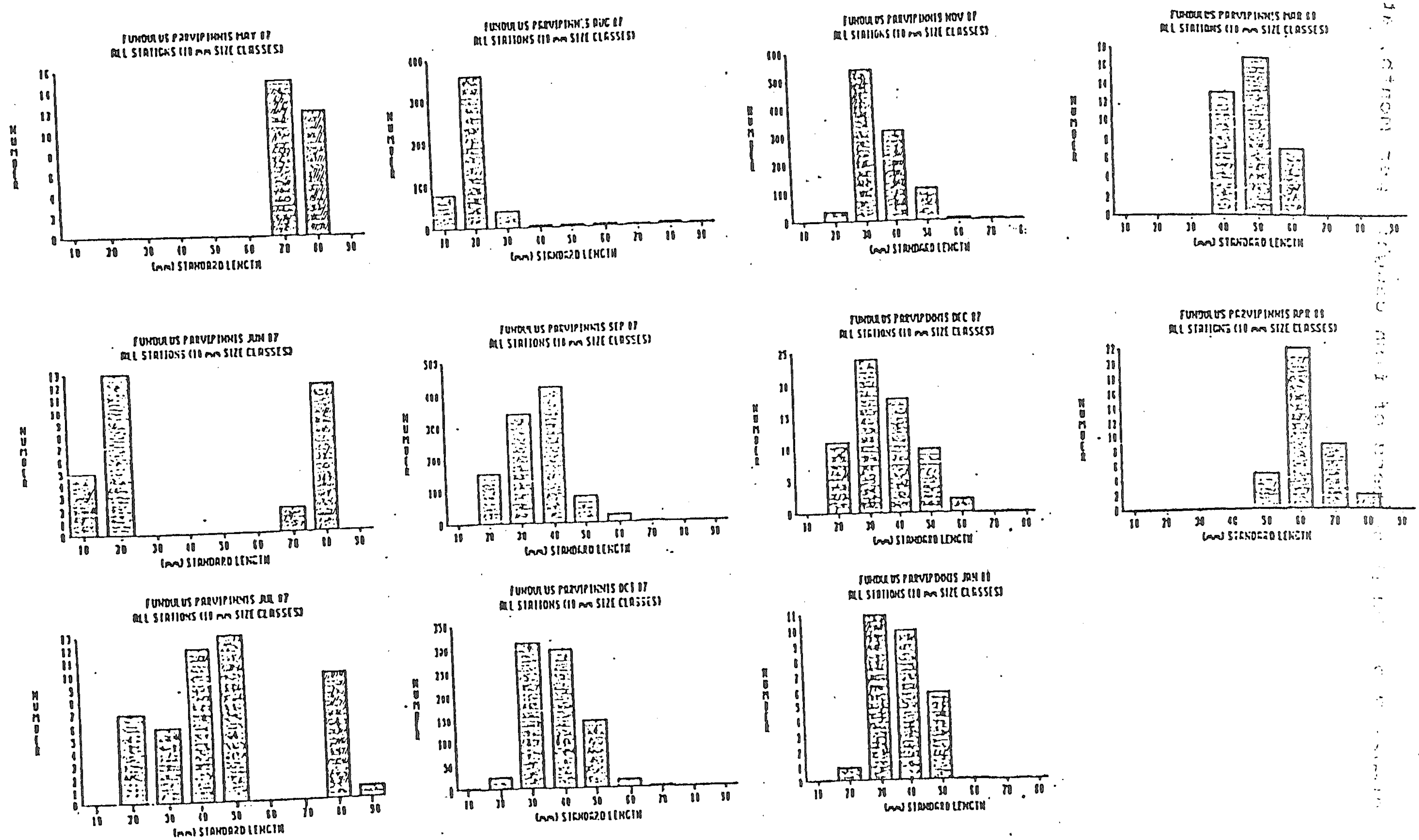


Figure 7.11 Standard length, in 10 mm groupings, of California killifish (Fundulus parvipinnis) found at all stations, per month, in the lagoon over the one year study period.

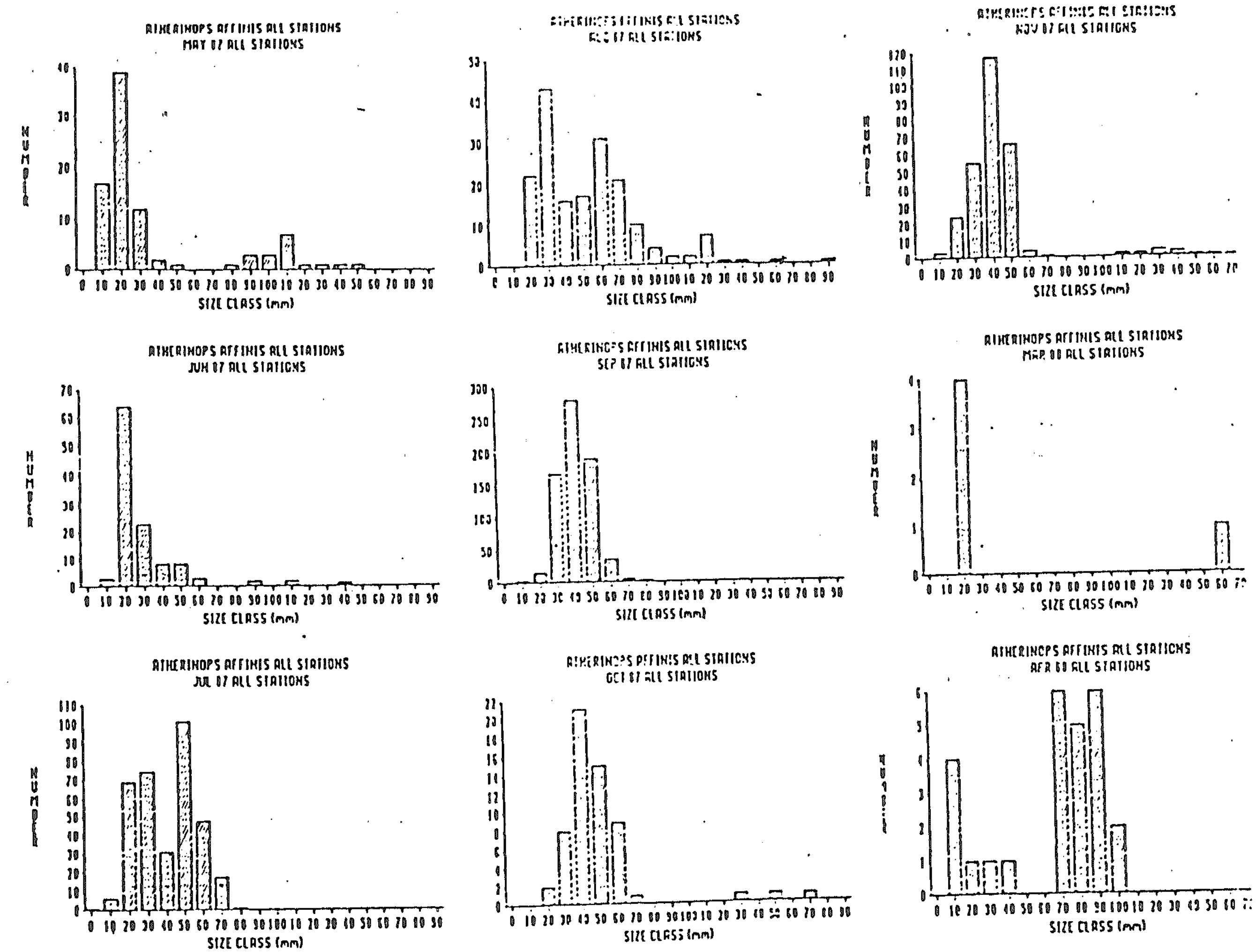


Figure 7.12 Standard length, in 10 mm groupings, of topsmelt (Atherinops affinis) found at all stations, per month, in the lagoon over the one year study period.

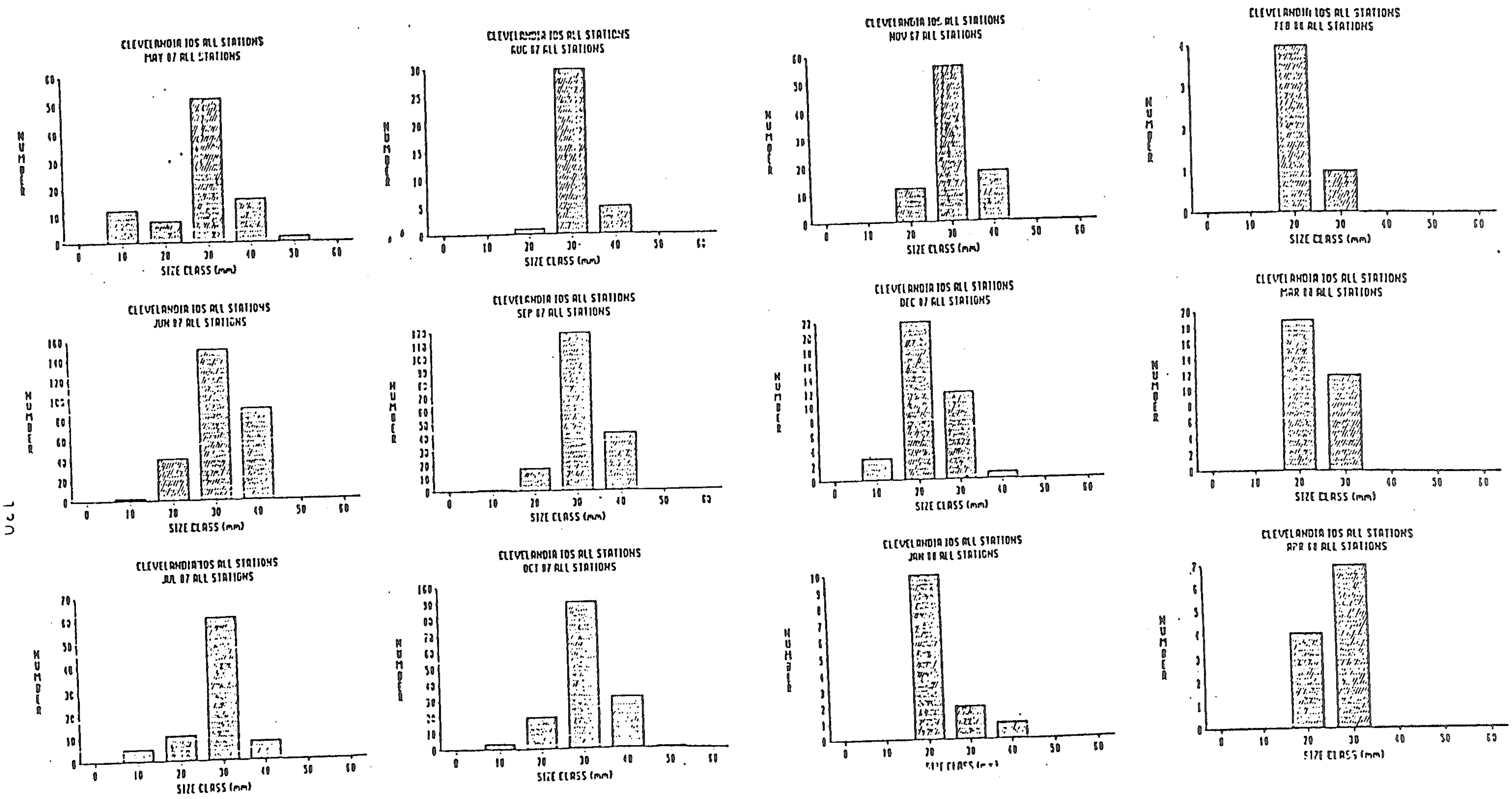


Figure 7.13 Standard length, in 10 mm groupings, of arrow goby (Clevelandia ios) found at all stations, per month, in the lagoon over the one year study period.

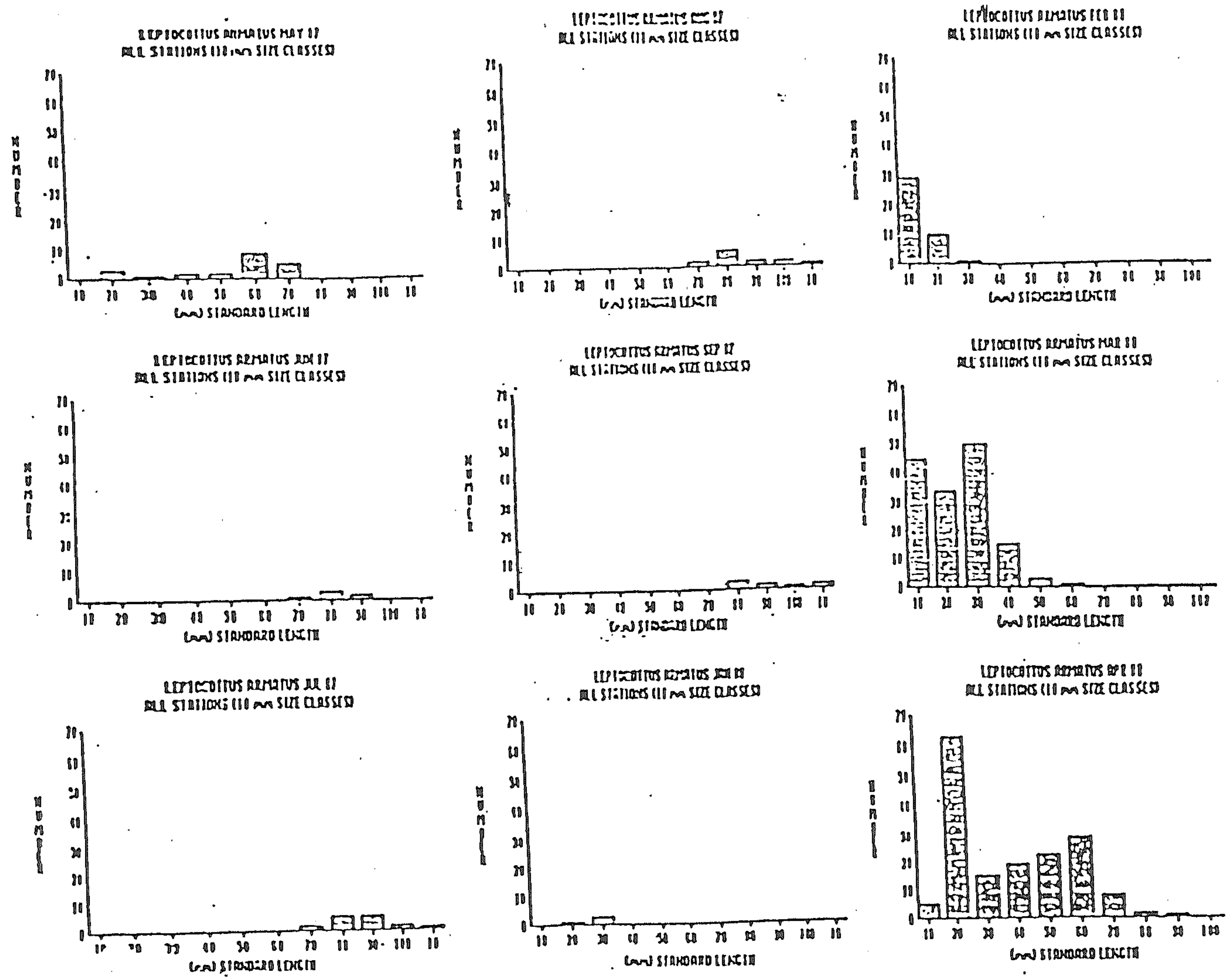


Figure 7.14 Standard length, in 10 mm groupings, of Pacific staghorn sculpin (Leptocottus armatus) found at all stations, per month, in the lagoon over the one year study period.

In terms of the sampling gear employed for this study, it has long been recognized that obtaining good samples of the fish populations requires much effort and expense (Haedrich and Hall 1976). In the present study a haul seine was used because it was inexpensive and fairly efficient (17.27%). Haul seines have been employed in many areas where, due to the nature of the waters being sampled, it was the best alternative (Calliet, et. al. 1986). The areas that were sampled were generally shallow - 1 meter. It would have been very difficult to use casting nets, otter trawls, or drop nets in the channel arms of the Lagoon. The use of a bag seine may have given us a better estimate of the fish communities in the Lagoon.

The haul seine, by itself, cannot effectively sample all the different fish species of Malibu Lagoon. Fast swimming fish, such as adult striped mullet and topsmelt, may be able to escape this net and therefore are not consistently surveyed. Blocking nets were used to gauge the fishing efficiency of the haul seine, but they are very labor intensive and time consuming to use. For these reasons, the blocking nets could not be used in the monthly samplings, and thus, the size and structure of the fish populations may not have been as effectively sampled as by other means.

The volumes of water fished, figure 7.2, were quite variable, both month to month, and station to station. This is an important factor to keep in mind as the data from these stations is reviewed. The causes of the variations in water volume are a combination of several factors, such as tidal height and the degree of Lagoon mouth closure. Station E, located on the main Lagoon body, consistently had the most volume of water fished.

A total of thirteen species of fish were collected from the five stations of the Lagoon (see table 7.1.). (Ed. note: A 14th species, a bay pipefish (<u>Syngathus sp.</u>) was collected during a September 1988 survey). A previous study performed on Malibu Lagoon, Fitzgerald and Hasz (1982), revealed eleven species of fish over a two-year period. A species list assembled by Swift (1982) shows that, from historical accounts and more recent studies, there is a total of twenty-five species recorded for the Lagoon. This study can add several fishes to this listing. They are the: California halibut (<u>Paralichthys californicus</u>), spotted turbot (<u>Pleuronichthys ritteri</u>), crevice kelpfish (<u>Gibbonsia montereyensis</u>), and a juvenile serranid (<u>Paralabrax sp.</u>).

A similar study was done on Los Penasquitos Lagoon (Nordby and Covin 1988), another small estuarine saltmarsh, where they found eleven species of fish during their one-year survey. The Malibu Lagoon species list is quite different in that fourteen species of fish were found in Malibu Lagoon. The two lagoon systems are different from one another. Los Penasquitos Lagoon has been measured to have 13 hectares (33 acres) of channel habitat which is about 2.5 times that of Malibu Lagoon, which has 5.2 hectares (13 acres) of similar habitat. Los Penasquitos Lagoon is also located in a more southern region of California than is Malibu Lagoon.

When comparing the total number of fishes present in the Lagoon (figure 7.9) throughout the year, it can be seen that there are more individuals present during the months of August through November. This has been recognized as a general pattern in the studies of temperate estuarine fish populations (Allen 1982). This is partially due to the young of the year (YOY) of California killifish, topsmelt, and arrow goby being present at this time. These months are very important to the survival of these species in the Lagoon system. It is during this time that the Lagoon waters are generally warmer (figure 7.3), and there is an abundance of food available to the YOY of these species.

Four species of fish accounted for 98.87% of the total catch (see table 7.2). THe most numerous species found in the Lagoon was the California killifish (figure 7.10). It accounted for 60.78% of the total catch. It is the large amount of YOY killifish found in the months of August through November (figure 7.11) that account for this percentage. This species was found in the Lagoon in all samples except February's. It appears that the California killifish are year-round residents of the Lagoon, and that during the winter and early spring the population consists of mainly adults. The California killifish has been considered to be a resident of other similar lagoon systems (Allen and Horn 1975).

Other year-round residents of the Lagoon appear to be the arrow goby and the staghorn sculpin. The most consistent of these being the arrow goby (figure 7.10), which was caught at some point on all sampling dates. The topsmelt was frequently found in the Lagoon, but was absent from all samples in the months of December, January, and February. This, in part, may be due to the schooling nature of these fishes, and the fact that our sampling method seemed to catch the juvenile topsmelt much more readily than the adults, with the fast-swimming adults (greater than 100 mm) escaping the net. The topsmelt is probably a year-round resident of the Malibu Lagoon system, when compared to other lagoon and estuarine systems (Allen and Horn 1975; Klingbeil, et. al. 1975), just not caught by our sampling methods.

Topsmelt were found the most abundant in the months of July, August, September, and November with the heaviest use in September (figure 7.10). Arrow goby were found in the largest numbers in the months of June, September, and October (figure 7.10).

The staghorn sculpin (figure 7.10) has a different pattern of temporal use. It is present in the Lagoon from January to September. No staghorn sculpins were found in the Lagoon in the months of October, November, and December. It is found in the most abundant numbers in the months of February, March, and April. This is when the YOY sculpin are present (figure 7.14). This pattern is in agreement with that found by Tasto (1975). Tasto (1975) also found that staghorn sculpin eat the juvenile arrow goby, which is abundant during these months.

There were no staghorn sculpins caught at station B throughout the year-long survey, although it was caught at all other stations. The fact that station B was drained during periods of low tide, and that staghorns have been observed to exhibit little movement (Tasto 1975) suggest that the YOY staghorns would not settle at this station and would not move into the station as adults at a later date.

Patterns of Lagoon use by the YOY of the four most abundant species can be seen in the following figures: California killifish (7.11), topsmelt (7.12), arrow goby (7.13), and Pacific staghorn sculpin (7.14). These figures, consisting of standard length data broken into 10 mm size classes, can be used to follow the growth of the YOY fishes from month to month in the Lagoon system. The 10 mm size class grouping did not resolve any distinct patterns in arrow gobies because of their small size. It should be noted that adult-sized topsmelt and staghorn sculpin were not taken in the Lagoon. The adult topsmelt has been taken in Anaheim Bay (Klingbeil et. al. 1975). The adult staghorn sculpin may move out of the Lagoon to spawn offshore (Tasto 1975).

Simpson and Shannon-Weiner diversity indices have been included in this report, although it seems that indices of this type should be de-emphasized (Green 1979). Green (1979) now feels that a simple index like S (the number of species) are biologically more meaningful as indicators of change in the environment. Future studies may be better able to use a measure of S, as opposed to the calculated diversity indices, in order to see changes in fish populations. It is for this reason that S has been presented in figure 7.7.

Station B (figure 7.6) has the least diversity of all stations. It also had the highest measure of dominance, that is, where one organism is found in much greater numbers. Station B is interesting in that the fishes found here could not be residents of this station. This is due to the fact the station B would be drained of standing water at low tide. The fishes caught here must move in and out of this station with the incoming or outgoing tides. This type of movement has been observed in the California killifish found at this station, which turns out to be over 87% of the total catch at this station.

It can be seen in figure 7.5 that the mean monthly values of the Shannon-Weiner diversity index is highest (1.416) in May 1987 and lowest (.158) in February 1988. The pattern of high and low diversity found here is somewhat different from that found in Colorado Lagoon by Allen and Horn (1975). They obtained their highest values (1.11) in April and June and their lowest value (0.03) in September.

The Shannon-Weiner diversity index value calculated for Malibu Lagoon was 1.423. When this is compared to the annual Shannon-Weiner diversity index values calculated for various estuarine areas (Moore 1978), six values above and six values below the calculated diversity index for Malibu Lagoon are found. It can be concluded that the calculated mean diversity value is similar to other estuarine areas.

All of the stations that were sampled are in effect little microhabitats in the Lagoon system. The physical proximity of these stations to each other and to the main body of the Lagoon may determine what fish communities are found there. The fish communities of each station were compared and contrasted in order to see if there may be a microhabitat difference. Table 7.5 shows that the most dissimilar stations from each other are B&D, B&E. This is probably due to the close proximity of stations D and E to the Lagoon mouth. Station B is the farthest of all stations (see figure 7.1) from the Lagoon mouth and the potential influx of ocean water. Station B is also the most variable station with respect to water height and volume.

7.7 DISCUSSION

There are many ecological reasons to promote the preservation and wise management of these small estuarine saltmarsh habitats (Horn 1980). Malibu Lagoon does serve as a breeding and nursery ground for various coastal fishes. The California killifish and the arrow goby, although not important commercial fishes, may provide forage for economically more important higher-level consumers in the ecosystem.

It is now quite important that threats to the normal functioning of Malibu Lagoon be taken into account. One of the major problems facing the Lagoon will be the influx of treated or untreated water. There have been major housing developments placed at the headwaters of the Malibu Creek drainage system. These contribute influxes of waste water from washing cars, watering lawns, etc., into the Creek system that could possibly influence the Lagoon.

The proposed expansion of the Tapia Water Reclamation Facility will increase the influx of treated effluent into Malibu Creek. This will be an increase to approximately 15 million gallons per day (MGD), up from the current 8-10

MGD. In combination with a proposed satellite plant, the total discharge of treated effluent may rise to 25 MGD.

There will be ecological problems associated with the release of this treated water into the Lagoon. Historically the Lagoon has had little or no freshwater influx during the summer and fall months. This, along with the natural closing of the Lagoon mouth, would cause very brackish conditions in the Lagoon. Now, with the constant release of treated water into the Lagoon, the Lagoon will experience reduced salinities and increased nutrient concentrations (Zedler 1986). This will have an effect on the fishes found in the Lagoon system. If the water is released on a very even schedule, bringing with it lowered salinities and increasing nutrient concentrations, it may predispose the Lagoon system to favor one species over another, thereby adversely affecting the normal patterns of selection in this system.

There should be some emphasis placed on releasing the water in such a manner as to reflect natural seasonal streamflow patterns of freshwater influx into the Lagoon system. As Zedler (1984) suggests, a system of impounding the treated effluent and the release of it with the outgoing tide may help in minimizing the effects of this freshwater influx. The release of the treated water may also be staggered so that the Lagoon may return to semi-natural conditions between discharges.

If this water is to be stored in percolation/retention ponds or a similar structure, an effort should be made to monitor the physical/chemical characteristics of this water mass prior to its release. The water mass may develop physically/chemically distinct qualities that again may influence the natural system of the Lagoon with respect to the flora and fauna. This influence may affect the recruitment patterns of coastal fishes that may use the Lagoon as a nursery ground (Boehlert and Mundy 1988). Percolation/retention ponds may exert a significant influence upon the rejuvenation of the steelhead fishery in this watershed.

The editors note that surveys for steelhead trout (Oncorhynchus mykiss) during the expected migration period and the tidewater goby (Eucyclogobius newberryi), two species historic to Malibu Lagoon, were unsuccessful. On Feb. 14, 1988, a single adult female steelhead trout was recorded in Malibu Creek (California Trout, Inc., Izaak Walton League of America records, 1988).

The anadromous steelhead trout (Oncorhynchus mykiss) is an example of a fish whose historic numbers in Malibu Creek and Lagoon have dramatically decreased over time to extremely low levels. Malibu Creek is presently the southernmost range extension of this highly regarded fish species, which enters Malibu Lagoon to spawn in Malibu Creek.

The Rindge Dam has been a substantial geographic barrier to migration of steelhead since the 1920s. The creek segment upstream from the dam is believed to be the optimum spawning habitat for steelhead along Malibu Creek (Tippets 1988 pers. comm.).

Malibu Lagoon is a critical habitat component in the life cycle of local steelhead trout. (pers. comm. Camm Swift 1989) Opening the Lagoon entrance artificially, as is currently done, will likely have a continual destructive impact upon the steelhead fishery in Malibu Creek. A coastal lagoon may hold the entire year's crop of juvenile steelhead, and sudden non-natural exposure to the sea may fatally affect them all (Clark 1988). Management must continually adjust to the myriad of variables which themselves are in a state of flux.

The subject of steelhead management is beyond the scope and intent of the present study, yet it is of great interest and importance and merits further research.

7.8 SUMMARY

Thirteen species of fish were caught in Malibu Lagoon over a one-year sampling period. The California killifish (Fundulus parvipinnis) made up 68.78% of the total catch. The top four species of fish accounted for 98.87% of the total catch. Patterns of Lagoon use by young-of-year fishes were established and can by considered typical of a west coast temperate estuary. Calculated diversity indices show that the Lagoon is not a very diverse system, which is typical of estuarine saltmarshes. Malibu Lagoon appears to be a functioning estuary, even though it is relatively small in size.

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8.0 BIRDS OF MALIBU LAGOON

8.1 INTRODUCTION

Malibu Lagoon contains a high diversity of bird species and relatively high numbers of birds for its small size (Kiff and Nakamura 1979). Most of the birds appear in the Lagoon between October and March, with minimum numbers occuring between May and August (Figure 8.1), coinciding with migration times along the Pacific Flyway.

The Lagoon is used by both landbirds and waterbirds as resting, bathing, feeding, mating and nesting habitat. Although some species observed at the Lagoon use it for all of these purposes, most species do not. Some species such as the snowy plover (Charadrius alexandrinus) and bald eagle (Haliaeetus leucocephalus) formerly nested in and around Malibu Lagoon, but no longer do so because of habitat destruction and increased human activity (Kiff and Nakamura 1979).

8.2 OBJECTIVES

The goal of this survey is to gather accurate baseline data on seasonal population trends, habitat use, current local status of rare and endangered species, and to compile an overall list of bird species utilizing Malibu Lagoon. Birds are important indicators of environmental problems within an ecosystem, for example, thinning of pelican eggshells caused by DDT (Anderson and Gress 1983). Therefore, baseline information becomes a valuable tool in documenting and comparing future change in environmental conditions within this estuarine system, and will yield important data, enhancing the long-term management potential of Malibu Lagoon.

8.3 MATERIALS AND METHODS

The birds of Malibu Lagoon were observed and counted for a total of 51 surveys, averaging 1.5 hours per survey from April 1987 to March 1988. Counts were made using a 20X spotting scope and 7X35 binoculars from several locations (Map 8.A) around the inlets of the Lagoon (1,2,3) and three locations around the main Lagoon (4,6,7). The beach and the ocean were surveyed from two locations, one (4) near the Lagoon and one on the beach (5). The upper Lagoon, bounded North by the storm drain from Malibu Civic Center and South by the Pacific Coast Highway Bridge, was surveyed from several locations (8,9,10,11). This was necessary because of tall thick vegetation along the edges of the upper Lagoon.

Map 8.A. Aerial Photograph of Malibu Lagoon. 1986. Entrance closed. Locations of bird observation stations. Inlets (1,2,3), Main Lagoon (4,6,7), Beach and Ocean (4,5), and Upper Lagoon (8,9,10 11). Location of Adamson Property (A).

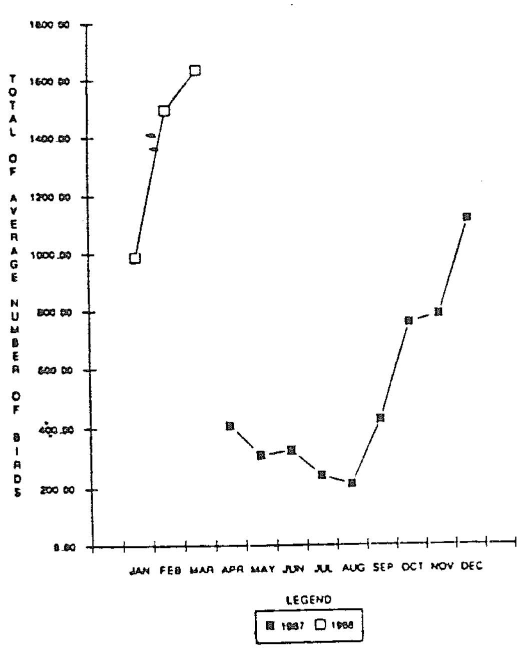


Figure 8.1. Monthly Averages for All Species of Waterbirds at 11 Census Sites. April 1987 - March 1988.

In the main Lagoon, the survey was conducted by counting the individuals of one species before moving on to the next species. This was necessary because of interference from humans and dogs disturbing the birds. The inlets of the Lagoon were easier to survey because fewer birds utilized them. Several species could be counted at one time because of the low numbers there.

The beach and ocean survey was conducted in the same manner as the main Lagoon survey. This was complicated by heavy usage of the beach by people and dogs. Most of the birds congregated on or around the floating rafts in the ocean. The survey of the upper Lagoon was done by continually moving upstream from site to site and counting the birds. Most surveys were conducted by two individuals and independent identification was performed as a measure of accuracy. This insured that any misidentification could be corrected before species were recorded. Several birds that appeared rarely were confirmed on The Audubon Society recorded tape for that time period.

When counting birds, several problems can potentially bias the totals and identification of birds. Disturbances which cause the birds to take flight and then re-settle, make it extremely difficult to get an accurate count, especially when numbers encountered for a species may exceed 300. To avoid a serious miscount, when a mass movement to a new area occurred, those species whose counts had not been completed were recounted. Otherwise only the areas not previously counted were surveyed.

Species identification was sometimes complicated because of distance from the observation points, especially with small shorebirds. This problem was overcome by counting after moving to a better vantage point where the birds could be properly identified.

Habitat usage and sightings of bird species were further confirmed using data collected by students involved in marine science school programs. These programs were conducted by the Topanga-Las Virgenes Resource Conservation District, with students being assisted by leaders trained in bird identification. Information was collected twice weekly during the school year (October to June) and once weekly during summer programs.

8.4 OBSERVATIONS

There were a total of 151 bird species sighted in Malibu Lagoon, 78 waterbird species and 73 landbird species, from April 1987 to March 1988. Numbers of birds dropped in the late spring and remained low through the summer. Numbers began climbing in late summer, continued climbing through winter and peaked in March, then dropped again in late spring (Figure 8.1).

8.4.1 SITE OBSERVATIONS

UPPER LAGOON

The upper Lagoon is primarily fresh water with rocky shores. Dumpsters behind the supermarket attract scavengers and human feeding of birds sustains a population of feral ducks. The rocky shoreline provides food for surface feeding shorebirds, while the channelized creek provides food for wading fishers (fish eating birds), surface divers, coots and dabbling ducks. It is also used for bathing and mating by dabbling ducks, and for bathing by a few gulls. It is here that most of the over-wintering ducks are observed.

MAIN LAGOON

A combination of sand and cobble rock shoreline and tidally exposed cobble rock in the main lagoon provides feeding habitat for every group of birds. Several species were observed mating within the Lagoon. The fresh water from Malibu Creek is used by plunge divers, gulls, surface divers and dabbling ducks for bathing and drinking. Shorelines and tidally exposed areas are used by most groups for roosting.

INLETS

Inlet substrates varied depending on location within the Lagoon. In areas close to the Lagoon and ocean, there is sand with some mud, while the substrate near the back of the inlets is muddy. At high tide or when the Lagoon entrance is closed, the inlets are used by the fishing birds, and occasionally by dabbling ducks. At low tide, when the lagoon entrance is open, mudflats are exposed and shorebirds, dabblers, and coots feed on the algae and invertebrates. Channelized sections of the inlets where amounts of sedimentation are relatively low are usually covered with water, providing fishing habitat for wading fishers even at low tide.

BEACH AND OCEAN

During the summer months (June-September) the beach is heavily used by people and very few birds other than scavengers are found at this time. Most birds are found on two man-made wooden rafts anchored approximately 200 yards offshore and on the Eastern edge of the lagoon by the Adamson house, where human activity is low. During the winter months when human use of the beach is lower, surface-feeding and probing shorebirds, gulls, and wading fishers use the area for roosting and feeding. The plunge divers also use the beach for roosting. Offshore, plunge divers, surface divers and diving ducks occur throughout the year.

8.4.2 WATERBIRD POPULATIONS

Waterbird populations are divided into groups based on feeding strategy. The groups are:

Gulls	Dabbling Ducks and Geese	Surface Divers
Coots	Surface-feeding Shorebirds	Diving Ducks
Plunge Divers	Probing Shorebirds	Wading Fishers

Landbird populations are divided taxonomically:

Birds of Prey	Swifts and Swallows	Flycatchers
Waxwings	Thrushes and Mimic Thrushes	Warblers
Hummingbirds	Blackbirds and Orioles	Weavers
Woodpeckers	Pigeons and Doves	Wrens
Jays and Crows	Wrentits, Titmice and Bushtits	
Finches	Grosbeaks, Buntings and Sparrows	
Starlings	Pipits and Wagtails	

Some species of birds are "Blue listed" which refers to the National Audubon Society's listing of bird populations that have declined significantly in recent years. Species of Special Concern are those that have declined slightly but not significantly (Tate 1986). Note: Since 3-5 surveys were taken per month, totals were averaged for both numbers seen per month and area usage.

GULLS

Gulls were the most populous group of all with an average of 347 birds seen per survey . Within this group are five of the eleven most commonly occuring species in the Lagoon (Figure 8.2). Gull populations follow a seasonal pattern with low numbers during spring and summer, rising through fall and winter and peaking in March (Figure 8.3).

Gulls use the main Lagoon for roosting, feeding and bathing. They were often seen immediately below the Highway bridge washing in the fresh water from Malibu Creek. Gulls roosted and fed upon the rocky tidal island located in the main lagoon, on the beach and on the ocean. Heermann's Gulls (Larus heermanni) often attempted to steal food from Brown Pelicans (Pelecanus occidentalis). Gulls also scavenged from trash left by humans on the beach in the picnic area, and from dumpsters behind the supermarket near Malibu Creek (Map 8.1).

Of the gull species occuring at Malibu Lagoon, the Heermann's Gull and the California Gull (Larus californicus) are experiencing significant population threats. These

Figure 8.2. Waterbird species abundance and catagory ranking; overall species abundance ranked in decreasing order. Mean number of birds seen per census, averaged for all seasons for 11 census sites. Landbird occurance. April 1987 - March 1988.

Category	Rank in Abundance	Species	Number seen per census
1		GULLS	347.51
	1	California Gull (*Larus californicus*)	142.59
	2	Bonaparte's Gull (*Larus philadelphia*)	107.16
	4	Western Gull (*Larus occidentalis*)	69.41
	10	Ring-billed Gull (*Larus delawarensis*)	14.37
	11	Heermanns Gull (*Larus heermanni*)	13.88
	*	Mew Gull (*Larus canus*)	0.04
		Herring Gull (*Larus argentatus*)	0.02
		Franklin's Gull (*Larus pipixcan*)	0.02
		Thayer's Gull (*Larus thayeri*)	0.02
		Black-legged Kittiwake (*Rissa tridactyla*)	0.02
	***	Glaucous-winged Gull (*Larus glaucescens*)	
	***	Pomarine Jaeger (*Stercorarius pomarinus*)	
2		DABBLING DUCKS AND GEESE	94.33
	5	Mallard (*Anas platyrhynchos*)	69.02
	12	American Wigeon (*Anas americana*)	13.71
	15	Green-winged Teal (*Anas crecca*)	5.41
	17	Gadwall (*Anas strepera*)	5.10
	38	Cinnamon Teal (*Anas cyanoptera*)	0.65
	52.5	Canada Goose (*Branta canadensis ssp.*)	0.13
	52.5	Canada Goose (*Branta canadensis minima*)	0.13
	54	Northern Shoveler (*Anas clypeata*)	0.10
	*	Brant (*Branta bernicla*)	
9		DIVING DUCKS	1.59
	37	Bufflehead (*Bucephala albeola*)	0.71
	41	Ruddy Duck (*Oxyura jamacensis*)	0.49
	44	Surf Scoter (*Melanitta perspicillata*)	0.37
	*	Lesser Scaup (*Aythya affinis*)	0.02
3		COOTS	86.24
	3	Coot (*Fulica americana*)	
		SHOREBIRDS	
4		SURFACE-FEEDING SHOREBIRDS	77.59
	6	Sanderling (*Calidris alba*)	30.86
	8	Black-bellied Plover (*Pluvialis squatarola*)	15.00
	13	Snowy Plover (*Charadrius alexandrinus*)	11.59
	21	Killdeer (*Charadrius vociferus*)	4.31
	22	Ruddy Turnstone (*Arenaria interpres*)	3.86
	23	American Avocet (*Recurvirostra americana*)	3.76
	24.5	Western Sandpiper (*Calidris mauri*)	3.41
	28	Black Turnstone (*Arenaria melanocephala*)	2.25
	34	Least Sandpiper (*Calidris minutilla*)	1.18
	35	Spotted Sandpiper (*Actitis macularia*)	0.86
	40	Semipalmated Plover (*Charadrius semipalmatus*)	0.51
	*	Wilson's Phalarope (*Phalaropus tricolor*)	
	***	Baird's Sandpiper (*Calidris bairdii*)	

Figure 8.2. (cont).

Category	Rank in Abundance	Species	Number seen per census
6		PROBING SHOREBIRDS	19.05
	16	Dowitcher (*Limnodromus sp.*)	5.26
	18	Willet (*Catoptrophorus semipalmatius*)	5.06
	20	Marbled Godwit (*Limosa fedoa*)	4.94
	27	Whimbrel (*Numenius phaeopus*)	2.90
	39	Dunlin (*Calidris alpina*)	0.63
	49.5	Greater Yellowlegs (*Tringa melanoleuca*)	0.20
	*	Black-necked Stilt (*Himantopus mexicanus*)	0.04
		Long-billed Curlew (*Numenius americanus*)	0.02
	***	Common Snipe (*Gallinago gallinago*)	
8		WADING FISHERS	10.33
	19	Snowy Egret (*Egretta thula*)	5.04
	29	Green-backed Heron (*Butorides striatus*)	1.82
	31	Black-crowned Night-Heron (*Nycticorax nycticorax*)	1.47
	32	Great Blue Heron (*Ardea herodias*)	1.33
	42	Great Egret (*Casmerodius albus*)	0.47
	49.5	Cattle Egret (*Bubulus ibis*)	0.20
7		SURFACE DIVERS	16.86
	14	Double-crested Cormorant (*Phalacrocorax auritus*)	8.45
	24.5	Western Grebe (*Aechmophorus occidentalis*)	3.41
	26	Pied-billed Grebe (*Podilymbus podiceps*)	2.98
	30	Red-breasted Merganser (*Mergus serrator*)	1.59
	46	Common Merganser (*Mergus merganser*)	0.25
	*	Red-throated Loon (*Gavia stellata*)	0.08
		Common Loon (*Gavia immer*)	0.02
		Hooded Merganser (*Lophodytes cucullatus*)	0.02
		Pacific Loon (*Gavia pacifica*)	0.02
		Pelagic Cormorant (*Phalacrocorax pelagicus*)	0.02
	***	Horned Grebe (*Podiceps auritus*)	
	***	Eared Grebe (*Podiceps nigricollis*)	
	***	Clark's Grebe (*Aechmophorus clarkii*)	
	***	Brandt's Cormorant (*Phalacrocorax penicillatus*)	
5		PLUNGE DIVERS	36.95
	7	Forster's Tern (*Sterna forsteri*)	19.24
	9	Brown Pelican (*Pelecanus occidentalis*)	14.75
	33	Caspian Tern (*Sterna caspia*)	1.29
	36	Elegant Tern (*Sterna elegans*)	0.75
	43	Belted Kingfisher (*Ceryle alcyon*)	0.41
	45	Least Tern (*Sterna antillarum*)	0.33
	51	Royal Tern (*Sterna maxima*)	0.14
	*	Black Skimmer (*Rhynchops niger*)	0.04
	***	Common Tern (*Sterna hirundo*)	
10		RAILS	
		Sora (*Porzana carolina*)	0.02
		TOTAL WATERBIRD SPECIES: 78	
		LAND BIRDS	
		BIRDS OF PREY	
	**	Red-shouldered Hawk (*Buteo lineatus*)	
		Red-tailed Hawk (*Buteo jamaicensis*)	
		Osprey (*Pandion haliaetus*)	
		Northern Harier (*Circus cyaneus*)	
		American Kestrel (*Falco sparverius*)	
		Loggerhead Shrike (*Lanius ludovicianus*)	
		Turkey Vulture (*Cathartes aura*)	

Figure 8.2. (cont).

PIGEONS AND DOVES
Rock Dove (Columba livia)
Mourning Dove (Zenaida macroura)
*** Spotted Dove (Streptopelia chinensis)

SWIFTS AND SWALLOWS
White-throated Swift (Aeronautes saxatalis)
Cliff Swallow (Hirundo pyrrhonota)
Barn Swallow (Hirundo rustica)
Violet-green Swallow (Tachycineta thalassina)
*** Tree Swallow (Tachycineta bicolor)
*** Northern Rough-winged Swallow (Stelgidopteryx serripennis)

HUMMINGBIRDS
Anna's Hummingbird (Calypte anna)
*** Allen's Hummingbird (Selasphorus sasin)
*** Black-chinned Hummingbird (Archilochus alexandri)

WOODPECKERS
*** Nuttall's Woodpecker (Picoides nuttallii)
*** Downy Woodpecker (Picoides pubscens)

FLYCATCHERS
Black Phoebe (Sayornis nigricans)
Say's Phoebe (Sayornis saya)
*** Ash-throated Flycatcher (Myiarchus cinerascens)
*** Western Kingbird (Tyrannus verticalis)
*** Cassin's Kingbird (Tyrannus vociferans)
*** Western Flycatcher (Empidonax difficilis)

WAXWINGS
*** Cedar waxwing (Bombycilla cedrorum)
*** Phainopepla (Phainopepla nitens)

JAYS AND CROWS
Scrub Jay (Aphelocoma coerulescens)
American Crow (Corvus brachyrhyncos)
Common Raven (Corvus corax)

WRENTITS, TITMICE, AND BUSHTITS
*** Wrentit (Chamaea fasciata)
*** Plain Titmouse (Parus inornatus)
Bushtit (Psaltriparus minimus)

WRENS
Bewick's Wren (Thyromanes bewickii)
*** House Wren (Troglodytes aedon)
*** Marsh Wren (Cistothorus palustris)

THRUSHES AND MIMIC THRUSHES
Northern Mockingbird (Mimus polyglottos)
California Thrasher (Toxostoma redivivum)
*** Ruby-crowned Kinglet (Regulus calendula)
*** American Robin (Turdus migratorius)

PIPITS AND WAGTAILS
*** Water Pipit (Anthus spinoletta)

STARLINGS
European Starling (Sturnus vulgaris)

Figure 8.2. (cont).

WARBLERS
Yellow-rumped Warbler (Dendroica coronata)
Common Yellowthroat (Geothylpis trichas)
*** Orange-crowned Warbler (Vermivora celata)
*** Yellow Warbler (Dendroica petechia)
*** Wilson's Warbler (Wilsonia pusilla)
*** Yellow-breasted Chat (Icteria virens)

GROSBEAKS, BUNTINGS, AND SPARROWS
Brown Towhee (Pipilo fuscus)
Song Sparrow (Melospiza melodia)
White-crowned Sparrow (Zonotrichia leucophrys)
*** Black-headed Grosbeak (Pheucticus melanocephalus)
*** Lazuli Bunting (Passerina amoena)
*** Rufous-sided Towhee (Pipilo erythrophthalmus)
*** Savannah Sparrow (Passerculus sandwichensis)

BLACKBIRDS AND ORIOLES
Brewer's Blackbird (Euphagus cyanocephalus)
Red-winged Blackbird (Agelaius phoeniceus)
Tricolored Blackbird (Agelaius tricolor)
Yellow-headed Blackbird (Xanthocephalus xanthocephalus)
Rusty Blackbird (Euphagus carolinus)
Western Meadowlark (Sturnella neglecta)
Brown-headed Cowbird (Molothrus ater)
*** Northern Oriole (Icterus galbula)
*** Hooded Oriole (Icterus cucullatus)
*** Western Tanager (Piranga ludoviciana)

FINCHES
American Goldfinch (Carduelis tristis)
House Finch (Carpodacus mexicanus)
*** Purple Finch (Carpodacus purpureus)
*** Lesser Goldfinch (Carduelis psaltria)
*** Pine Siskin (Carduelis pinus)

WEAVERS
House Sparrow (Passer domesticus)

TOTAL LANDBIRD SPECIES: 73
TOTAL NUMBER OF SPECIES: 151

* Those species seen less than 0.10 per census not ranked.
** Landbirds not ranked
*** From Kimball Garrett, Personal Communication.
Natural History Museum of Los Angeles County
Section of Birds and Mammals

problems stem from the gulls having restricted breeding areas, as Raza Island in the Gulf of California holds 96 percent of the breeding population of Heermann's Gulls. Human impact on the island from fishermen, boaters and natural history tours has lead to lower productivity among the gulls. Presently several private organizations are providing funding for wardens on the island (Anderson and Keith 1980, Hand 1980, Croxall et al. 1984). The California Gull is on the California Fish and Game "Species of Special Concern" list due to threats to certain inland colonies such as Mono Lake (K. Garrett, Pers. comm. 1988). As water is diverted from Mono Lake, islands that the California Gulls nest on are becoming connected to the mainland and the colonies are being abandoned as predators invade them (Gaines 1987).

DABBLING DUCKS AND GEESE

Dabbling duck and goose numbers are fairly constant because of a large resident population of feral mallards (Anas platyrhynchos) (Figure 8.4). This was augmented by a transient population of wild mallards, as well as other species of ducks and geese to make them the group with the second highest numbers, averaging 95 birds per survey. The feral mallards were quite successful in nesting in 1987-1988, with at least 10 females raising young. There was evidently some mortality among the young mallards as one female started with thirteen young and ended up with only nine. This was the first of the clutches to hatch and so was easy to monitor. Mallards were observed several times mating in the upper Lagoon, where four to five males would mate with the same female.

Two Canada Geese (Branta canadensis moffetti and B.c. minima) and a Greater White-fronted Goose (Anser albifrons) also appeared in the Lagoon and were almost certainly of wild origin (K. Garrett, Pers. comm. 1988). Black Brant (Branta bernicla) stop to forage at the Lagoon even though it lacks the eelgrass beds that normally attract them (Small 1974). The brant usually stay about two months in the spring and have been observed feeding on green algae (Enteromorpha sp.) mats. The dabbling ducks and geese preferred the upper Lagoon but also used the main Lagoon for feeding and resting. Some utilization of the inlets occured at low water when Cinnamon (Anas cyanoptera) and Green-winged (Anas crecca) Teal would feed on the algal scum growing on the mud (Figure 8.5).

DIVING DUCKS

Diving ducks occured in low numbers in the Lagoon (only 1.1 birds per survey). Bufflehead (Bucephala albeola) feed on shrimp, small fish and bivalve mollusks (Small 1974; Palmer 1976). The bufflehead stayed for a longer period of time and appeared in the main Lagoon in flocks of six to fifteen birds (Figure 8.5). Surf scoters (Melanitta perspicillata) did not come into the Lagoon but were seen offshore around the anchored rafts and near the entrance to the Lagoon. The diving ducks disappeared during July and August (Figure 8.6).

COOTS

Coots were often the most numerous birds to be counted on surveys but on average were only the third most numerous, averaging 86.2 birds per survey (Figure 8.2). Because coots only breed in freshwater marshes (Small 1974) they disappear from May through August from the lagoon, except for a few oversummering individuals. These few individuals utilize large algae mats which grow during this time, until the rest of the coots return in time to forage on this resource before the winter rains wash the mats out to sea. The population peaks in October and remains high until March dropping in April to almost zero in May again (Figure 8.7). At low tide the coots graze on the delicate green algae growing on the surface of the mud. When water levels are high, they feed on pickleweed (Salicornia virginica) in upland areas of the inlets. Coots were also observed feeding on jacknife clams during a December die-off of the clams. Coots were most often observed in the main and upper Lagoon (Figure 8.8) but also came into the inlets to feed.

SHOREBIRDS

Shorebirds were divided into two categories, surface-feeding and probing shorebirds. During the spring and summer the population average moves up and down (Figure 8.10), likely because the shorebird migration occurs during this period (Garrett and Dunn 1981).

SURFACE-FEEDING SHOREBIRDS

Surface-feeding shorebirds are short-billed shorebirds which feed either on the surface or immediately below the surface of the sediments. These comprised the group with the fourth greatest numbers, having on average 77.6 birds per survey. Most of these shorebirds fed within the main Lagoon, although they also foraged along the shore of the upper Lagoon, on the mud flats of the inlets and on the beach (Figure 8.9).

Territoriality was observed in the semipalmated plover (Charadrius semipalmatus) on the mudflats in the inlets where one plover would chase other plovers which came within approximately six feet of where the first one was feeding. The only shorebird that mated and nested was the killdeer (Charadrius vociferus). It was hoped that the snowy plovers (Charadrius alexandrinus) would nest in a sandy area along the beach, since they are known to have nested in the past.

Figures 8.3 - 8.6. All data from April 1987 - March 1988 from 11 census sites.

Figure 8.3. Average number of Gulls per month.

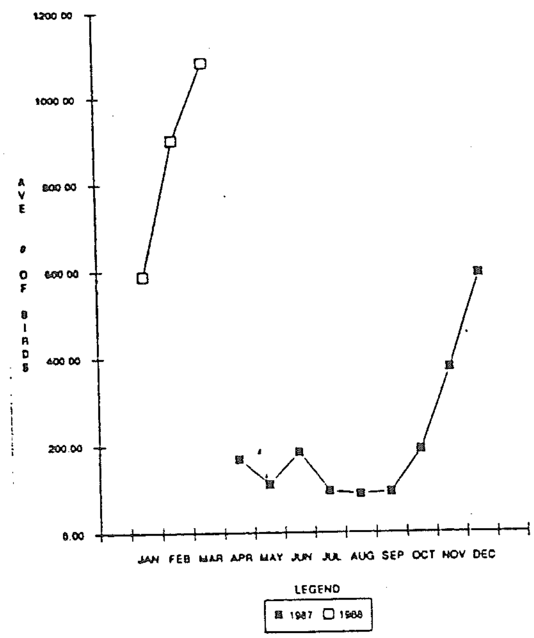


Figure 8.4. Average number of Dabbling Ducks and Geese per month.

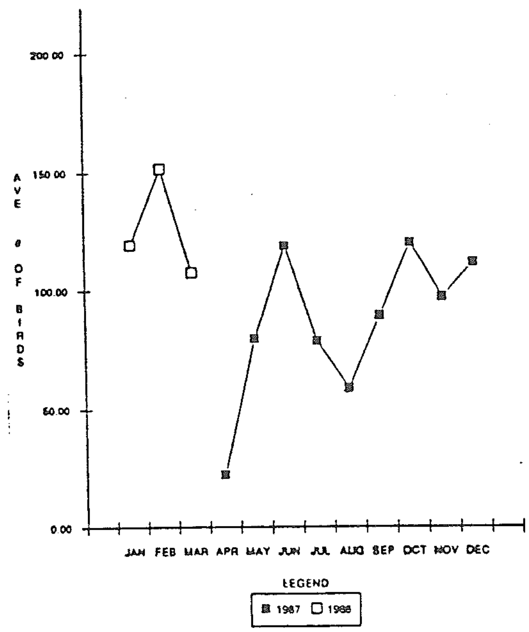


Figure 8.5. Area use for Dabbling Ducks and Diving Ducks.

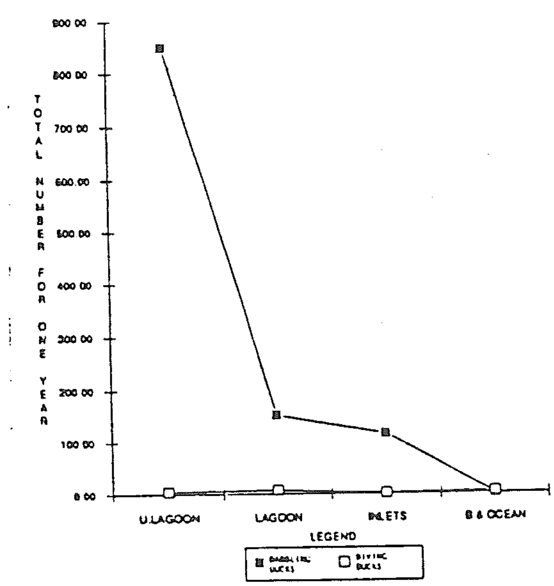
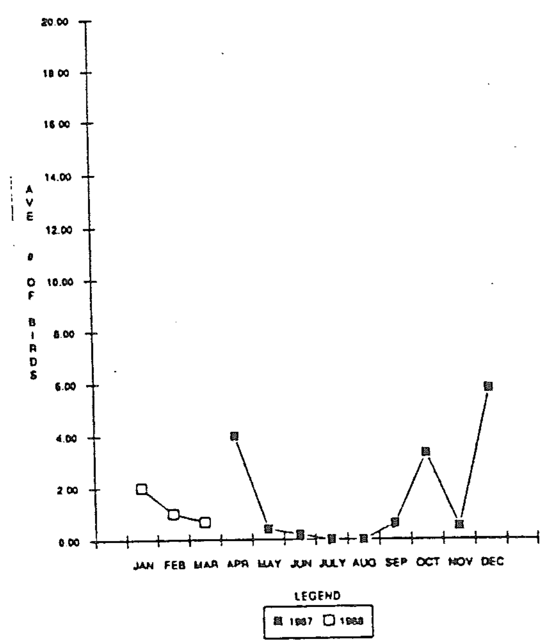


Figure 8.6. Average number of Diving Ducks per month.



Figures 8.7 - 8.9. All data from April 1987 - March 1988 from 11 census sites.

Figure 8.7. Average number of Coots per month.

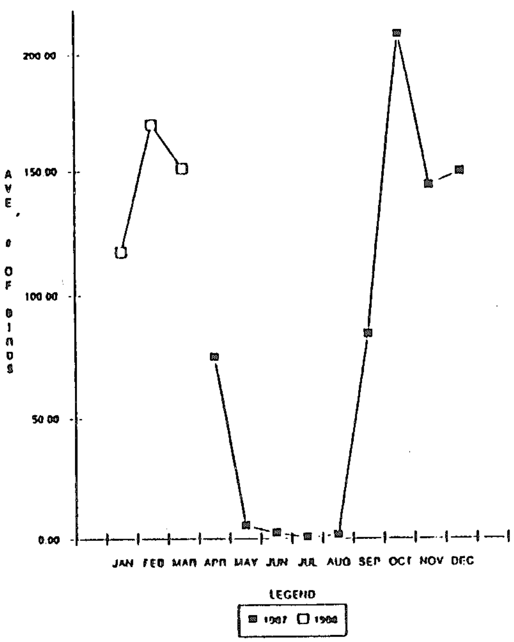


Figure 8.8. Area use by Gulls and Coots.

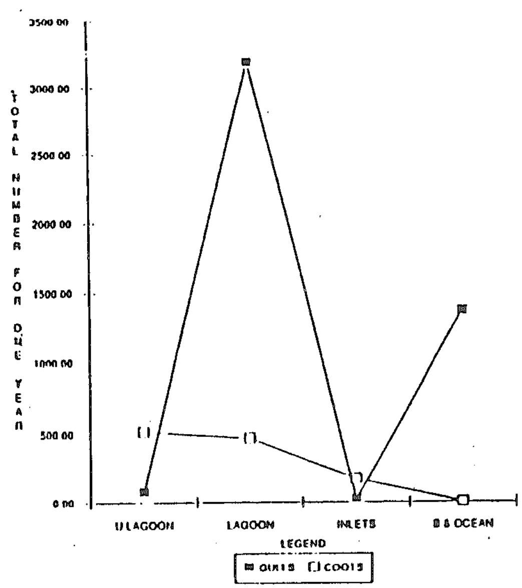
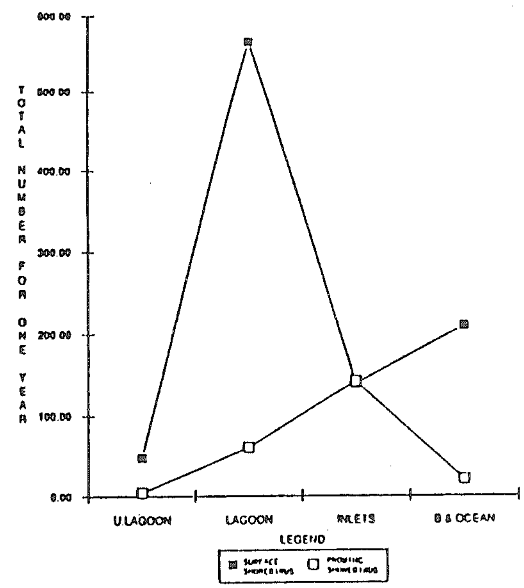


Figure 8.9. Area use by Surface-feeding and Probing Shorebirds.



Unfortunately the heavy human intrusion starting in the 1950s have eliminated the plovers as breeding residents (Kiff and Nakamura 1979). Volley ball nets were recently erected near the plovers roosting area on the eastern edge of the Lagoon. This is also used as a turn around point for joggers. Plovers were formerly seen roosting in wind cups in the sand or in among the washed up kelp but numbers of birds decreased as numbers of humans increased. However, since many plovers migrate to the interior to breed at the time of the decrease, humans are not necessarily the cause (K. Garrett. Pers. comm. 1988).

The snowy plover was Blue listed from 1972 to 1982 and was of Special Concern in 1986 (Tate 1986). This plover has been of historic concern on the West Coast as shown by the Blue list (Tate 1986).

PROBING SHOREBIRDS

Probing Shorebirds are those shorebirds with medium to long bills used for delving deeply into soft sediments for invertebrates, such as mollusks and crustaceans. This group has the sixth greatest numbers averaging 19.1 birds per survey. They are highly seasonal, mainly appearing between September and March (Figure 8.11). They utilize the main Lagoon mostly for roosting although they will search the cobble for food. They also feed on the beach, searching the cobble and probing in the sand. Most of the feeding occurs on the mudflats in the inlets (Figure 8.9), where they probe deeply into the sediments. They have been observed feeding on jacknife clams (Tagelus californianus) but since there was a large die-off of these clams it is unclear whether the birds capture them on their own or only when a die-off occurs. Whimbrels (Numenius phaeopus) were observed chasing other whimbrels and willets (Cataptrophorus semipalmatius) during feeding but both species flocked together when at rest. This suggests that the aggressive behavior observed is related to feeding territories. Long-billed curlews (Numenius americanus) were rarely seen in the Lagoon because of limited habitat (i.e. tidal mudflats), not because of a declining population (K. Garrett. Pers. comm. 1988). Curlews were Blue listed in 1981 and of Special Concern in 1986 (Tate 1986).

WADING FISHERS

Wading fishers rank eighth in number seen per census, averaging 10.3 birds per survey. The population peaked during the winter months much like all other bird groups, with the highest numbers occuring in December (Figure 8.12). This is consistent with other southern California coastal wetland population fluctuations.

These birds spend most of their time foraging along the edges of the Lagoon and inlets, although snowy egrets (Egretta thula) and green-backed herons (Butorides striatus)

Figures 8.10 - 8.12. All data from April 1987 - March 1988 from 11 census sites.

Figure 8.10. Average number of Surface-feeding Shorebirds per month.

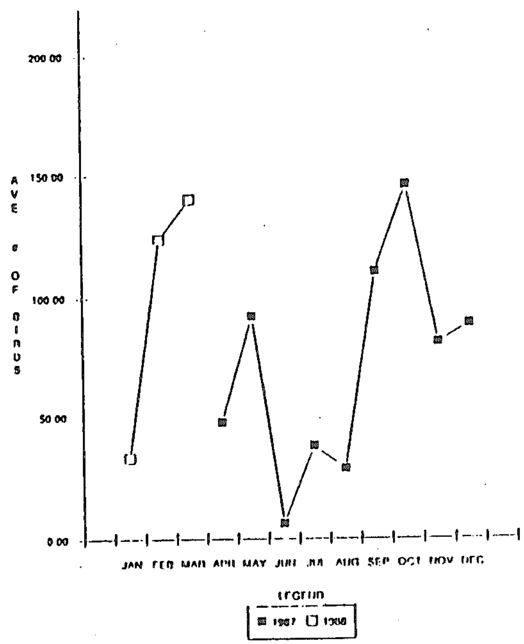


Figure 8.11. Average number of Probing Shorebirds per month.

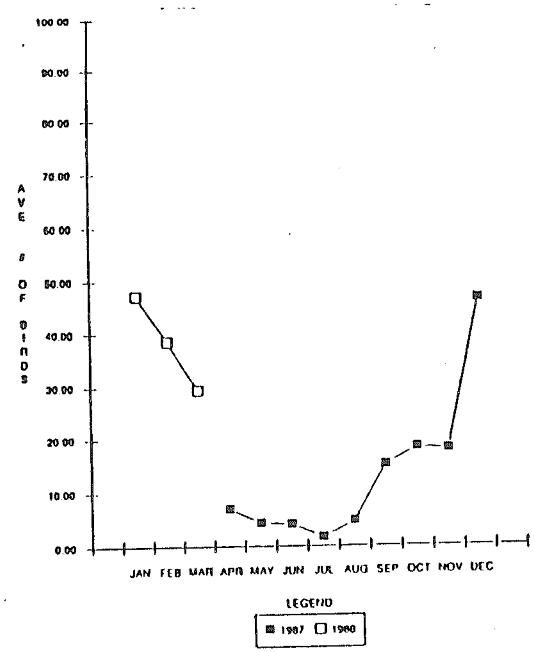
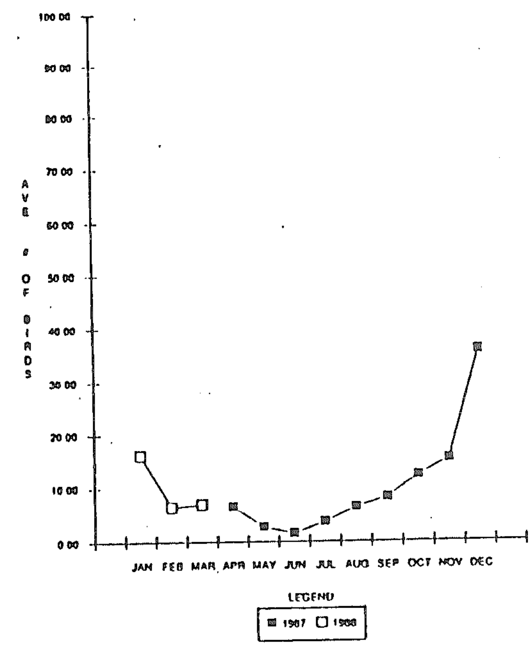


Figure 8.12. Average number of Wading Fishers per month.



were also observed feeding on lizards caught on raised areas of land between the inlets (Figure 8.13). Great blue herons (Ardea herodias) used the raised areas for roosting but seemed to prefer three large trees near the southwest edge of the Lagoon for most of their roosting.

Snowy egrets were also observed foraging among the exposed cobble both in the Lagoon and on the beach at low tide. This only occurred during periods when the beach was not being used by humans. These egrets usually roosted on the side of the Lagoon near the Adamson House in an area mostly undisturbed by human activity. They were seen following a group of red-breasted mergansers (Mergus serrator) that were feeding in the Lagoon along the shoreline. The egrets were apparently catching the fish that were escaping from the mergansers. This behavior was seen on several surveys and has been previously described (Christman 1957).

Within this group, great blue herons and black-crowned night-herons (Nycticorax nycticorax) were Blue listed 1980-1981 and 1972-1981 respectively. Both were classified as being of special concern in 1982 and under local concern in 1986 (Tate 1986).

SURFACE DIVERS

Surface Divers are fish eating birds which dive from the surface of the water and chase fish by swimming after them. These birds were seen at the average rate of 16.8 birds per survey (Figure 8.2). They leave during the spring and summer and gradually return during the fall, with peak numbers observed in winter (Figure 8.14). During the winter of 1987-1988, fish populations dropped off significantly in the Lagoon, coinciding with winter rain flows through the Lagoon. The surface diver population moved at this time from the upper Lagoon and main Lagoon to the ocean. Double-crested cormorants (Phalacrocorax lauritus) after fishing within the Lagoon are often observed spreading their wings in order to dry the feathers. The tidal island in the Lagoon and the strip of beach between the Lagoon and the ocean were the most commonly used areas by the cormorants for this purpose. The man-made raft and a rocky reef offshore were used by the cormorants for roosting.

The double-crested cormorant, formerly Blue listed, has been making a slight recovery over the last decade. Western grebes (Aechmophorus occidentalis) were on the Blue list from 1973 to 1982 and of special concern in 1984 (Tate 1986). These grebes are present from September to March both in the Lagoon and offshore but are absent during the breeding season when they travel to inland lakes and marshes to nest, rest and feed (Small 1974).

PLUNGE DIVERS

Plunge divers are those that plunge from flight to capture fish. They are ranked fifth with an average rate of 37 birds per survey (Figure 8.2). These populations drop during the summer and rise during the fall to peak in late winter/early spring (Figure 8.15).

Pelicans were seen most often on two man-made wooden rafts anchored approximately 200 yards offshore and also within the main Lagoon (Figure 8.13). Brown pelicans (*Pelecanus occidentalis*) were often seen feeding upon the many fish within the Lagoon, flapping a few times to gain altitude then plunging into the water. They were also observed bathing in the fresh surface water. These birds often left the main Lagoon when they were disturbed by helicopters, traffic noise from the highway or from heavy human usage on that strip of beach. Often when startled, they would fly out to the anchored rafts offshore. This is where the majority of sightings occurred. During the summer months, one of the rafts is used as a covered boat dock which makes it unavailable for the birds. They were also observed feeding in the ocean. Brown pelicans, still classified as an endangered species on the west coast, have recovered since DDT was banned in 1972. They now have populations of between 75,000 and 90,000 birds occurring in fall off the west coast (Jehl 1984).

In late summer, many juvenile pelicans are in the Lagoon learning to fish, first scooping fish from the surface, then low altitude plunging. Adult un-mated males assist in training the young (K. Garrett. Pers. comm).

Terns utilize the sandy areas around the Lagoon and the tidal island for roosting and for mating (Fig. 8.13). Two pair of elegant terns (*Sterna elegans*) were observed mating several times on the tidal island, although this species does not nest here. All species of terns would stand in the Lagoon water but were not observed bathing. All species of terns foraged within the Lagoon and inlets, plunging into the water for food. Elegant and royal (*S. maxima*) terns have exhibited lowered productivity in the Gulf of Mexico because of both direct and indirect human disturbance (Anderson and Keith 1980; Hand 1980; Jehl 1984). Again this disturbance is on Raza Island. Malibu Lagoon has late summer peaks of elegant terns but in 1987, numbers were low (Figure 8.15). However, in 1988, 700 to 1500 elegant terns appeared in the lagoon (K. Garrett. Pers. comm. 1988). Least terns (*S. antillarum*) are listed as a declining species (Jehl 1984) and also are on the U.S. Fish and Wildlife Service endangered species list (Tate 1984) The California Least Tern (*S.a. browni*) is considered endangered in California because the open sandy or gravelly shores near fishing areas have experienced heavy human disturbance (Garrett and Dunn 1981).

Figures 8.13 - 8.15. All data from April 1987 - March 1988 from 11 census sites.

Figure 8.13. Area use by Plunge Divers, Surface Divers and Wading Fishers.

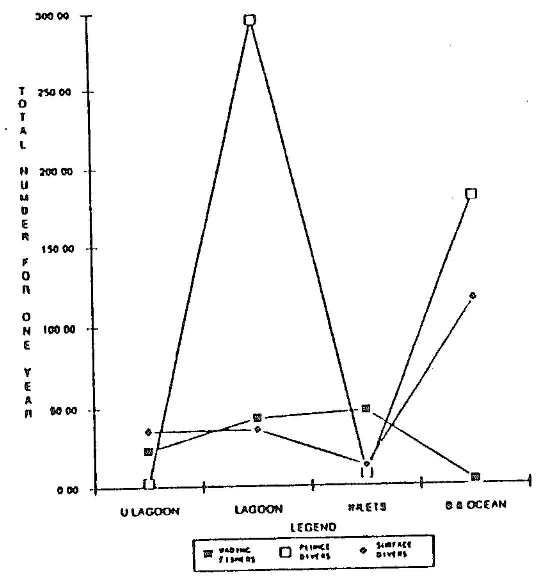


Figure 8.14. Average number of Surface Divers.

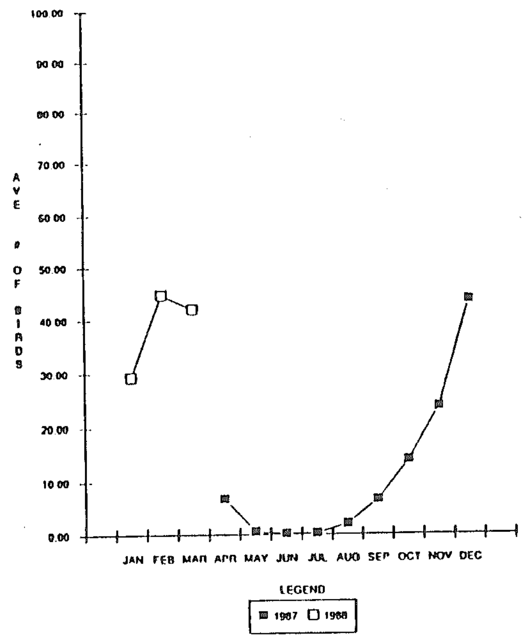
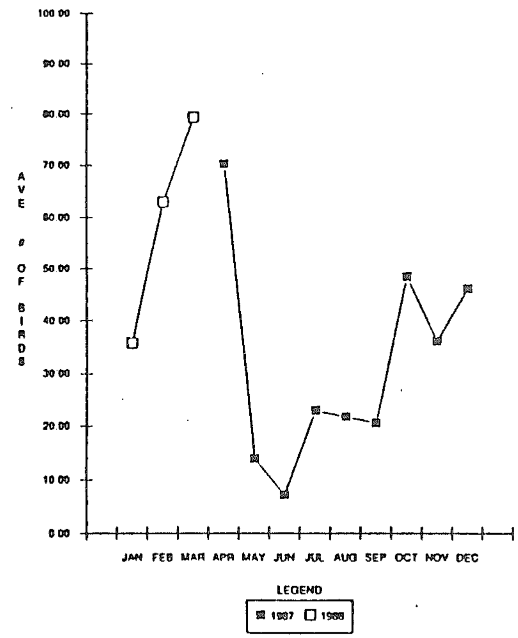


Figure 8.15. Average number of Plunge Divers.



8.5 DISCUSSION

Malibu Lagoon displays a high diversity of bird species considering the amount of disturbance from human activity, and its relatively small size compared to many other wetlands along the coast. However, there is still much that could be done to improve the habitat for birds. Using this species list for Malibu Lagoon, it might be possible to manage the habitat for those species that are having difficulty not only in the Lagoon, but also in other areas.

Since the total area of the Lagoon is limited, it might be advisable to create foraging and resting areas for as many species as possible, rather than creating breeding areas for only rare or endangered species. This is because most of the birds that utilize the Lagoon breed in other areas and only use the Lagoon for foraging and resting. The snowy plover has not decreased in numbers as has the least tern, since the plovers have a more extensive breeding range, from Mexico to Oregon (Small 1974) and because they also nest commonly at interior localities in the West (Garrett and Dunn 1981). Snowy plovers often nest on the more secluded northern beaches (Small 1974). Another reason snowy plover population has not declined as severely as least terns is their willingness to nest in areas close to human activity (Small 1974).

Least terns are colony nesters which are easily disturbed by a single intruder which will put the entire colony into flight. Snowy plovers are not colony nesters and are therefore more tolerant of human intrusion (Small 1974). This tolerance of human activity should not be tested too severely however. Fencing off areas suitable for snowy plovers and least terns would solve both the domestic predator (i.e. cats and dogs) and the human intrusion problem. Snowy plovers are currently absent from the beach which seperates Malibu Lagoon from the ocean. As mentioned earlier, this could either be from human intrusion into the roosting area or migration to other less disturbed nesting areas. Snowy plovers formerly nested at Malibu Lagoon but disappeared as a breeding resident when heavy human use began in the 1950s (Kiff and Nakamura 1979).

If a species is not currently rare or endangered but is Blue listed as a declining population, habitat could be set aside as additional breeding grounds. It is possible that a small population of snowy plovers and least terns could be established at Malibu Lagoon with the provision of suitable habitat, free from human intrusion and predation.

Should the Lagoon be altered for breeding grounds, several measures would have to be taken. First of all, the domestic predators should be either removed or totally restricted from entering the breeding areas. This could be

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9.0 MANAGEMENT CONSIDERATIONS FOR THE MALIBU CREEK WATERSHED AND MALIBU LAGOON

9.1 INTRODUCTION

The Malibu Creek-Malibu Lagoon area is a unique ecological, recreational, educational, and research resource harboring significant value for present and future generations. Species compositions patterns can reveal the relative health of an ecosystem, provide an early warning system, or demonstrate the relative intensity of pollution problems. Biotic community analysis can often identify types of pollution and other potential problems affecting the habitat. Impacts from almost everything that occurs in a watershed system show up in streams and affect the faunal and floral community composition (Mangum 1986).

Human understanding of estuaries is still rudimentary, and comprehensive baseline data and monitoring programs are lacking. Therefore, vigilant and flexible management programs need to be adopted and implemented. Zedler (1986) believes adoption of a management program for southern California's Tijuana Estuary should emphasize "experimentation, evaluation, and progressively improved treatments...". This type of flexible approach would also be a valuable framework for managing Malibu Creek and Lagoon.

Human-generated disturbances continue to have a significant cumulative impact on the Malibu Creek-Malibu Lagoon ecosystem complex. Because of the ecological pressure exerted by humans on the natural resources of this area, active resource management is necessary for long-term maintenance of the native biota (plants and animals). Active management, in this report, is considered to refer to the stringent control and regulation of human impacts upon the ecosystem, and to the ecological restoration and maintenance of the physical and biotic environment.

Cooperative interagency resource management and community involvement are essential for the native biota of Malibu Creek and Malibu Lagoon to survive. The long-term viability of this watershed is tied to the implementation of comprehensive natural resource management plans that address the enhancement of habitat conditions for all native faunal and floral groups.

These two ecosystems (creek and lagoon) are intimately linked by virtue of their shared aqueous environment. Because these ecosystems are contiguous, management of the whole watershed is necessary in order to conserve them in perpetuity. Additionally, for managemement to be successful, further research focusing on Malibu Creek and Malibu Lagoon as a single interacting ecosystem complex is vital. Therefore, in addition to considerations based on the summary data, the following problems concerning Malibu Creek, which flows into Malibu Lagoon, warrants examination.

9.1.1 STREAMFLOW MODIFICATION

Excessive freshwater input into creeks connected to coastal wetlands is detrimental to these biotic ecosystems and results in a reduced diversity of estuarine species (Zedler 1982). Under normal conditions the native estuarine flora and fauna naturally recover from periodic winter storm flooding. However, they cannot recover from freshwater flooding on a more frequent or daily basis, as is presently occuring. For example, according to Zedler (1984), comparative studies indicate that prolonged periods of unnatural freshwater influence in a coastal wetland environment would greatly reduce or extirpate many native species. For instance, diversity of fish species will be lowered from a potential high of about forty species to a low of approximately fourteen fish species. In addition, most species of estuarine invertebrates are eliminated with prolonged periods of freshwater innundation. Plant species undergo significant shifts in boundaries (see 9.2.2) when innundated by prolonged or unseasonal freshwater. In general, many native faunal and floral groups are likely to experience detrimental changes in species composition when natural streamflow patterns are altered.

Malibu Creek and Malibu Lagoon are currently experiencing a human-generated input of imported freshwater which results in a non-natural streamflow pattern. The natural hydrologic regime in this watershed of periodic winter storm flooding has been artificially extended by the addition of large amounts of tertiary-treated wastewater. The additional water flows directly into Malibu Creek and ultimately into Malibu Lagoon. This alteration of the hydrologic regime exerts a negative cumulative impact on many species of flora and fauna.

Recent historical documentation, for example, indicates 25 recorded species of fish inhabiting Malibu Lagoon. Our study has documented a current total of fourteen fish species. Native species utilizing Malibu Creek which may be affected by altered streamflow cycles and ultimate change in species composition are the arroyo chub (Gila orcutti), Pacific sea lamprey (Entosphenus tridentatus), and steelhead trout (Salmo gairdnerii). Native species of Malibu Lagoon which could be affected are listed in Table 7.1 of chapter 7. Introduced non-native fish species in Malibu Creek may be in the process of usurping the ecological niches of some native fish species, partly due to altered streamflow patterns. Those non-native species include, but are not limited to, the black bullhead (Ictalurus melas), green sunfish (Lepomis cyanellus), and largemouth bass (Micropterus salmoides) (Swift 1982).

Presently, the major contributor of additional non-natural streamflow in Malibu Creek is the Tapia Water Reclamation Facility. Tapia is a tertiary treatment facility which discharges up to 8-10 MGD from October through June. The water from Tapia is of exceptionally high quality, thus providing a significant opportunity for Creek and Lagoon restoration and re-establishment of a more natural seasonal streamflow cycle.

The primary building blocks in wetland ecosystem restoration are the existence of clean water and natural streamflow cycles. Thus the potential for successful management and wetland restoration exists for the contiguous Malibu Creek-Malibu Lagoon ecosystems. For this potential to be actualized, we strongly recommend a cooperative-adaptive management strategy by those agencies and communities affecting the watershed. The primary recommended goal is to restore and maintain the natural seasonal streamflow cycle within the Malibu Creek watershed, and to regulate pollution entering this aquatic ecosystem.

An important management consideration and potential benefit to Malibu Creek and Malibu Lagoon include the refinement of existing percolation ponds near the Tapia treatment plant. This may be an effective method for controlling streamflow in Malibu Creek. Specific potential benefits of refined wetland percolation/retention ponds are:

1. Maintenance of a streamflow pattern which mimics natural seasonal conditions.

2. Controlling excessive algae-promoting nutrients.

3. Controlling water temperatures in the Creek in order to mimic natural temperature conditions for native biotic elements that lack "ecological plasticity" (i.e. the ability to adapt to varying environmental conditions).

4. Controlling excessive freshwater influence on Malibu Lagoon and its associated biota (plants and animals).

5. The ponds could become additional habitat for wildlife, especially birds migrating along the Pacific Flyway.

The maintance of natural seasonal streamflow patterns in Malibu Creek is essential for many native fishes using Malibu Creek and Lagoon. The total amount of freshwater entering the Creek at any one time, and the length of time (temporal component) the non-natural water source continues to flow into the Creek are the two critical components of the local streamflow pattern.

The percolation/retention pond concept could be a significant strategy in regulating the excessive human influence on the Malibu Creek watershed. With the current prolonged and non-seasonal streamflow pattern, the Creek and Lagoon ecosystems may be predisposed, by altered physical and chemical parameters, to favor one fish species over another, thus changing the overall species composition in these habitats. Ponds designed for a controlled release of water would be likely to successfully mitigate any potential detrimental change in fish species composition. Other faunal and floral assemblages could also experience changes in species composition. These changes are a critical subject area that merits future examination. If the percolation/ retention pond concept proves unworkable, it will be important to consider other alternatives that would restore the natural streamflow pattern.

9.2.0 SUMMARY OF LAGOON STATUS

9.2.1 WATER QUALITY

1. As in many estuaries, salinities, dissolved oxygen, and pH at Malibu Lagoon fluctuate widely. At the Lagoon, these fluctuations often occur within a short time frame. These fluctuations are associated with tidal change, the unseasonal addition of large volumes of freshwater from the Tapia Water Reclamation Facility and problems associated with the management of the Lagoon entrance by the California Department of Parks and Recreation (DPR). Often this relatively freshwater remains ponded in the Lagoon for several days, even after Lagoon water levels have reached the mandated opening level of 3.5 feet.

2. Water samples at 5 stations in the Lagoon (Map 9a) were taken to the U.C.L.A. Biomedical and Environmental Studies Lab for analysis. The results indicate that no elements appear to be at toxic levels, although manganese, cobalt, lithium and vanadium are often below the lower limits set for maintaining healthy growth of organisms.

3. Data provided by the Las Virgenes Municipal Water District (LVMWD), plus our own observations, indicate that the Tapia facility is well operated, and the water discharged is of high quality. The high volume of freshwater released directly into Malibu Creek has probably slowed the ecologic recovery process at Malibu Lagoon after the 1983 restoration by limiting the colonization of species that are less tolerant of fresh water.

4. The tertiary-treated water discharged from the Tapia facility has received national acclaim for its quality. Yet, biological pollution does occur in the Lagoon. Data provided by the LVMWD and the L.A. County Dept. of Health indicates that total coliform levels in the Lagoon and in

Malibu Creek, above as well as below the Tapia Plant, are often above the standard considered healthy for bodily contact. This indicates that other sources of pollution exist and need to be identified. (see chapter 2.4). Total coliform levels are presently used as an indicator of the potential for the presence of disease-causing pathogens, rather than a measure of actual pathogens.

Coliform levels are highest when water levels are high in the Lagoon, either due to closure of the entrance, extremely high tides, or storms. The source (or sources) of this pollution has not yet been determined, although studies prior to the 1983 restoration have indicated non-point source pollution causes, and that aging or poorly maintained septic systems in nearby Malibu Colony are one potential source. Often, when water levels in the Lagoon exceed 3 feet, foam, bubbles, and floating scum are observed, especially in channel C (Map 9b) bordering Malibu Colony. The large drain at the western end of C channel seems to be a main source of suds observed occasionally at the Lagoon, and which account for high pH levels.

5. Wide fluctuations of all physical and chemical parameters have been observed during this study.

9.2.2 SEDIMENTATION AND WATER FLOW

1. Sedimentation after the 1983 restoration has followed a predictable pattern, with coarser sediments being deposited in the main Lagoon, and finer silts and muds finding their way to the back reaches of the channels, where water movement is slowest. The large volumes of freshwater have probably accelerated this process. The schedule of managing the Lagoon entrance has resulted in an increase in sedimentation of beach sands near the entrance, which has affected water flow patterns in the Lagoon.

2. Water levels sometimes reach above 5 ft. prior to scheduled opening of the entrance, causing a dramatic exit of large volumes of water from the Lagoon over a two hour period, after which the Lagoon stabilizes at the 2 ft. level. This rapid outflow of water causes sediments and benthic organisms residing in them to be removed.

9.2.3 EMERGENT VEGETATION

1. Of the 18 marsh species normally encountered in estuaries in Southern California, only 7 have been observed during vegetative surveys at Malibu Lagoon, out of a potential total of 133 species in southern California.

9.2.6 THE FISHES

1. Malibu Lagoon supports a fish population that is characterized by low diversity and fairly low productivity, which may be typical for a lagoon of this size. In the 12 surveys conducted this year at 5 stations reflecting habitat gradients within the Lagoon, 14 fish species have been encountered, with four species regularly being present. The decreased diversity in fish species observed here is consistent with other estuaries which have received large influxes of freshwater from sewage treatment plants.

2. Fish numbers peak in the summer and early fall months, and decline to relatively small numbers during the winter. Year round residents include the California killifish (Fundulus parvipinnis), topsmelt (Atherinops affinis), arrow goby (Clevlandia ios), and staghorn sculpin (Leptocottus armatus).

3. Malibu Lagoon appears to be an important nursery area for several species of fish. Growth of topsmelt, arrow goby, California killifish, striped mullet (Mugil cephalus), and staghorn sculpin have been followed as increasing size classes in the Lagoon. Eggs of topsmelt have been observed attached to algae mats in the late spring and early summer. Young of year (YOY) of several marine species have been encountered, with large numbers of YOY opaleye perch (Girella nigricans) being caught. The period from August through November, when Lagoon waters are warm and much food is available, appears to be most critical for the developing YOY.

9.2.7 THE BIRDS

1. For an estuary of such small size, Malibu Lagoon shows a high diversity of bird species. A total of 151 species have been sighted at the Lagoon, including 78 species of waterbirds and 73 landbird species. Greatest numbers of birds are observed during the winter months and during migration periods, when birds use the Lagoon primarily as a feeding, freshwater source, bathing and resting area.

2. The most populous species at the Lagoon are the gulls. Two species which over-winter at the Lagoon are experiencing population threats. California gull (Larus californicus) numbers are tied to the continued health of Mono Lake while numbers of Heermann's gulls (Larus heermanni) are being reduced, due to the commercial development of their island breeding site off the coast of Baja California.

3. Numbers of over-wintering wild ducks observed at the Lagoon are quite low. This may be the result of the relatively small area of the Lagoon or the loss of wetlands

where these ducks breed. Most ducks have been observed in the upper Lagoon where water is fresh and there is less disturbance by humans.

4. Most birds utilize the Lagoon when water levels are low, exposing more area for feeding. The mudflat area at channel B is most heavily used by probing shorebirds. The west end of channel C (Map 9b), nearest Malibu Colony, is the least used.

5. The Lagoon is utilized by a few species of shorebirds as a breeding and nesting area. Two threatened species, the snowy plover (Charadrius alexandrinus) and the least tern (Sterna antillarum), and the endangered bald eagle (Haliaeetus leucocephalus) historically nested at the Lagoon. As a result of habitat destruction, increased human activities, and the presence of unleashed dogs and cats, these species no longer nest here. The bald eagle no longer is a Lagoon visitant. Only the snowy plover has demonstrated an ability to co-exist with beach-goers, and a small breeding colony might be re-established at the Lagoon with the availability of suitable habitat.

6. Malibu Lagoon is an important resource for the brown pelican (Pelicanus occidentalis), which nests on Anacapa Island. Young brown pelicans, trained by non-breeding adult males, use the Lagoon as a learning area for catching fish.

7. Riparian areas near Malibu Creek and Malibu Lagoon, with relatively little human disturbance and a diversity of riparian vegetation, serve as a breeding area for several species of water and landbirds.

8. Birds respond to human disturbances and unleashed pets at the Lagoon by moving to areas where they are not threatened. The main roosting area when large numbers of beach-goers are present is the east side of the Lagoon, which presently is subject to light recreational use. Offshore rafts are also used as roosts.

9.2.8 OTHER ANIMALS

1. Relatively few wildlife corridors, such as ones existing in the Malibu watershed, remain in the Santa Monica Mountains. These corridors are important to the success of many species.

2. Although not studied, several vertebrate species have been observed in the upper and main Lagoon areas. Mule deer (Odocoileus hemionus) have been observed at the upper Lagoon, and tracks of deer and raccoon (Procyon lotor) have been seen in both the main Lagoon and inlets.

3. Vegetated upland habitat hosts a number of vertebrates Audubon's cottontail (Sylvilagus audubonii) is a common resident where there is sufficient cover. Sightings of the long-tailed weasel (Mustela frenata) were made at both the main and upper Lagoon. Vole (Microtus sp.) trails are evident throughout the saltgrass vegetation. Pocket gophers (Thomomys bottae) exist throughout upland areas, with large numbers being observed in the managed lawn near the interpretive area. In the upper Lagoon, many Beechy ground squirrels (Citellus beecheyi) exist along the creek bank.

4. Western fence lizards (Sceloporus occidentalis), the San Diego gopher snake (Pituophis melanoleucus annectens) and the striped racer (Masticophis lateralis) are the reptiles sighted at the Lagoon. Pacific rattlesnakes (Crotalus viridis helleri) have been sighted adjacent tothe upper Lagoon.

9.3 MANAGEMENT CONSIDERATIONS PROPOSED FOR MALIBU LAGOON

9.3.1 WATER QUALITY

The two major influences on the water quality at Malibu Lagoon are the large and unseasonal volumes of fresh water released from the Tapia Water Reclamation Facility of the Las Virgenes Municipal Water District and the frequent closure of the Lagoon entrance.

Until recently (see 9.3.2), all waste water has been pumped from the Tapia facility directly into Malibu Creek during "off peak" hours. The increased flow rate generated by this practice has most likely increased the rate of erosion in the Creek, with increased sedimentation downstream. In the future, these effects need to be measured. A reduction in the amount of non-seasonal fresh water which reaches Malibu Lagoon, with management for lower Lagoon water levels would greatly benefit this ecosystem.

In providing a management plan that would be acceptable to nearby Malibu Colony residents and to the recreational users of Surfrider State Beach, the natural regime of the Malibu Lagoon ecosystem was compromised. Prior to restoration, the entrance of the Lagoon was opened by the first winter storms each year. During periods of high water flow in Malibu Creek, the entrance remained open, with a gradual eastward drift. Usually by mid-April the entrance closes, to be opened again by storm cycles of the following year. Post restoration, a mandated opening of the Lagoon entrance at a location just east of Malibu Colony was required by the California Department of Parks and Recreation (DPR) when water levels reach 3.5 ft. Maintaining the entrance at its present location has probably preserved the longshore break for surfing at Surfrider State Beach. However, with only one bulldozer to serve all parks in this area, this management plan is not functioning well.

Impoundment of brackish water due to infrequent opening of the Lagoon entrance provides the potential for biological pollution. Coliform bacteria multiply rapidly under the brackish water conditions which exist in the Lagoon, and are killed by salt water. Management for lower Lagoon water levels would greatly benefit this ecosystem. The high coliform counts noted when Lagoon water levels are high, (recorded by LVMWD and L.A. County Dept. of Health) need to be reduced and sources of biological pollutants determined. In particular, septic systems and road run-off need to be controlled.

9.3.2 FRESHWATER RELEASE

Excessive amounts of freshwater released directly into Malibu Creek increase the rate of streambed scouring and downstream sedimentation in Malibu Lagoon. The recent use of existing percolation ponds adjacent to the Tapia facility has somewhat modified the effects of the release of large volumes of freshwater. However, the present percolation ponds are inadequate for the large volumes of water presently being released.

A preferred management scheme would be one which would more fully restore the natural hydrologic regime. For this to occur, the additional freshwater generated from the Tapia facility must not impact the biota of the Lagoon. These options may be considered:

1. Establish an overflow pipe in the Lagoon to siphon off the less dense surface freshwater when water levels reach a pre-determined height for the best functioning of this ecosystem. This overflow pipe would have to be eastward of any storm-erosive forces, and directed far enough seaward to prevent plugging by sand carried by the longshore current. The Lagoon entrance to the sea would be determined by natural events. Studies are needed to determine if this is a feasible alternative.

2. Minimize the impact of fresh water by establishing additional and refined percolation/retention ponds for a more gradual, controlled release of reclaimed water. Additional percolation/retention ponds can benefit wildlife and may serve as recreational facilities in an area experiencing extensive development. Returning to a natural hydrologic regime will restore the historic brackish marsh, reduce the amount of sedimentation in Malibu Lagoon and possibly enhance re-establishment of a permanent steelhead fishery.

2. Locate and eliminate the source(s) of pollutants entering the Lagoon from the large drain at the back of the C channel. This drain appears to be a main source of non-point source pollutants, such as suds and oils observed at the Lagoon.

9.4.8 PROPOSED SAND DUNE COMMUNITY

1. Vegetate the dune with native plants (based on historic records) for this estuary.

2. Provide interpretive exhibits so that the public can gain a better understanding of dunes historic to this area. Provide post and cable fencing, similar to that already in the Lagoon, to guide visitors away from sensitive areas of the dune community. Post an interpretive sign to let visitors know that this is a sensitive area, with reasons why they should stay out. A DO NOT ENTER sign alone often has the opposite effect.

3. Provide a wide-mesh fence next to the dune, which will permit the drift of sand and keep predators out, and help to maintain dune stability.

9.4.9 EAST SIDE OF MALIBU LAGOON, ADJACENT TO THE BEACH

1. This area presently has little public access, and is an important semi-secluded area where shorebirds retreat when human visitation at the Lagoon is high.

2. Future trails should have guided fencing leading toward the beach, similar to that on the west side of the Lagoon, with vegetative screening established between the trail and areas where birds roost. Any establishment of a trail system on this side of the Lagoon should be away from the Creek and the Lagoon. The area along the east shore contains sensitive nesting habitat and is the only area where water birds can currently roost when public visitation at the Lagoon is high. The potential exists here for establishing a fenced least tern (Sterna antillarum) breeding area to the east of a proposed trail, in the area at the back of the beach which has little public visitation. Similar breeding areas have been established for this endangered species at McGrath and Venice beaches.

9.4.10 ENTRANCE TO MALIBU LAGOON:

1. The Lagoon entrance to the sea is a keystone management area within the Malibu Creek watershed. Our recommended management strategy is to allow the entrance condition to be determined by natural events rather than by

humans. Non-natural Lagoon conditions generated by human manipulation of the environment (i.e. additional freshwater flow from Tapia, artificial opening) is likely to affect species composition patterns in this estuary and needs to be controlled.

2. Opening the entrance of the Lagoon should be a priority in the management of this resource only until other management methods are implemented. The high water levels which remain in the Lagoon for many days after water levels reach the mandated 3.5 feet are associated with high levels of coliform bacteria and surface pollution. Maintenance of the entrance at a lower water level (approximately 3 ft.) may prevent overflow from nearby septic systems leaching into the Lagoon.

3. An additional management alternative would be to have the entrance determined by natural events and establish the overflow pipe referred to in section 9.3.2. Impounded water from the current management scheme poses a problem of biological pollution, since coliform counts are highest when water levels in the Lagoon are high.

9.5 SUMMARY

1. The importance of total watershed management cannot be overstated. Only when entire watersheds and landscapes are conserved and managed responsibly, will conservation of biodiversity, including humans, be successful in perpetuity.

2. Malibu Creek is a significant riparian wildlife corridor within the Santa Monica Mountains.

3. Our recommended management strategy is to mimic the natural streamflow cycle for the Malibu Creek watershed. The non-seasonal (extended season) and excessive seasonal influxes of freshwater originating from domestic sources needs to be controlled and regulated. Water levels in the Lagoon need to be effectively managed for native species.

4. This data base provides a preliminary understanding of the local aquatic ecology and some of the human disturbance factors impacting the Malibu Creek and Malibu Lagoon ecosystems. Continued ecological studies are needed in conjunction with pollution studies for our understanding of this system to reach a point where we can effectively and efficiently manage these two contiguous ecosystems.

5. Since the 1983 restoration Malibu Lagoon has made progress towards physical and ecological recovery. However, generally low diversity at the species level is a major concern which requires knowledge to lead the way to solutions.

MAP 9b

SPECIFIC SITES AT MALIBU LAGOON FOR MANAGEMENT CONSIDERATIONS