# ATTACHMENT 23

# HABITAT REQUIREMENTS AND SEASONAL PATTERNS OF DISTRIBUTION AND ABUNDANCE FOR FISHES OF INNER SAN DIEGO BAY

By

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Principal Investigator
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Final Report for Phase III

Prepared for

The San Diego Regional Water Quality
Control Board

and

The Teledyne Research Assistance Program
Teledyne Ryan Aeronautical, San Diego, CA

Under the Terms of
Contract No 55666003Y
An Assessment of Marine Habitats in San Diego Bay
and Their Vulnerability to Pollution and Disturbance Effects

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## INTRODUCTION

One of the primary objectives of the work conducted under the terms of Contract No. 556660034 was to carry out field studies and analyses of important habitats in San Diego and their associated plant and animal populations. The work described in this report on the fishes of inner San Diego Bay is the third such study conducted as part of this contract. Separate reports have been submitted on the other two studies, which are:

Takahashi, E. and R.F. Ford. 1992. Invertebrate Communities Associated with Natural and Transplanted Eelgrass (*Zostera marina*) Beds in San Diego Bay, California. Final Report for Phases I and II. May 1992.

VanderWeele, D. and R.F. Ford. 1994. The Effects of Copper on the Bivalve Mollusc *Mytilus edulis* and the Amphipod Crustacean *Grandidierella japonica* in Shelter Island Yacht Basin, San Diego Bay, California. Interim Report for Phase III. June 1994.

South San Diego Bay (Figure 1) supports communities of benthic and pelagic marine organisms characteristic of the inner portions of relatively undisturbed bays and estuaries in California and Baja California. Ecologically similar forms inhabit bays and estuaries in other temperate areas of the world. In general, most of the marine species found in the South Bay to be tolerant of moderately wide ranges of temperature, salinity, dissolved oxygen content, turbidity and other variables, and thus are able to survive seasonal and short-term changes in these factors that occur there. The numbers and composition of species, the relative abundances of those species, and the biomass of plants and animals which form the benthic communities vary both seasonally and from year to year.

Unlike most Atlantic and Gulf Coasts estuaries, as well as those found higher rainfall areas to the north, San Diego Bay is rarely subject to the influx of large quantities of fresh water (Zedler 1982; MacDonald, 1977, 1986). Fresh-water flows occur only during the winter and spring, and even during these seasons such flows are highly intermittent and usually of short duration. Except during rare periods or extreme periods of extreme flooding, as described in a previous section for February 1980, runoff rates are very low relative to the tidal transport of seawater. Consequently, dilution of the bay water is usually very limited in both time and extent. For this reason,, San Diego Bay is inhabited by many fishes and other organisms that have a much lower tolerance for low salinity water than estuarine organisms found in areas of more frequent or higher rainfall runoff.

Previous work by Richard Ford and others suggests that the fish fauna of inner San Diego Bay is typical of other shallow water embayments along the coast of southern California and Baja California. At least 67 species of bottom living and open water fishes are known to occur in South San Diego Bay. The dominant species in terms of abundance and biomass is the round stingray (*Urolophus halleri*). Other characteristic species include the horn shark (*Heterodontus francisci*), gray smoothhound shark (*Mustelus californicus*), leopard shark (*Triakis semifasciata*), deepbody anchovy (*Anchoa compressa*), slough anchovy (*A. delicatissima*), specklefin midshipman (*Porichthys myriaster*), California needlefish (*Strongylura exilis*), California killifish (*Fundulus parvipinnis*), topsmelt (*Atherrinops affinis),* Jacksmelt *(A. californicus*), pipefishes (*Syngnathus spp.*), staghorn sculpin (*Leptocottus armatus*), spotted and barred sandbass (*Paralabrax maculatofasciatus* and *P. nebulifer*), queenfish (*Seriphus politus*), yellowfin croaker (*Umbrina roncador*), black croaker (*Cheilotrema saturnum*), shiner surfperch (*Cymatogaster aggregata*), striped mullet (*Mugil cephalus*), bay blenny (*Hypsoblennius gentilis*), at least seven species of gobies, the diamond turbot (*Hypsopsetts guttulata*), the spotted turbot (*Pleuronichthys ritteri*), and the California halibut (*Paralichthys californicus*).

Inner San Diego Bay appears to be an important nursery area for juvenile California halibut and very likely also for the young of spotted and barred sandbass and other species. Young of the year and larger juveniles of the white seabass (*Atractoscion nobilis*) have been taken in samples from South San Diego Bay during recent years. This is particularly significant because the population of white seabass in southern California apparently has been reduced significantly by overfishing or other causes.

Therefore, it is clear that inner San Diego Bay is an important environment for marine fishes, both because of the variety of fish habitats present there and because those habitats serve as nurseries for the young of several important species. Such nursery habitats are important in maintaining the fish fauna of the entire bay and also contribute to populations, such as those of the California halibut and white seabass, whose adults live primarily on the open coast.

The purpose of the research described in this report was to make detailed analyses of existing data on the marine fishes of inner San Diego Bay in order to better understand their habitat requirements and size-specific seasonal patterns of distribution and abundance. The existing data sets include those from studies conducted for the San Diego Gas & Electric Company and the San Diego Unified Port District during the period 1968-1983 by Richard Ford, Lockheed and others. They also include the more comprehensive seasonal data sets obtained during 1988-1989 in studies of marine fishes conducted by Richard Ford and Michael Brandman Associates for the San Diego Unified Port District and the California State Coastal Conservancy (Mac Donald et al. 1989). Primary emphasis has been placed on the seasonal data obtained in the latter studies.

## MARINE ECOLOGICAL SAMPLING METHODS FOR FISHES

Quantitative sampling was conducted in South San Diego Bay as part of the study by Macdonald et al. (1989) study from July 1988 through May 1989 in order to provide seasonal ecological information about marine plants, invertebrates, and fishes associated with intertidal mudflat and subtidal habitats. The time periods during which these seasonal samples were taken were July 23-29, and November 7-14, 1988; February 20 - March 5, 1989; and associated measurements of important physical and chemical parameters were also made at each station location at the time of biological sampling.

The following subsections describe the locations of these sampling stations and the specific methods employed to take the samples of fishes in the field. Also described are the associated methods used to process and analyze these samples in the field or in the laboratory. In addition, the differences between these methods and methods employed in other previous studies of the area are discussed in order to assess how comparable are the data from these different studies.

## SAMPLING STATIONS

As indicated in Figures 2 and 3, this 1988-1989 ecological sampling was conducted at a total of 35 locations in South San Diego Bay. Ten stations were employed for sampling of the plant mat and invertebrates of the infauna, using an 0.1 m Van Veen grab. These were designated stations G-1 through G-10, with locations as shown in Figure 2.

The plant mat, larger epifaunal invertebrates, and demersal fishes associated with subtidal bottom areas were sampled by using a 5.5 m (18 ft.) otter trawl at the 17 station locations (T-1 through T-17) shown in Figure 3. Open water fishes were sampled at the two sampling stations designated GN-1 and GN-2 (Fgure 3), using 45.7 m (150 ft.) long multiple panel gill nets of five different mesh sizes. Marine plants, epifaunal invertebrates, and both demersal and open water fishes in the intertidal and adjacent shallow subtidal were sampled using 26 m (85 ft.) and 5.2 m (17 ft.) long beach seines at stations S-1 through S-16 (Figure 2).

## TRAWL SAMPLING

Two replicate otter trawl samples were taken at each of the 17 stations shown in Figure 3 (T-1 through T-17) during each quarterly sampling. A Marinovich otter trawl was towed by a 17 ft. Boston Whaler skiff equipped with a fathometer, gasoline powered trawling winch, and towing frame. The width of the mouth opening of this trawl was 5.5 m (18 ft.), measured along the lead line, and the length of the trawl from center of the lead line to the cod end was 4.5 m (14.8 ft.). The length of the head rope between the net wings and the board was 1 m (3 ft.). The body of the trawl had a mesh size of 17 mm (0.7 in.) square measure and mesh of 6 mm (0.25 in.) in the cod end area.

A weighted buoy line was first placed to mark the station point. The two replicate trawl hauls were then made by towing the net away from the station point. The replicate tows were made in opposite directions and were centered on the station point. Each tow was made for a duration of exactly 5 minutes from the time the net reached the bottom, and at a standard towing speed of 2.5 knots. The bottom area sampled by each 5 minute haul was estimated to be approximately 1,200 $m^2$. While these trawl hauls are not truly quantitative measures of the abundance of invertebrates and demersal fishes taken by them, they provide good, standard measures of relative abundance because they were all taken with the same duration and towing speed.

At the completion of each replicate haul, the contents of the net were removed and sorted into labelled plastic bags and placed on ice in ice chests. They were then transported to shore, where they were held in the ice chests until processed.

All material taken by the trawls was processed in the field, except for a limited number of species that required further examination under a microscope. All individuals taken in each haul were identified to species and enumerated. The total length of each individual was measured to the nearest 1 mm, using selected fish measuring board. In the case of very abundant species, which exceeded 150 individuals per haul, a randomly selected sample of 150 individuals was measured to provide representative size data for the larger group. Using a battery powered electronic balance, the aggregate wet weight biomass of each species was then determined to the nearest 1 g. All individuals of a given species were weighed in aggregate, even if their total number exceeded 150 individuals.

Each individual fish was examined for evidence of deformities, lesions or fin erosion. This information was used as a basis for assessing in a general way possible effects of pollutants on fishes in South San Diego Bay.

Larger epifaunal invertebrates taken in each replicate haul were processed in essentially the same way as described above for the fishes. They were identified to species or to the lowest possible taxonomic category and enumerated. Size measurements appropriate to the species were made on all or a representative subsample of individuals of most species. The aggregate blotted wet weight biomass of each species or taxon was then determined to the nearest 1 g.

The total blotted wet weight biomass of the algal and eelgrass mat was determined to the nearest 1 g. Estimates were also made of the percentage composition by volume of the primary plant species making up the plant mat.

The trawl sampling methods and associated analyses described above for the 1988-1989 study (Macdonald et al. 1989) were identical to those employed in the 1985-86 studies off Coronado Cays by Ford (1985, 1986a, 1986b). Therefore, the two sets of data are directly comparable.

The trawl sampling conducted as part of the San Diego Gas & Electric Co. studies by Ford (1968) and Ford et al. (1971a), employed a beam trawl with different characteristics than the otter trawl described above. This beam trawl had a fixed mouth opening of 1.5 m (4.9 ft.) and a length of 3-5 m (11.5 ft.). The net had a mesh size of 8 mm (0.3 in.) square measure, a cod end liner of 3 mm (0.1 in.). Towing speeds used were essentially the same, but the beam trawl was towed for 4 minutes, compared with 5 minutes for the otter trawl. Because of its smaller path width and shorter towing time, the beam trawl probably caught fewer larger individuals of most species than did the otter trawl. On the other hand, because of its smaller mesh size (8 mm), the beam trawl undoubtedly tended to catch larger numbers of small fish and invertebrates than did the otter trawl (17 mm mesh). Despite these differences, the data from samples obtained by the two trawls probably are fairly directly comparable, at least for purposes of general comparisons.

Other large scale trawling studies of central and southern San Diego Bay, such as those of Lockheed (1979, 1983) and SDG&E (1980), also employed Marinovich otter trawls. The baywide reconnaisance Lockheed (1979) conducted for the San Diego Port District Master Plan (SDUPD 1980) employed what was described as a 7.6 m (25 ft.) Marinovich semi-balloon otter trawl with a 38 mm (1.5 in.) mesh. This was towed for a standard duration of 5 minutes at a speed of 2 knots. Because of its larger path width and larger mesh size, this trawl would tend to take larger numbers of fishes of the larger sizes and fewer individuals of small size than the otter trawl described above for the 1988-1989 study (Macdonald et al. 1989). Therefore, the catch data obtained by the two methods are only generally comparable. The studies of fishes in industrial areas of central San Diego Bay conducted by Lockheed (1983) employed a smaller Marinovich otter trawl with a path width of 3.05 m (10 ft.) and a length of 4.3 m (14 ft.). The mesh size of this trawl was 19 mm (0.75 in.) square measure, with a cod end liner of 7 mm (0.25 in.) mesh. It was towed for 5 minutes at a speed of 2-3 knots. This trawl was essentially identical to that described above for the 1988-89 studies. Therefore, the data obtained by both trawls are directly comparable. The same trawl was employed in seasonal studies of fishes near Ballast Point by MBA (1989), the only difference being that tows were limited to 2 minutes duration.

## BEACH SEINE SAMPLES

Replicate samples were taken at each of 16 intertidal seining stations (S-1 through S-16), as shown in Figure 2. With the exception of tidal creek station S-13, two replicate samples each were taken by using two different types of seines. The first of these was a 26 m (85 ft.) long bag type beach seine. This larger seine had a wall height of 1.9 m (6.2 ft.) and a mesh size of 5 mm (0.2 in.) square measure. It was deployed from shore by using a 17 ft. or 13 ft. Boston Whaler skiff. When fully deployed, the 26 m seine sampled a mean path width of 20.5 m (range 19.5-21.6 based on 10 trials). The second type of seine used was a standard "mimmow seine" without a bag. This seine was 5.2 m (17.1 ft.) long with a wall height of 1.15 m 93.8 ft.) and a mesh size of 3 mm (0.1 in.). When fully deployed, the 5.2 m seine sampled a mean path width of 4.6 m (range 4.2-5.4 m based on 10 trials).

One replicate seine haul was made on each side of the station point, taking care that none of the four seine hauls made passed over the path of a previous haul. The material retained in each replicate haul was sorted into plastic bags with labels and maintained in ice chests until processing.

Station S-13 was located in a tidal creek of E the Street Marsh (Figure 2). At that location wall nets of 3 mm (0.1 in.) mesh were used to seal off a 10 m long section of the creek, which was 5 m wide at the high tide line. A 5.2 m minnow seine (see description above) was then used to make repeated seine hauls of the 50 $m^2$ area sealed off by wall nets in order to remove nearly all of the fishes present. Two replicate, 50 $m^2$ sections of the tidal creek were sampled in this way. The aggregate catches of all seine hauls made in each replicate section were then retained as the two replicate samples.

The plant mat, invertebrates, and fishes taken in each of the 26 m, 5.2 m, and tidal creek seine samples were processed in the field, using exactly the same methods described above for the trawl samples. In some cases, it was necessary to return smaller invertebrates and fishes to the laboratory for further examination under a microscope.

The beach seines employed in the studies at Coronado Cays by Ford (1985-86) were the same as those described above for the 1988-89 study. The smaller beach seine used in studies of the South Bay Power Plant (Ford 1968) was essentially the same as that described above for the 1988-89 studies. Therefore, the data obtained using this minnow seine are directly comparable. The larger bag seine employed by Ford (1968) was only 15.2 m (50 ft.) long with a wall height of 1.5 m (5 ft.) and a mesh size of 8 mm (0.3 in.) square measure, in contrast to the characteristics of the bag seine employed in 1988-89 (26 m; 5 mm mesh size). Therefore, the catches obtained by these two bag seines might be expected to differ, with smaller numbers of fish taken by the 15.2 m seine and fish of somewhat smaller size taken by the 26 m seine.

The specific characteristics of the beach seine used by Lockheed (1979) in their reconnaisance of San Diego Bay for the SDUPD (1980) Master Plan are not given in either of those reports. Therefore it is not possible to assess how comparable the data from the Lockheed study are to those obtained in the 1988-89 study. The seine employed by Hoffman (1986) in his evaluation of fishes associated with eelgrass beds was 15.2 m (50 ft.) long, with a wall height of 1.2 m (4 ft.) and a mesh size of 5 mm (0.2 in.). Because of its smaller path width, this seine probably took fewer individuals per haul than did the 26 m seine used in the 1988-89 studies (Macdonald et al. 1989). The 5 mm mesh size of Hoffman's seines probably also took somewhat smaller fishes than did the 26 m seine. However, the data obtained with these two seines should be fairly comparable.

## GILL NET SAMPLES

Monofilament gill nets were used in July, February, and May at two locations (Stations GN-1 and GN-2) in order to sample open water fishes and other fishes not normally taken by the otter trawl because of their size or their behavior (Macdonald et al. 1989). These special multi-panel gill nets were 45.7 m (150 ft.) long with a wall height of 2.4 m (8 ft.). They consisted of 10 separate gill net panels tied together, each panel being 4.6 m (15 ft.) long. The first five panels each had a different mesh size. Those mesh sizes were, in order, 1.3 cm (0.5 in.), 1.8 cm (0.75 in.), 2.5 cm (1 in.), 3.1 cm (1.25 in.), and 3.8 cm (1.5 in.) square measure. The repeating pattern of the second set of five panels was the same as described above. For purposes of this study, the two series of panels were considered as paired replicates.

These nets were deployed at the station location at 1700 hrs. and left in place until 0900 hrs. the following morning (15 hrs. fishing time). The lower edge of the net was held at the bottom by small lead weights on the line and by anchors attached to the spar buoys at each end of net array. Floats on the net itself and on the spars served to keep the top of the net at the surface. In the shallow water of the Station GN-1 and GN-2 locations (Figure 2), this means that the gill nets were always fishing in the water column from the surface to the bottom.

After the nets were pulled, they and the attached fishes were returned to shore in plastic trash cans. The fishes caught in each panel of the gill net were removed and held in separate plastic bags for processing. Data obtained for fishes taken in each of the five panel series of different mesh sizes were recorded separately as paired replicates. The fishes taken in the gill net samples were processed in the field, using exactly the same methods described above for the otter trawl and beach seine samples.

Similar, multipanel gill nets were employed in other large scale studies of inner and central San Diego Bay by SDG&E (1980) and Lockheed (1983). The seasonal studies by MBA (1989b) near Ballast Point in outer San Diego Bay employed a gill net array essentially identical to that described above for the 1988-89 studies of inner San Diego Bay, except that the MBA net lacked the smallest (1.3 cm) mesh size and had one larger mesh size (6.4 cm or 2.5 in.). The data obtained from all of this gill net sampling should, therefore, be directly comparable. It is important to note for most purposes, however, that gill nets of the same design deployed during the day often produce very different catches than those deployed at night, and that orientation of the nets can also affect what is caught.

## OTHER BIOLOGICAL SAMPLING METHODS

Studies by Ford (1968) and Lockheed (1979, 1983) also employed direct, quantitative observations by divers in order to census larger epifaunal invertebrates and fishes. The study by Ford (1968) also employed fish traps. The extensive entertainment and impingement studies by SDG&E (1980) made extensive use of round haul net sampling and intake screen sampling for open water fishes.

It is important to note that each of these special methods tends to take different species of fishes and that data from these methods are not directly comparable to those obtained by more standard methods such as trawl and beach seine sampling. Nevertheless, these special methods are very important in order to provide a more comprehensive picture of the fish fauna.

All of the sampling methods described above provide valuable information about a certain segment of the South San Diego Bay fish populations. None of the methods is truly quantitative, however, and while comparisions among different samples taken by the same method are generally valid, samples collected by different methods cannot be directly compared. Intercalibration of sampling gear, adequately randomized samples, and truly quantitative sampling schemes are obviously all highly desirable.However, because they are time and cost intensive, they are rarely performed.

The critical importance of sampling methods and their relative effectiveness must not be underestimated. The otter trawl, for example, is designed to sample bottom and near-bottom dwelling fishes. While it efficiently captures slower moving species, such as stingrays, faster moving species can avoid the trawl, while some small fishes may pass through the mesh. Calibration against a fixed-mouth beam trawl, specifically designed to collect quantitative samples of juvenile California halibut (Kramer and Hunter 1987, 1988), indicates that the otter trawl captures fewer small halibut (standard length <200 mm) per unit area than the quantitative device, but that both nets are about equally effective in capturing halibut 200-250 mm long. Similar calibration tests against widely used beach seines indicate they provide very poor abundance data for most shallow water species -- especially juvenile halibut. Despite these limitations of otter trawl and beach seine samples, it is the schools of anchovies (Engraulidae) and Atherinids (including Topsmelt) -- small, fast-moving, plantivorous pelagic fishes -- that are least likely to be adequately sampled. These are species typically captured in gill nets, but their abundances are usually seriously underestimated. John Hunter (NMFS, Southwest Fisheries Center, pers. comm.) suggests that these species may well represent the greatest biomass of fishes moving throughout San Diego Bay.

## PHYSICAL AND CHEMICAL SAMPLING

A series of measurements of physical and chemical characteristics were made at each subtidal station at the time each set of seasonal biological samples was taken. Water depth was measured using both a fathometer and a weighted line. The degree of clarity of the water was measured using a standard secchi disc. The temperature of the water at the surface and just above the bottom was measured using a Yellow Springs Instruments electronic thermister thermometer accurate to 0.1 °C. Dissolved oxygen content of the water was measured just above the bottom, using a Yellow Springs Instruments polarographic oxygen electrode unit accurate to 0.1 mg/L.

Water samples were taken just above the bottom, using a Van Dorn bottle, to determine salinity. These salinity samples were returned to the laboratory where the determinations were made on a Plessey salinometer accurate to 0.01 ppt.

These methods are essentially the same as those employed in the other ecological studies of fishes in South San Diego Bay considered in this report. Therefore, the data obtained are directly comparable.

## DATA SUMMARIES FOR 1988-89 SEASONAL STUDY OF FISHES

The complete, basic sets of ecological data on fishes taken in the samples are presented in detailed form in Volume IV of Macdonald et al. (1989). These data on fishes, epifaunal invertebrates, and plants taken in otter trawl samples are presented in Tables 14 - 17 of Macdonald et al. (1989, Vol IV). Those concerning fishes, epifaunal invertebrates, and plants of intertidal and shallow water and demersal fishes taken by the gill nets are shown in Vol. IV, Tables 8 - 13; similar data on open water and demersal fishes taken by gill nets are given in Tables 18 - 20.

Measurements of physical and chemical parameters made in conjunction with this biological sampling are shown in Tables 1 - 3 of Volume IV (MacDonald et al. 1989). None of those detailed data tables are reproduced in this report.

The data on fishes presented in Volume IV of Macdonald et al. 1989 provide one basis for the Tables and Figures, summaries and discussion presented in this section of the report. The data tabulations in Volume IV are also of direct value as baseline information for use in future ecological studies of South San Diego Bay and as one basis for carrying out and evaluating habitat restoration and mitigation projects in the area.

## THE FISH FAUNA OF INNER SAN DIEGO BAY

At least 67 species of bottom living and open water fishes are known to occur in South San Diego Bay. These species are listed in Table 1, in which the specific references to their occurrence are given. Ford et al. (1971b) reported taking only nine species of fishes in tidal creeks of the Sweetwater River and Paradise Creek Marshes. These species are listed in Table 2. All nine species also occur in other marine habitats of South San Diego Bay.

The fish fauna of inner San Diego Bay is typical in other shallow water embayments along the coast of southern California and Baja California. The dominant species in terms of abundance and biomass is the round stingray (*Urolophus halleri*). Other characteristic species include the horn shark (*Heterodontus francisci*), gray smoothhound shark (*Mustelus californicus*), leopard shark (*Triakis semifasciata*), deepbody anchovy (*Anchoa compressa*), slough anchovy (*A. delicatissima*), specklefin midshipman (*Porichthys myriaster*), California needlefish (*Strongylura exilis*), California killifish (*Fundulus parvipinnis*), topsmelt (*Atherinops affinis),* Jacksmelt (*A. californicus*), pipefishes (*Syngnathus spp.*), staghorn sculpin (*Leptocottus armatus*), spotted and barred sandbass (*Paralabrax maculatofasciatus* and *P. nebulifer*), queenfish (*Seriphus politus*), yellowfin croaker (*Umbrina roncador*), black croaker (*Cheilotrema saturnum*), shiner surfperch (*Cymatogaster aggregata*), striped mullet (*Mugil cephalus*), bay blenny (*Hypsoblennius gentilis*), at least seven species of gobies, (Table 1) the diamond turbot (*Hypsopsettsaguttulata*), the spotted turbot (*Pleuronichthys ritteri*), and the California halibut (*Paralichthys californicus*).

South San Diego Bay appears to be an important nursery area for juvenile California halibut and possibly for the young of spotted and barred sandbass and other species. Young of the year and larger juveniles of the white seabass (*Atractoscion nobilis*) have been taken in samples from South San Diego Bay during recent years. This is particularly significant because the population of white seabass in southern California apparently has been reduced significantly by overfishing or other causes.

The California halfbeak (*Hyporhamphus rosae*) seems to occur in South San Diego Bay primarily over more sandy intertidal and shallow subtidal areas such as those along the shoreline of Coronado Cays. While it probably is not abundant in the South Bay, its occurrence there is noteworthy.

The Pacific seahorse (*Hippocampus ingens*) is another unusual inhabitant of South San Diego Bay. It has been observed there and elsewhere in San Diego Bay in recent years only since the advent of warm water conditions produced by El Niño in the 1980's. The Pacific seahorse normally is not common in sourthern California, occurring primarily farther south in warmer waters along coast of Baja California. It appears that this species was able to move farther north during El Niño conditions and that a population has become established in the warmer areas of San Diego Bay (Jones et al. 1988).

Most of the other species listed in Table 1 are less common in South San Diego Bay than they are in central and northern areas of the bay. However, their occurrence in the South Bay suggests that there is relatively cosmopolitan distribution of many fish species throughout San Diego Bay. That conclusion is also supported by the fact that many of the abundant and characteristic fish species of inner San Diego Bay also occur in the central and outer areas of the bay, as discussed subsequently.

In the study by San Diego Gas & Electric Co. (1980), the following six additional species of marine fishes were observed in samples taken from the intake screens of the South Bay Power Plant during 316(b) impingement studies in 1979-1980:

FAMILY CARCHARINIDAE (Requiem Sharks)
*Prionace glauca* Blue shark
FAMILY EXOCETIDAE (Flying fishes)
*Cypselurus heterurus* California flyingfish
FAMILY SYNGNATHIDAE (Pipefishes and Seahorses)
*Syngnathus californiensis* Kelp pipefish
FAMILY SCORPAENIDAE (Scorpionfishes)
*Scorpaena guttata* Spotted scorpionfish
FAMILY GERREIDAE (Mojarras)
*Eucinistomus* sp. Mojarra
FAMILY SCORPIDIDAE (Halfmoon)
*Medialuna californicusis* Halfmoon

However, so few individuals of each were taken in these samples that these species must be consedered rare inhabitants of South San Diego Bay and probably are not regular residents there. For that reason they are not listed in Table 1.

It seems very likely that the individuals of these six species found on the intake screens were "strays" from their outer bay or open coast habitats. However, it is important to note that they were taken in South San Diego Bay. With them included, the total number of marine fishes observed in South San Diego Bay is 73.

## COMPARISON OF FISH SPECIES BETWEEN 1892 AND PRESENT

It is particularly instructive to compare the species composition of fishes from San Diego Bay reported by Eigenmann with that known from recent studies of South San Diego Bay. This comparison is provided in Table 1. Eigenmann reported a total of at least 56 species of fishes from the Bay. All of these species were also encountered in one or more of the recent studies in South San Diego Bay conducted since 1968 (Table 1), although some are not common in the South Bay. This suggests very strongly that the species composition of fish populations now living in South San Diego Bay (and in San Diego Bay in general) is probably essentially the same as it was under more natural conditions almost 100 years ago. Of course, there is no way to compare the relative abundances of these species between the two time periods, so that aspect cannot be considered.

As shown in Table 1, 44 species of fishes were taken in South San Diego Bay during the intensive seasonal sampling conducted as part of the study by Macdonald et al. (1989) during 1988-89. Of these 44, only four were not reported from San Diego Bay by Eigenmann (1892).

## TABLE 1

## SOUTH SAN DIEGO BAY

## BENTHIC AND OPEN WATER FISHES, 1892 - 1989

Species of benthic and open water fishes inhabiting South San Diego Bay which were taken subtidally in trawl, gill net, trap, fyke net, or round haul seines and by diver observation or intertidally in beach seine samples during the period 1968 to 1989. Species names are arranged by family. The accepted common name (Miller & Lea 1972) is given opposite the scientific name. The reports in which each species were listed are indicated with a "+" sign. Those reports are as follows: 1968 (Ford 1968 - trawls, traps and beach seines); 1971 (Ford et al 1971a - trawls); 1979 (Lockheed 1979a, San Diego Unified Port District 1980 - trawls, beach seines, diver observations); 1979-1980 (San Diego Gas & Electric Co 1980 - gill nets, fyke nets, round haul seines, beach seines); 1980-1981 (Hoffman 1986 - beach seines); 1982-1983 (Lockheed 1983 - trawls, gill nets, diver observations; 1985-1986 (Ford 1985, 1986b - trawls, beach seines); 1988-89 (this study - trawls, gill nets, beach seines). Species reported from San Diego Bay by Eigenmann (1892) are also indicated.

TABLE 1

| SCIENTIFIC NAME | COMMON NAME | YEARS OF RECORD 92 | 68 | 71 | 79 | 79-80 | 80-81 | 82-83 | 85-86 | 88-89 |
|---|---|---|---|---|---|---|---|---|---|---|
| FAMILY HETERODONTIDAE (Bullhead sharks) | | | | | | | | | | |
| Heterodontus francisci | Horn shark | + | | | | + | | + | | + |
| FAMILY CARCHARINIDAE (Requiem sharks) | | | | | | | | | | |
| Carcharhinus remotus | Narrowtooth shark | + | | | | + | | | | |
| Mustelus californicus | Gray smoothhound | + | + | + | | + | + | + | | + |
| Triakis semifasciata | Leopard shark | + | | | | + | + | + | + | + |
| FAMILY PLATYRHINIDAE (Thornbacks) | | | | | | | | | | |
| Platyrhinoidis triseriata | Thornback | + | | | + | | | | | + |
| FAMILY RHINOBATIDAE (Guitarfishes) | | | | | | | | | | |
| Rhinobatos productus | Shovelnose guitarfish | + | | | + | + | | + | | + |
| Zapteryx exasperata | Banded guitarfish | + | | | | + | | | | |
| FAMILY MYLIOBATIDIDAE (Bat rays) | | | | | | | | | | |
| Myliobatis californica | Bat ray | + | | + | | + | | | | + |
| FAMILY GYMNURIDAE (Butterfly rays) | | | | | | | | | | |
| Gymnura marmorata | Butterfly ray | + | | | | + | | | | |
| FAMILY DASYATIDAE (Stingrays) | | | | | | | | | | |
| Urolophus halleri | Round stingrays | + | + | + | + | + | + | + | + | + |
| FAMILY CLUPEIDAE (Herrings) | | | | | | | | | | |
| Dorosoma petense | Threadfin shad * | | | | | + | | | | |
| Clupea harengus pallasii | Pacific herring | + | | | | + | | | | |
| Sardinops sagax caeruleus | Pacific sardine | + | | | | + | | + | | |
| FAMILY ENGRAULIDAE (Anchovies) | | | | | | | | | | |
| Cetengraulis mysticetus | Anchoveta | | | | | + | | | | |
| Engraulis mordax | Northern anchovy | + | | | + | + | + | | | + |
| Anchoa compressa | Deepbody anchovy | + | + | + | + | + | + | + | | + |
| Anchoa delicatissima | Slough anchovy | + | + | + | + | + | + | | + | + |

## TABLE 1 (CON'T)

| SCIENTIFIC NAME | COMMON NAME | YEARS OF RECORD 92 | 68 | 71 | 79 | 79 80 | 80 81 | 82 83 | 85 86 | 88 89 |
|---|---|---|---|---|---|---|---|---|---|---|
| FAMILY BATRACHOIDIDAE (Toadfishes) | | | | | | | | | | |
| Porichthys myriaster | Specklefin midshipman | + | + | + | + | + | | + | | + |
| FAMILY HEMIRHAMPHIDAE (Halfbeaks) | | | | | | | | | | |
| Hyporhamphus rosae | California halfbeak | + | + | + | + | | + | | + | + |
| FAMILY BELONIDAE (Needlefish) | | | | | | | | | | |
| Strongylura exilis | California needlefish | + | | | | + | | + | | + |
| FAMILY CYPRINODONTIDAE (Killifish) | | | | | | | | | | |
| Fundulus parvipinnis | California killifish | + | + | + | + | + | + | | + | + |
| FAMILY ATHERINIDAE (Silversides) | | | | | | | | | | |
| Atherinopsis californiensis | Jacksmelt | + | | | | + | | + | + | + |
| Atherinops affinis | Topsmelt | + | + | + | + | + | | + | + | + |
| Leuresthes tenuis | California grunion | + | | | | + | + | | | |
| FAMILY SYNGNATHIDAE (Pipefishes and Seahorses) | | | | | | | | | | |
| Hippocampus ingens | Pacific seahorse | | | | | | | | + | + |
| Syngnathus leptorhynchus | Bay pipefish | + | + | + | | + | + | | + | + |
| Syngnathus auliscus | Barred pipefish | + | + | + | + | + | | | | |
| FAMILY COTTIDAE (Sculpins) | | | | | | | | | | |
| Leptocottus armatus | Staghorn sculpin | + | + | + | + | + | + | | + | + |
| FAMILY SERRANIDAE (Sea basses) | | | | | | | | | | |
| Morone (Roccus) saxatilis | Striped bass | | | | | + | | | | |
| Paralabrax chlathratus | Kelp bass | + | + | + | + | + | | | | + |
| Paralabrax maculatofasciatus | Spotted sand bass | + | + | + | + | + | + | + | + | + |
| Paralabrax nebulifer | Barred sand bass | + | + | + | + | + | + | + | + | + |
| FAMILY CARANGIDAE (Jacks) | | | | | | | | | | |
| Trachurus symmetricus | Jack mackeral | | | | + | + | | + | | |
| Caranx caballus | Green jack | | | | | + | | | | |
| Caranx hippos | Crevalle jack | | | | | + | | | | |
| FAMILY PRISTIPOMATIDAE (Grunts) | | | | | | | | | | |
| Xenistius californiensis | Salema | + | | | | | | + | | |
| Anisotremus davidsonii | Sargo | + | | | | | + | | | |

## TABLE 1 (CON'T)

| SCIENTIFIC NAME | COMMON NAME | YEARS OF RECORD | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 92 | 68 | 71 | 79 | 79 80 | 80 81 | 82 83 | 85 86 | 88 89 |
| FAMILY SCIAENIDAE (Croakers) | | | | | | | | | | |
| Seriphus politus | Queenfish | + | | | + | + | | + | | + |
| Atractoscion nobilis | White seabass | + | | | | + | | + | | + |
| Umbrina roncador | Yellowfin croaker | + | | | | + | + | + | | + |
| Menticirrhus undulatus | California corbina | + | | | | + | + | + | | + |
| Genyonemus lineatus | White croaker | + | | | | + | + | + | | + |
| Roncador stearnsii | Spotfin croaker | + | | | | + | | | | + |
| Cheilotrema saturnum | Black croaker | + | + | + | + | + | | + | | + |
| FAMILY EMBIOTOCIDAE (Surfperches) | | | | | | | | | | |
| Amphistichus argenteus | Barred surfperch | + | | | | + | | | | |
| Hyperprosopon argenteum | Walleye surfperch | + | | | | | + | | | |
| Cymatogaster aggegata | Shiner surfperch | + | | + | | + | + | + | + | + |
| Phanerodon furcatus | White seaperch | + | | | | + | | | | |
| FAMILY MUGILIDAE (Mullet) | | | | | | | | | | |
| Mugil cephalus | Striped mullet | + | + | + | + | + | + | | | + |
| FAMILY SPHYRAENIDAE (Barracuda) | | | | | | | | | | |
| Sphyraena argentea | California barracuda | + | | | | + | | + | | |
| FAMILY BLENNIIDAE (Combtooth blennies) | | | | | | | | | | |
| Hypsoblennius gentilis | Bay blenny | + | + | + | + | | + | | | + |
| FAMILY CLINIDAE (Clinids) | | | | | | | | | | |
| Heterostichus rostratus | Giant kelpfish | + | | | | | + | | + | + |
| FAMILY GOBIIDAE (Gobies) | | | | | | | | | | |
| Gobionellus longicaudus | Longtail goby | | | | | | | | | + |
| Gillichthys mirabilis | Longjaw mudsucker | + | + | + | + | + | | | | + |
| Lepidogobius lepidus | Bay goby | | | | | | + | | + | + |
| Acanthogobius flavimanus | Yellowfin goby | | | | | | | | | + |
| Ilypnus gilberti | Cheekspot goby | + | + | + | + | + | + | | + | + |
| Clevelandia ios | Arrow goby | + | + | + | + | + | + | + | + | + |
| Quietula y-cauda | Shadow goby | + | + | + | | | + | | | + |

## TABLE 1 (CON'T)

| SCIENTIFIC NAME | COMMON NAME | 92 | 68 | 71 | 79 | 79-80 | 80-81 | 82-83 | 85-86 | 88-89 |
|---|---|---|---|---|---|---|---|---|---|---|
| FAMILY SCOMBRIDAE (Mackerals) | | | | | | | | | | |
| _Scomber japonicus_ | Pacific mackeral | + | | | | | | + | | + |
| _Scomberomorus sierra_ | Sierra | | | | | | | + | | |
| _Sarda chiliensis_ | Pacific bonito | + | | | | + | | | | |
| FAMILY STROMATEIDAE (Butterfishes) | | | | | | | | | | |
| _Peprilus simillimus_ | Pacific butterfish | + | | | | + | | | | |
| FAMILY CYNOGLOSSIDAE (Tonguefish) | | | | | | | | | | |
| _Symphurus atricauda_ | California tonguefish | + | | | | | | + | | |
| FAMILY BOTHIDAE (Left handed flatfishes) | | | | | | | | | | |
| _Paralichthys californicus_ | California halibut | + | + | + | + | + | + | + | + | + |
| _Hippoglossina stomata_ | Bigmouth sole | | | | | + | | | | |
| FAMILY PLEURONECTIDAE (Right handed flatfishes) | | | | | | | | | | |
| _Pleuronichthys verticalis_ | Hornyhead turbot | | | | | + | | | | |
| _Pleuronichthys ritteri_ | Spotted turbot | + | | | | + | | + | + | + |
| _Hysopsetta guttulata_ | Diamond turbot | + | + | + | + | + | + | + | + | + |
| Total Number of Species | | 56 | 23 | 25 | 25 | 54 | 28 | 30 | 20 | 44 |

Column headings are YEARS OF RECORD.

* Introduced species from Central America and Eastern United States

## TABLE 2

**SALT MARSH TIDAL CREEK FISHES, 1971**

Species of marine fishes obtained with blocking nets and repeated seining in tidal creeks of the Sweetwater River and Paradise Creek Marshes, September 1971 (Ford et al 1971b).

| SCIENTIFIC NAME | COMMON NAME |
|---|---|
| FAMILY CYPRINODONTIDAE (Killifish) | |
| <u>Fundulus parvipinnis</u> | California killifish |
| FAMILY ATHERINIDAE (Silversides) | |
| <u>Atherinops affinis</u> | Topsmelt |
| FAMILY COTTIDAE (Sculpins) | |
| <u>Leptocottus armatus</u> | Staghorn sculpin |
| FAMILY MUGILIDAE (Mullet) | |
| <u>Mugil cephalus</u> * | Striped mullet |
| FAMILY GOBIIDAE (Gobies) | |
| <u>Gillichthys mirabilis</u> | Longjaw mudsucker |
| <u>Ilypnus gilberti</u> | Cheekspot goby |
| <u>Quietula y-cauda</u> | Shadow goby |
| FAMILY BOTHIDAE (Left handed flatfishes) | |
| <u>Paralichthys californicus</u> | California halibut |
| FAMILY PLEURONECTIDAE (Right handed flatfishes) | |
| <u>Hypsopsetta guttulata</u> | Diamond turbot |

* Observed, but not taken in samples

Those species are the pacific seahorse (*Hippscampus ingens*), the longtail goby (*Gobionellus longicaudus*), tha bay goby (*Lepidogobius lepidus*), and the yellowfin goby (*Acanthogobius flavimanus*). The Pacific seahorse occurs in the San Diego area only during warm water periods such as that produced by the recent El Niño, and, therefore, would not have been present at the time of Eigenmann's sampling. The three goby species apparently are uncommon in the Bay and most likely would have been missed by Eigenmann's less intensive collecting methods.

Records from the impingement study of 1979-1980 (San Diego Gas & Electric Co. 1980) also indicate that three species of introduced freshwater fishes were taken in very small numbers on the intake screens of the South Bay Power Plant. These are: carp (*Cyprinus carpio*), the golden shiner (*Notemigonus crysoleucas*) and an unidentified sunfish (*Lepomis* sp.) as shown in Table 1. It appears very likely that these fish were carried into South San Diego Bay from the adjacent Otay River or Sweetwater River freshwater drainages and became impinged on the intake screens of the power plant.

The threadfin shad (*Dorosoma petense*), which can live in both freshwater and seawater, is an introduced species (Table 1) not native to San Diego Bay. It was orginally introduced into California lakes from its native habitats in Central America and the eastern United States. Since that time it has also been taken in Long Beach Harbor and in several northern California bays (Miller and Lea 1972). The fact that it was taken in net samples and in samples of the intake screens suggests that at least a small population of threadfin shad inhabits or did inhabit San Diego Bay. The data reported by San Diego Gas & Electric Co. (1980) represent the first evidence of such a population in San Diego Bay.

At the present time the only species for which there is a commercial fishery in South San Diego Bay is the striped mullet. At least two commercial fisherman take this species off the Otay River entrance and elsewhere in the South Bay, using gill nets (John Duffy, California Department of Fish and Game, pers. comm.)

Other species taken by recreational fisherman in South San Diego Bay include the black croaker, yellowfin croaker, California halibut, spotted and barred sandbass, and possibly the diamond turbot and queenfish. It is important to note, however, that the California halibut population of inner San Diego Bay appears to consist primarily of juvenile and young adult fish smaller than the legal fishery size.

Fish species considered "unimportant" to man are, in fact, vital to the biological economy of the South Bay ecosystem. As the food web diagram of Figure 4 shows, only the striped mullet and topsmelt utilize detritus and lower organisms directly by ingesting sediment. The other fish species feed primarily on other smaller fishes, benthic or pelagic invertebrates, and algae. The California killifish, the shadow goby, and the barred pipefish, which are the most common small species of fishes living on or near the bottom, as well as the larger and very abundant round stingray, all prey upon a wide variety of smaller invertebrates. The slough anchovy is a filter feeder on small plankton. Larger species, such as the black croaker and sand basses, feed primarily on fishes, large crustaceans, and molluscs, while the diet of the California halibut is almost exclusively mysid crustaceans and small or medium size benthic and pelagic fishes. The smaller fishes generally live in holes or within the plant and bryozoan mats on the bottom and have protective patterns and coloration which allow them to avoid these predators. As shown in the food web diagram of Figure 5, fishes are an important source of food for a wide variety of marine birds.

Several detailed studies of fish species common in South San Diego Bay have been conducted elsewhere in southern California. They provide valuable information about the life history stages and population ecology of these species. These include studies of the life history and ecology of the round stingray (*Urolophus halleri*) by Babel (1967), species structure and distribution of the longjaw mudsucker (*Gillichthys mirabilis*) by Barlow (1963), comparative ecology and behavior of three common gobies (*Clevelandia ios, Ilypnus gilberti, and Quietula y-cauda*) by Brothers (1975), ecology of the topsmelt (*Atherinops affinis*) by Frank (1969), ecology of the California halibut (*Paralichthys californicus*) by Haaker (1975) and Kramer and Hunter (1987, 1988), and life history characteristics of the diamond turbot (*Hypsopsettaguttulata*) by Lane (1975).

Hoffman (1986) conducted a comparative study concerning utilization by fishes of eelgrass beds and adjacent non-vegetated bottom areas in San Diego Bay. One of his sampling sites was located along the western shoreline of inner San Diego Bay within the South Bay Wildlife Preserve just south of Emory Cove. Of the 36 species he captured in replicate seine hauls in these eelgrass and non-vegetated habitats in San Diego Bay, topsmelt (*Atherinops affinis*), shiner surfperch (*Cymatogaster aggregata*) and four species of gobies (*Clevelandia ios, Lepidogobius lepidus, Ilypnus gilberti* and *Quietula y-cauda*) 93% of the individuals taken. Six species, the topsmelt, shiner surfperch, spotted sandbass (*Paralabrax maculatofasciatus*), staghorn sulpin (*Leptocottus armatus*), round stingray (*Urolophus halleri*) and California halibut (*Paralichthys californicus*) formed more than 87% of the fish biomass sampled (Hoffman 1986). Pooled data from all three sampling sites in San Diego are shown in Table 3 for eelgrass bed habitats and in Table 4 for adjacent non-vegetated habitats. Based on his comparison of data shown in theses two tables, Hoffman (1986) concluded that more than twice as many individuals were caught in the seines at the eelgrass locations than at the non-vegetated locations. The mean number of fish species taken at the eelgrass locations was also approximately twice the number captured at the non-vegetated sites. Seasonal sampling at these sites indicated that the total numbers of individuals and total biomass of fishes inhabiting eelgrass beds tended to remain fairly stable over the year (Hoffman 1986). These results emphasize the importance of the eelgrass habitats of inner and central San Diego Bay in supporting fish populations. The recent strong recovery and spreading of the eelgrass habitat in these areas is, therefore, very encouraging.

Despite a relatively constant species list for southern California offshore fisheries (i.e., based on species presence/absence data only), these fisheries are known to have changed substantially over the past century. The dramatic decline of the Sardine fishery is commonly cited, but many other commercially important species have also experienced population declines. Anecdotal data suggest that broad changes in population patterns have occurred. Many regionally important commercial species have population centers well to the south, off Mexico and Central Amercia. Historically, large adults of these species were found year-round off the southern California coast and may have maintained local breeding populations. Additional adults and large numbers of younger fish would migratenorthward into southern California from their population centers on a seasonal basis. Today most commercial species are solely represented by seasonal migrant stocks and the large adults and local breeding populations formerly seen are gone. Development of coastal fisheries is undoubtedly responsible for some of these population changes (McEvoy 1986), but negative impacts from pollution, habitat modification, and coastal urbanization may also have played significant roles (John Hunter, NMFS, Southwest Fisheries Center, pers. comm.).

As noted above, comparison of San Diego Bay species lists from the 1988-89 sampling data with those of Eigenmann in the 1890s indicates the majority of species present have remained the same. In the absence of historical quantitative population data, however -- and in light of the apparent changes among offshore fish populations noted above -- it remains impossible to determine if the absolute and relative abundances of species populations seen in San Diego Bay today are the same or different from those of the past. Eigenmann's descriptive notes from the 1890s. as well as anecdotal data from local fisherman (Macdonald et al. 1989 Vol I, Appendix A), suggest the average size of that fish may have been larger and their densities higher throughout the Bay in the past than they are today.

## FISH POPULATION DATA: 1968, 1979-80, 1988-89

As noted in a previous section of this report, there are three principal sets of quantitative samples that describe the fish populations of South San Diego Bay. The earliest of these data sets (Ford 1968) included records from 1.5 m (4.9 ft.) beam trawls, 15.2 m (50 ft.) bag seines, and 4.6 m (15 ft.) minnow seines used to collect fish throughout South Bay during August 1968. These data -- presented as average species biomass (average grams wet weight per species, per replicate net haul) -- are summarized in Table 5 and displayed graphically in Figure 6.

The second major data set was collected as part of the 316(b) Impingement and Entrainment Demonstration Study for the San Diego Gas & Electric, South Bay Power Plant (San Diego Gas & Electric Co. 1980).This is a very important data set, but it is relatively unknown because of the limited distribution the report received. One of the requirements of this study was quantitative charaterization of the South Bay fish populations (i.e., the balanced indigenous population) that might be impacted by the power plant cooling water intake and outflow systems. Adult, juvenile, and larval fishes were all sampled, but data presentation and analysis emphasized "critical species" and numbers of fish rather than biomass data. The study was conducted over a year-long period, with samples collected approximately bimonthly from February 1979 through January 1980. Roundhaul seines, gill nets, beach seines and fyke nets were all used to quantitatively assess different elements of South Bay fish populations. These data -- presented as average annual species abundances (average number of individuals per species, per replicate net haul, per year) -- are summarized in Table 6.

The third data set is that collected as part of the 1988-89 study by Macdonald et al. (1989). As described, in the Methods section, different elements of the fish assemblage were again sampled using several techniques -- standard 5.5m (18-foot) otter trawls, gill nets, 26m (85-foot) bag-type beach seines and 5.3m (17-foot) minnow seines. Seasonal samples were collected in July and November 1988, March and May 1989. The sample locations occupied each season for the otter trawls and beach seines are shown in Figures 2 and 3, respectively. Figure 2 also shows the two gill net sampling locations. In all cases, both density data and biomass data were recorded for the fish samples taken at these sites during each seasonal period.

The complete data sets for each of the 1988-89 fish sampling times are included (as Tables 8 - 20) in the Field Data Appendix, Volume IV, of Macdonald et al. (1989). Summary data for the entire study year -- presented as average annual species abundances (average numbers of individuals per species, per replicate net haul, per year) -- are summarized in Table 7. These 1988-89 results can be generally compared with those in Table 6 for 1979-80. However, potential effects of differences in sampling design and sampling gear must also be considered.

## TABLE 3

San Diego Bay, Eelgrass Stations: Total Individuals and Biomass of Fish Collected, All Sampling Periods[1]

| Common Name | Species | Individual No. | Individual % | Biomass g | Biomass % |
|---|---|---|---|---|---|
| Topsmelt | Atherinops affinis | 4,927 | 39.5 | 15,525 | 47.5 |
| | Gobies | 5,308 | 42.6 | 647 | 2.0 |
| Arrow goby | Clevelandia ios | | | | |
| Bay goby | Lepidogobius lepidus | | | | |
| Cheekspot goby | Ilypbus gilberti | | | | |
| Shadow goby | Quietula y-cauda | | | | |
| Shiner surfperch | Cymatogaster aggregata | 1,410 | 11.3 | 5,735 | 17.5 |
| Bay pipefish | Syngnathus leptorhynchus | 184 | 1.5 | 162 | 0.5 |
| Spotted sandbass | Paralabrax maculatofasciatus | 172 | 1.4 | 1,786 | 5.5 |
| California Killifish | Fundulus parvipinnis | 128 | 1.0 | 630 | 1.9 |
| Deepbody anchovy | Anchoa compressa | 98 | 0.8 | 491 | 1.5 |
| Staghorn sculpin | Leptocottus armatus | 48 | 0.4 | 951 | 2.9 |
| | Unidentified Kyphosid (Hermosilla azurea?) | 30 | 0.2 | 313 | 1.0 |
| California halibut | Paralichthys californicus | 30 | 0.2 | 1,236 | 3.8 |
| Queenfish | Seriphus politus | 29 | 0.2 | 464 | 1.4 |
| Diamond turbot | Hypsopsetta guttulata | 23 | 0.2 | 577 | 1.8 |
| Giant kelpfish | Heterostichus rostratus | 20 | 0.2 | 452 | 1.4 |
| Round stringray | Urolophus halleri | 17 | 0.1 | 3,133 | 9.6 |
| California halfbeak | Hyporhamphus rosae | 10 | 0.1 | 49 | 0.1 |
| Barred sandbass | Paralabrax nebulifer | 8 | 0.1 | 88 | 0.3 |
| Sargo | Anisotremus davidsonii | 7 | 0.1 | 18 | 0.1 |
| Bay blenny | Hypsoblennius gentilis | 7 | 0.1 | 49 | 0.1 |
| Walleye surfperch | Hyperprosopon argenteum | 4 | - | 252 | 0.8 |
| Striped mullet | Mugil cephalus | 2 | - | 2 | - |
| Northern anchovy | Engraulis mordax | 2 | - | 3 | - |
| Slough anchovy | Anchoa delicatissima | 2 | - | 4 | - |
| Yellowfin croaker | Umbrina roncador | 1 | - | 120 | 0.4 |
| | Unidentified blenny | 1 | - | 5 | - |
| TOTAL | | 12,468 | | 32,692 | |

[1] Source: Hoffman (1986)

# TABLE 4

San Diego Non-Vegetated Stations: Total Individuals and Biomass of Fish Collected, All Sampling Periods[1]

| Common Name | Species | Individual No. | Individual % | Biomass g | Biomass % |
|---|---|---|---|---|---|
| Topsmelt | Atherinops affinis | 4,425 | 81.3 | 24,306 | 85.8 |
| | Gobies | 673 | 12.4 | 260 | 0.9 |
| Arrow goby | Clevelandia ios | | | | |
| Bay goby | Lepidogobius lepidus | | | | |
| Cheekspot goby | Ilyphus gilberti | | | | |
| Shadow goby | Quietula y-cauda | | | | |
| Deepbody anchovy | Anchoa compressa | 133 | 2.4 | 463 | 1.6 |
| Diamond turbot | Hypsopsetta guttulata | 46 | 0.8 | 453 | 1.6 |
| California killifish | Fundulus parvipinnis | 43 | 0.8 | 132 | 0.5 |
| Shiner surfperch | Cymatogaster aggregata | 25 | 0.5 | 90 | 0.3 |
| Bay pipefish | Syngnathus leptorhynchus | 17 | 0.3 | 24 | 0.1 |
| California halibut | Paralichthys californicus | 17 | 0.3 | 290 | 1.0 |
| Staghorn sculpin | Leptocottus armatus | 11 | 0.2 | 182 | 0.6 |
| California grunion | Leuresthes tenuis | 11 | 0.2 | 148 | 0.5 |
| Round stingray | Urolophus halleri | 10 | 0.2 | 755 | 2.7 |
| Walleye surfperch | Hyperprosopon argenteum | 6 | 0.1 | 563 | 2.0 |
| Giant kelpfish | Heterostichus rostratus | 5 | 0.1 | 9 | - |
| Leopard shark | Triakis semifasciata | 4 | 0.1 | 135 | 0.5 |
| Kelp surfperch | Brachyistius frenatus | 3 | 0.1 | 276 | 1.0 |
| Gray smoothhound | Mustelus californicus | 2 | - | 80 | 0.3 |
| California corbina | Menticirrhus undulatus | 2 | - | 7 | - |
| Bay blenny | Hypsoblennius gentilis | 2 | - | 19 | 0.1 |
| Blacksmith | Chromis punctipinnis | 1 | - | 125 | 0.4 |
| Northern anchovy | Engraulis mordax | 1 | - | 4 | - |
| Queenfish | Seriphus politus | 1 | - | 20 | 0.1 |
| White croaker | Genyonemus lineatus | 1 | - | 1 | - |
| California halfbeak | Hyporhamphus rosae | 1 | - | 1 | - |
| | Unidentified sculpin | 1 | - | 1 | - |
| TOTAL | | 5,441 | | 28,344 | |

[1]Source: Hoffman (1986)

To provide an evaluation of seasonal differences in distribution and abundance of fishes in South San Diego Bay, selected data sets from the 1988-89 study (Macdonald et al. 1989), are presented in graphical form. First, a sequence of histograms summarizes the density and biomass data, for these species, on an average annual and seasonal basis, for each separate set of samples: standard 5.5m (18-foot) otter trawls (Figures 7, 8); gill nets (Figures 9, 10); 26m (85-foot) bag-type beach seines (Figures 11, 12); and 5.2m (17-foot) minnow seines (Figures 13, 14). Examination of these figures and comparisons among them, graphically demonstrate the patterns of seasonal occurrence and relative abundance exhibited by different fish species effectively sampled by each collection method. Clearly, the fish populations of inner San Diego Bay must be sampled by all of these different methods in order to provide a representative picture of what species are present and in what relative abundances.

The second set of figures summarizes occurrence data (average number of individuals, average biomass, or both, as noted) for a number of prominent fish species, as sampled by one or more of the different methods employed. Species are presented in taxonomic sequence (Table 7), with otter trawl data presented first, followed by 26m bag seine records, and lastly by 5.2m minnow seine data. The species represented are as follows: the bat ray (*Myliobatis californica*, Figures 15, 16), round stingray (*Urolophus halleri*, Figures 17, 18), slough anchovy (*Anchoa delicatissima*, Figures 19, 20), topsmelt (*Atherinops affinis*, figures 21-23), Pacific staghorn sculpin), (*Leptocottus armatus*, Figure 24), spotted sandbass (*Paralabrax maculatofasciatus*, Figures 25, 26), barred sand bass (*Paralabrax nebulifer*, Figures 27, 28), arrow goby (*Clevelandia ios*, Figure 29), California halibut (*Paralichthys californicus*, Figures 30, 31), and diamond turbot (*Hypsopsetts guttulata*,, Figures 32, 33). These species are among the more abundant fish found in South Bay and many are represented in the food web diagrams presented in Figures 4 and 5.

The data presented in Tables 1-7 and Figures 7-33 suggest very strongly that the species composition, relative abundances, and biomass of demersal and open water fishes have remained very similar over the 21 year period 1968-1989. As in the case of the marine algal and invertebrate assemblages, this indicates that there probably have been few changes in environmental conditions over that period affecting the fish populations inhabiting South San Diego Bay.

As indicated in Table 7 and associated Figures 7 and 8, the most dominant species taken in otter trawls during 1988-89 was the round stingray (*Urolophus halleri*). This species taken in the highest densities and the greatest biomass, both overall and at each seasonal sampling period. Clearly, it is a key predator in both the subtidal and intertidal mudflat habitats of South San Diego Bay, and one which undoubtedly has a significant impact on many of the invertebrate populations.

Second in abundance was the slough anchovy (*Anchoa delicatissima*). Third in abundance and second in biomass overall was the California halibut (*Paralichthys californicus*), which in the study area consisted primarily of juveniles and small adults. As shown in Figure 8, the California halibut was second highest in biomass in July, November, and February 1988-89, and third in biomass following the spotted sandbass (*Paralichthys maculatofasciatus*) in May 1989.

Figures 7-14 are particularly instructive in showing the overall ranking and levels of abundance and biomass for these and other fish species. They also indicate the patterns of seasonal change that occur in density and biomass for each species. It is evident in Figure 8 (otter trawl) and Figure 12 (26m seine) that densities of most species were lowest in November and highest in May. However, there were some exceptions to this.

As shown in Figures 15 and 16, the bat ray (*Myliobatis californica*) occurred very infrequently in otter trawl and 26 m seine samples, but contributed substantially to the biomass of those samples in which it did occur. This species probably was able to avoid the trawl and seine sampling gear most of the time, so it is unlikely that it was sampled accurately in relation to its true abundance in the South Bay.

In contrast, as shown in Figures 17 and 18, the round stingray (*Urolophus ahlleri*) was taken in nearly all replicate otter trawl and 26m seine samples. These two figures illustrate its distribution throughout the entire South San Diego Bay area.

As shown in Figure 21, the topsmelt (*Atherinops affinis*) was taken infrequently in otter trawl samples, in part because it occurs primarily near the surface. The density and biomass data for *Atherinops affinis* shown in Figure 22 (26m seine) give a much more accurate representation of its distribution and biomass throughout South San Diego Bay.

Data for the spotted sandbass (*Paralabrax maculatofasciatus*) in Figures 25 (otter trawl) and 26 (26m seine) show that it has a wide distribution through the South Bay. In general, density and biomass of this species were higher in February and May than in July and November, although there were some exceptions to this (Figures 25, 26).

The barred sandbass (*Paralabrax nebulifer*) also occurred throughout the South Bay, as shown in Figures 27 and 28. Biomass of this species was generally highest in November and May.

As shown in Figure 29, the arrow goby (*Cleveland ios*) was very abundant throughout the South Bay, as it is in most similar estuarine habitats elsewhere in sourthern California. Densities of this species were highest at most South San Diego Bay stations in May 1989 (Figure 29).

Data for the California halibut (*Paralichthys californicus*) and the diamond turbot (*Hypsosetta guttulata*) summarized in Figures 30-33 show that both species were widely distributed throughout South San Diego Bay and were taken at relatively high densities and levels of biomass throughout the year. As shown in Figure 32, the catches of *Hypsosetta guttulata* were quite variable from one station location to another.

## A COMPARISON OF THE FISH POPULATIONS OF INNER AND OUTER SAN DIEGO BAY

In order to provide a convenient comparison between fish populations found within the relatively protected tidal shallows of South San Diego Bay and those more typical of deeper water, more vigorously flushed habitats near the bay's ocean entrance, data from a recent study at Ballast Point, north San Diego Bay are presented in Figures 34 and 35. Average annual abundance (mean number of individuals per species, per replicate net catch, per year) and average annual biomass (average grams wet weight per species, per replicate net catch, per year) data for otter trawl (Figure 34) and gill net (Figure 35) sample sets are presented. Samples were collected at the U.S. Navy ARCO Drydock site and at a control area immediately adjacent to Ballast Point, in February, April, July and October 1988, using methods generally similar to those of Macdonald et al. (1989) (see methods). Details concerning the sampling program and an analysis of study results are presented in MBA (1989a).

# TABLE 5

## SOUTH SAN DIEGO BAY
## AVERAGE ANNUAL BIOMASS OF FISH, AUGUST 1968[a]

| FAMILY NAME<br>Species Name | 1.5 m<br>Beam<br>Trawl | 15 m<br>Bag Seine | 4.6 m<br>Minnow<br>Seine |
|---|---|---|---|
| DASYATIDAE | | | |
| Urolophus halleri | 25.40 | 5.80 | |
| ENGRAULIDAE | | | |
| Anchoa delicatissima | 0.40 | 0.10 | 2.70 |
| BATRACHOIDIDAE | | | |
| Porichthys myriaster | 0.03 | | |
| HEMIRHAMPHIDAE | | | |
| Hyporhamphus rosae | | | 1.60 |
| LYPRINODONTIDAE | | | |
| Fundulus parvipinnis | 0.40 | 18.50 | 5.60 |
| ATHERINIDAE | | | |
| Atherinops affinis | 0.01 | 7.80 | 1.10 |
| SYNGNATHIDAE | | | |
| Syngnathus auliscus | 3.20 | 3.30 | 1.00 |
| COTTIDAE | | | |
| Leptocottus armatus | | 4.50 | |
| SERRANIDAE | | | |
| Paralabrax clathratus | 0.01 | | |
| Paralabrax maculatofasciatus | 0.20 | | |
| GOBIIDAE | | | |
| Gillichthys mirabilis | 0.04 | 1.00 | 0.30 |
| Ilypnus gilberti | 0.01 | | 0.07 |
| Clevelandia ios | 0.07 | | 0.10 |
| Quietula y-cauda | 2.30 | | 0.10 |
| BOTHIDAE | | | |
| Paralichthys californicus | 5.10 | | |
| PLEURONECTIDAE | | | |
| Hypsopsetta guttulata | 3.60 | | |

a. Average biomass (grams wet weight) per replicate net haul using three different sampling methods. Sampling conducted during August 1968; see Ford (1968) for sample locations and additional explanation.

# TABLE 6

## SOUTH SAN DIEGO BAY
## AVERAGE ANNUAL ABUNDANCE OF FISH, 1979-1980.[a]

| FAMILY NAME<br>Species Name | Roundhaul Seines | Gill Nets | Beach Seines | Fyke Nets |
|---|---|---|---|---|
| HETERODONTIDAE | | | | |
| Heterodontus francisci | | 0.10 | | |
| CARCHARINIDAE | | | | |
| Carcharhinus remotus | | 0.03 | | |
| Mustelus californicus | 0.30 | 3.62 | | |
| Triakis semifasciata | | 0.42 | | |
| RHINOBATIDAE | | | | |
| Rhinobatos productus | 0.10 | 0.02 | | |
| MYLIOBATIDIDAE | | | | |
| Myliobatis californica | 1.47 | 0.05 | 0.03 | |
| DASYATIDAE | | | | |
| Urolophus halleri | 33.08 | 0.02 | 1.68 | 2.35 |
| ALBULIDAE | | | | |
| Albula vulpes | | 3.26 | | |
| CLUPEIDAE | | | | |
| Clupea harengus pallasii | | 0.03 | 0.08 | |
| Sardinops sagax caeruleus | 0.03 | 2.23 | | |
| ENGRAULIDAE | | | | |
| Cetengraulis mysticetus | 0.13 | | 1.33 | |
| Engraulis mysticetus | 0.12 | | 0.75 | |
| Anchoa compressa | 6.92 | 0.76 | 2.23 | 0.15 |
| Anchoa delicatissima | 50.70 | 0.04 | 22.05 | 1.15 |
| BATRACHOIDIDAE | | | | |
| Porichthys myriaster | 0.25 | 0.92 | | |
| HEMIRHAMPHIDAE | | | | |
| Hyporhampus rosae | | | 0.95 | |
| BELONIDAE | | | | |
| Strongylura exilis | 0.30 | 2.52 | 0.32 | |
| CYPRINODONTIDAE | | | | |
| Fundulus parvipinnis | | | 1.53 | |

TABLE 6 (CON'T)

| FAMILY NAME<br>Species Name | Roundhaul Seines | Gill Nets | Beach Seines | Fyke Nets |
|---|---|---|---|---|
| ATHERINIDAE | | | | |
| Atherinopsis californiensis | 0.57 | 8.96 | 0.20 | |
| Atherinops affinis | 3.35 | 0.29 | 69.73 | 44.30 |
| Leuresthes tenuis | | | 2.25 | |
| SYNGNATHIDAE | | | | |
| Syngnathus leptorhynchus | | | 0.03 | |
| Syngnathus auliscus | | | 0.08 | |
| Syngnathus spp. | | | | 0.15 |
| COTTIDAE | | | | |
| Leptocottus armatus | | | 1.73 | 0.35 |
| SERRANIDAE | | | | |
| Paralabrax chlathratus | | 0.02 | | |
| Paralabrax maculatofasciatus | 1.75 | 0.23 | | |
| Paralabrax nebulifer | 2.88 | 0.48 | | |
| CARANGIDAE | | | | |
| Trachurus symmetricus | | 1.20 | | |
| Caranx caballus | | 0.02 | | |
| Caranx hippos | | 0.02 | | |
| SCIAENIDAE | | | | |
| Seriphus politus | 2.23 | 3.76 | | 0.15 |
| Cynoscion nobilis | 0.03 | 0.19 | | |
| Cheilotrema saturnum | 0.38 | 0.86 | | |
| Genyonemus lineatus | | 0.11 | | |
| Menticirrhus undulatus | 0.03 | 0.41 | | |
| Roncador stearnsi | 0.10 | 0.41 | | |
| Umbrina roncador | 0.01 | 5.94 | | |
| EMBIOTOCIDAE | | | | |
| Cymatogaster aggregata | 0.32 | 0.06 | | |
| MUGILIDAE | | | | |
| Mugil cephalus | 0.03 | 2.91 | | 0.15 |
| GOBIIDAE | | | | |
| Coryphopterus nicholsii | | | 0.03 | |
| Gillichthys mirabilis | | | 0.03 | |
| Ilypnus gilberti | | | 0.70 | |

TABLE 6 (CON'T)

| FAMILY NAME<br>Species Name | Roundhaul Seines | Gill Nets | Beach Seines | Fyke Nets |
|---|---|---|---|---|
| Clevelandia ios | 2.30 | | 23.27 | |
| SCOMBRIDAE | | | | |
| Sarda chiliensis | | 0.82 | | |
| STROMATEIDAE | | | | |
| Peprilus simillimus | 0.32 | 0.11 | | |
| BOTHIDAE | | | | |
| Paralichthys californicus | 5.33 | 0.17 | 1.23 | 0.15 |
| PLEURONECTIDAE | | | | |
| Pleuronichthys verticalius | 0.10 | | 0.03 | |
| Pleuronichthys ritteri | 0.17 | 0.02 | | |
| Hysopsetta guttulata | 1.18 | 0.04 | 0.78 | 0.35 |

a. Average number of individuals per replicate net haul using four different sampling methods. Sampling conducted approximately bimonthly, February 1979 through January 1980; see SDG&E Co. (1980) for sample locations and additional explanation.

# TABLE 7

## SOUTH SAN DIEGO BAY
## AVERAGE ANNUAL ABUNDANCE OF FISH, 1988-89.[a]

| FAMILY NAME<br>Species Name | Otter<br>Trawl | Gill<br>Nets | 26m<br>Seine | 5.2m<br>Seine | Stn.13<br>Seine |
|---|---|---|---|---|---|
| CARCHARINIDAE | | | | | |
| Mustelus californicus | 0.10 | 9.70 | 0.05 | | |
| Triakis semifasciata | | 1.70 | 0.07 | | |
| PLATYRHINIDAE | | | | | |
| Platyrhinoidis triserata | 0.0[c] | | | | |
| RHINOBATIDIDAE | | | | | |
| Rhinobatos productus | | | 0.08 | | |
| MYLIOBATIDIDAE | | | | | |
| Myliobatis californica | 0.10 | | 0.03 | | |
| DASYATIDAE | | | | | |
| Urolophus halleri | 17.30 | 1.00 | 11.05 | 0.05 | |
| ENGRAULIDAE | | | | | |
| Engraulis mordax | | | 0.05 | | |
| Anchoa compressa | 0.90 | 27.30 | 0.60 | | |
| Anchoa delicatissima | 3.90 | | 1.50 | 0.53 | |
| SYNODONTIDAE | | | | | |
| Synodus lucioceps | 0.0[c] | | | | |
| BATRACHOIDIDAE | | | | | |
| Porichthys myriaster | 0.20 | | 0.02 | | |
| HEMIRHAMPHIDAE | | | | | |
| Hyporhamphus rosae | | 0.70 | 0.15 | | |
| BELONIDAE | | | | | |
| Strongylura exilis | | 1.70 | | | |
| CYPRINODONTIDAE | | | | | |
| Fundulus parvipinnis | | | 2.55 | 2.78 | 2.50 |
| ATHERINIDAE | | | | | |
| Atherinopsis californiensis | | 2.70 | | | |
| Atherinops affinis | 0.10 | 5.00 | 29.62 | 6.85 | |
| SYNGNATHIDIDAE | | | | | |
| Hippocampus ingens | 0.10 | | | | |
| Syngnathus leptorhynchus | 0.50 | | 0.87 | 0.37 | |

## TABLE 7 (CON'T)

| FAMILY NAME<br>Species Name | Otter Trawl | Gill Nets | 26m Seine | 5.2m Seine | Stn.13 Seine |
|---|---|---|---|---|---|
| COTTIDAE | | | | | |
| Leptocottus armatus | 0.10 | | 8.27 | 1.30 | |
| SERRANIDAE | | | | | |
| Paralabrax chlathratus | | 0.30 | | | |
| Paralabrax maculatofasciatus | 0.90 | 2.30 | 0.33 | | |
| Paralabrax nebulifer | 0.80 | | 0.97 | 0.02 | |
| SCIAENIDAE | | | | | |
| Seriphus politus | 0.0[c] | | 0.83 | 0.02 | |
| Atractoscion nobilis | 0.0[c] | 3.00 | | | |
| Umbrina roncador | 0.20 | 28.70 | | | |
| Menticirrhus undulatus | | 0.30 | | | |
| Genyonemus lineatus | 0.0[c] | | | | |
| Roncador stearnsii | | 0.30 | | | |
| Cheilotrema saturnum | 0.10 | 0.30 | | | |
| EMBIOTOCIDAE | | | | | |
| Cymatogaster aggegata | 0.40 | | 1.92 | 0.08 | |
| MUGILIDAE | | | | | |
| Mugil cephalus | | 3.70 | 0.37 | | |
| BLENNIIDAE | | | | | |
| Hypsoblennius gentilis | 0.10 | | 0.02 | | |
| CLINIDAE | | | | | |
| Heterostichus rostratus | 0.30 | 0.30 | 0.13 | 0.02 | |
| GOBIIDAE | | | | | |
| Gobionellus longicauda | | | 0.03 | | |
| Gillichthys mirabilis | | | 0.08 | | 27.00 |
| Lepidogobius lepidus | 0.0[c] | | 0.18 | 0.03 | |
| Acanthogobius flavimanus | 0.10 | | 0.07 | | |
| Ilypnus gilberti | 0.80 | | 1.20 | 0.20 | 2.00 |
| Clevelandia ios | | | 1.73 | 42.63 | |
| Quietula y-cauda | | | 0.68 | 0.25 | |
| SCOMBRIDAE | | | | | |
| Scomber japonicus | | 3.70 | | | |
| BOTHIDAE | | | | | |
| Paralichthys californicus | 3.20 | 0.30 | 0.77 | 0.08 | |

TABLE 7 (CON'T)

| FAMILY NAME<br>Species Name | Otter<br>Trawl | Gill<br>Nets | 26m<br>Seine | 5.2m<br>Seine | Stn.13<br>Seine |
|---|---|---|---|---|---|
| PLEURONECTIDAE | | | | | |
| Pleuronichthys ritteri | 0.10 | | 0.30 | 0.07 | |
| Hysopsetta guttulata | 0.70 | | 0.78 | 0.07 | |

a. Average number of individuals per replicate net haul using four different sampling methods. Sampling conducted July and November 1988, March and May 1989; see text for additional explanation.

b. Station 13, July 1988 and March 1989 seine hauls in Sweetwater Marsh tidal creek. See text for futher details.

c. Present; average abundance less than 0.05 individuals per replicate net haul.

Comparison of the 1988 data for the Ballast Point site (Figures 34, 35) with those obtained in the South Bay during essentially the same time period (Table 1 and Figures 7, 9) indicates that there were a number of obvious differences in species composition between the two sites. Twenty fish species were taken at the outer bay site that were not taken in the South Bay during 1988-89. Those species were:

| | |
|---|---|
| *Citharichthys stigmaeus* | speckled sanddab |
| *Gibbonsia montereyensis* | crevice kelpfish |
| *Symphurus atricauda** | California tonguefish |
| *Xystreurys liolepis* | fantail sole |
| *Scorpaena guttata** | scorpionfish |
| *Chilara taylori* | spotted cusk-eel |
| *Porichthys notatus* | plainfin midshipman |
| *Synodus lucioceps* | California lizardfish |
| *Sphyraena argentea** | California barracuda |
| *Halichoeres semicinctus* | rock wrasse |
| *Damalichthys vacca* | pile surfperch |
| *Phanerodon furcatus** | white seaperch |
| *Hyperprosopon argenteum** | walleye surfperch |
| *Embiotica jacksoni* | black surfperch |
| *Brachyistius frenatus* | kelp surfperch |
| *Anisotremus davidsoni* | sargo |
| *Trachurus symmetricus* | jack mackerel |
| *Sardinops sagax caeruleus* | Pacific sardine |
| *Mustelus henlei* | brown smoothhound |
| *Girella nigricans* | opaleye |

However, as shown in Table 1, eight of these (indicated above with an asterisk) were taken in other fish sampling of South Bay during the period 1979-1986. The remaining 12 species listed above are fishes with stronger ecological affinities for open coast habitats. Therefore, they might be expected to occur in the outer portion of San Diego Bay, but not in the South Bay.

Conversely, there were at least eight species taken in South Dan Diego Bay during 1988-89 that were not taken in the Ballast Point samples (Table 1, Figures 34, 35). Excluded from consideration are all goby species, which were not included in the Ballast Point study. Those species were:

| | |
|---|---|
| *Anchoa compressa* | deepbody anchovy |
| *Anchoa delicatissima* | slough anchovy |
| *Hyporhamphus rosae* | California halfbeak |
| *Strongylurus exilis* | California needlefish |
| *Hippocampus ingens* | pacific seahorse |
| *Syngnathus leptorhynchus* | bay pipefish |
| *Leptocottus armatus* | staghorn sculpin |
| *Hypsoblennius gentilis* | bay blenny |

All of these species are common in the central and inner parts of San Diego Bay and, therefore, would not be expected primarily to occur near Ballast Point.

As shown in Table 1 and Figures 34 and 35, there were at least 30 species of fishes which occurred in samples at both the Ballast Point and South San Diego Bay studies during 1988-89. Comparisons of the data on densities between Figures 7 and 9 and Figures 34 and 35 further suggests that the abundances of most of the 30 species were generally similar at both the outer and south Bay sites. However, because of the shorter trawl hauls made at the Ballast Point site (MBA 1986), it was not possible to make direct comparisons.

These results suggest that the two sites support many (30) of the same species of demersal and open water fishes. The outer Bay site differs primarily in having many additional species (20) with affinities to open coast habitats, while the South Bay sites support some species (8) not normally found in the outer portion of San Diego Bay.

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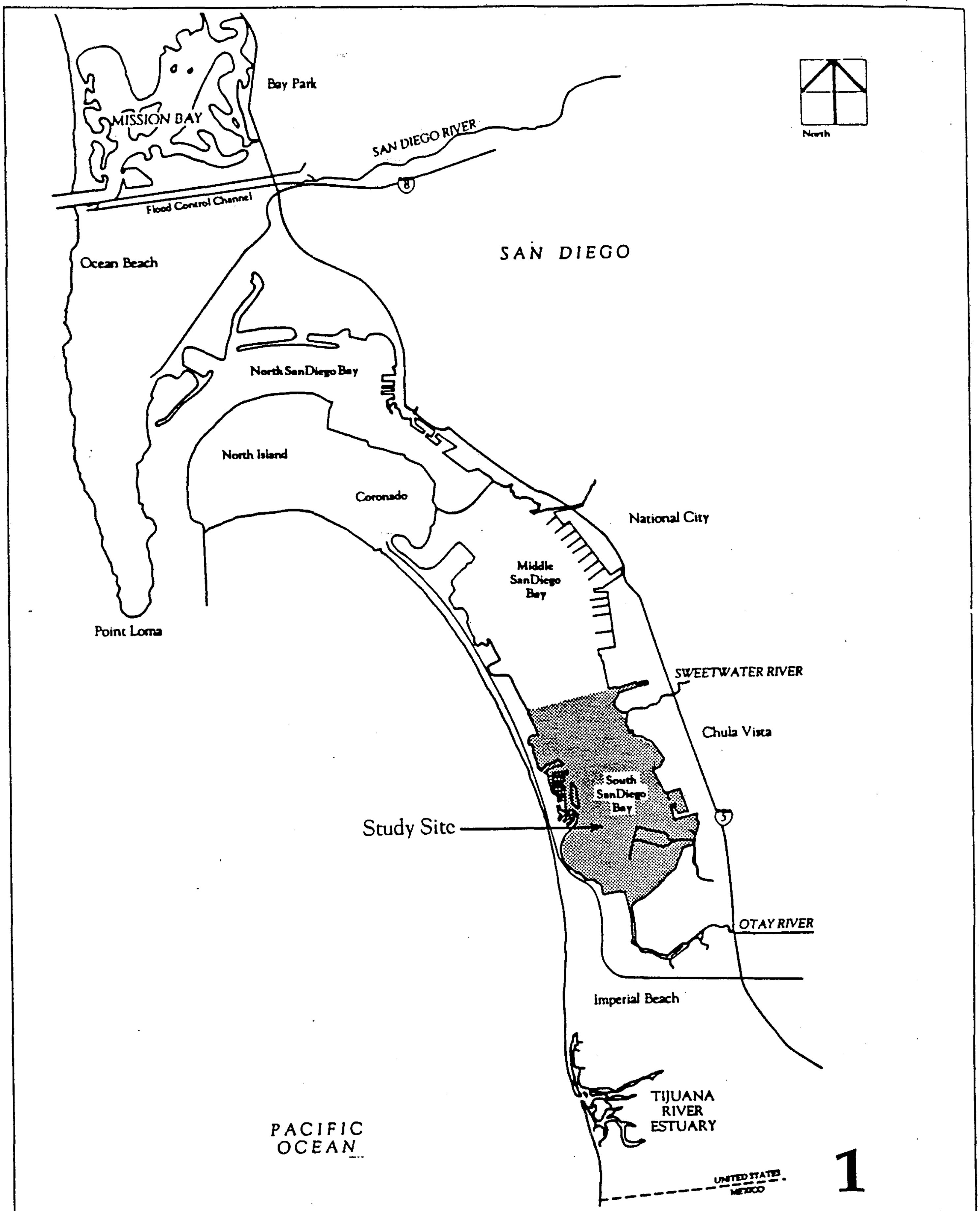



Regional Location Map

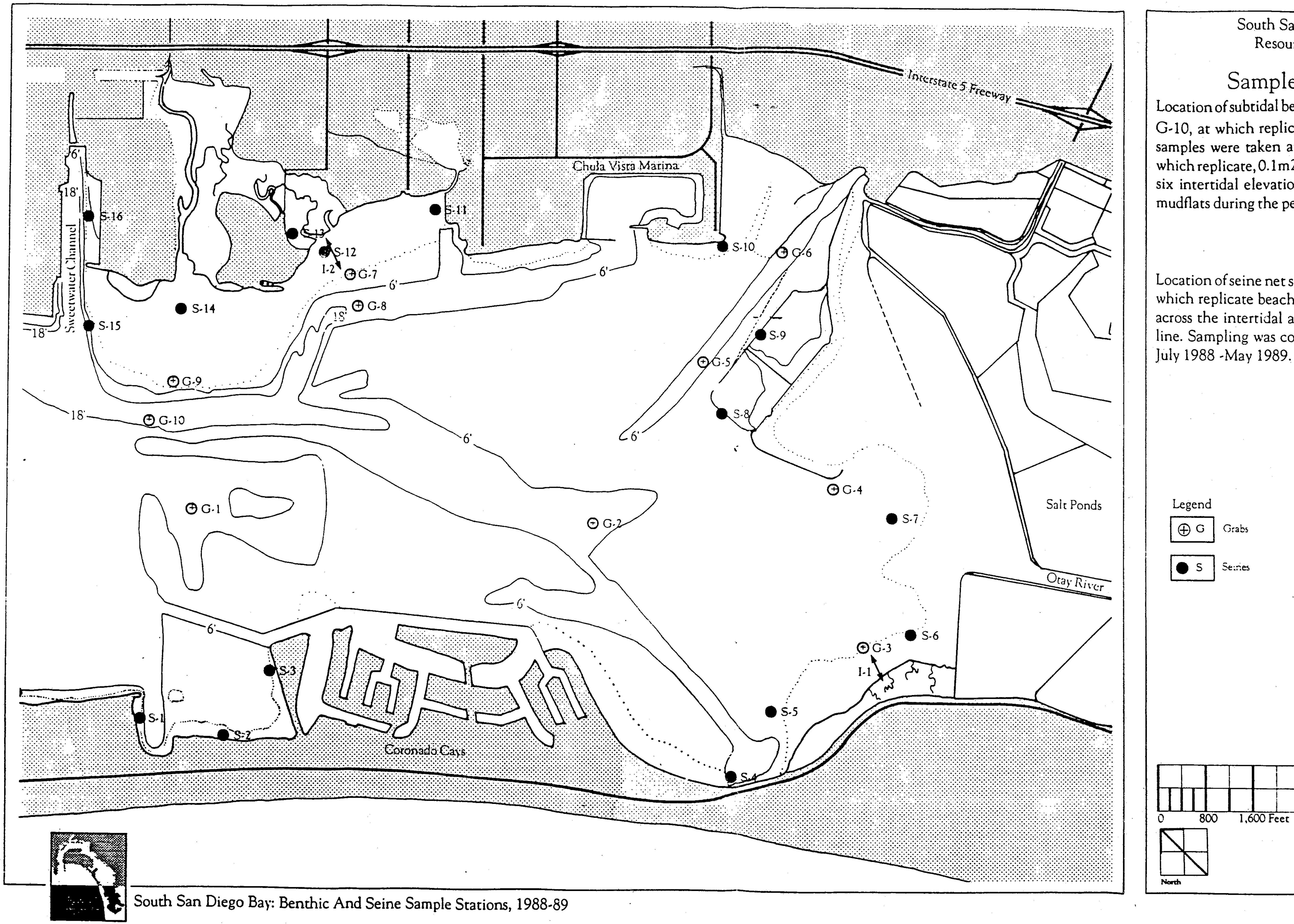
Figure No. 1

South San Diego Bay
Resources Atlas

## Sample Stations

Location of subtidal benthic stations G-1 through G-10, at which replicate, 0.1m² Van Veen grab samples were taken and stations I-1 and I-2, at which replicate, 0.1m2 core samples were taken at six intertidal elevations along a transect of the mudflats during the period July 1988 - May 1989.

Location of seine net stations S-1 through S-15 at which replicate beach seine samples were taken across the intertidal and shallow subtidal shoreline. Sampling was conducted during the period July 1988 -May 1989.




South San Diego Bay: Benthic And Seine Sample Stations, 1988-89

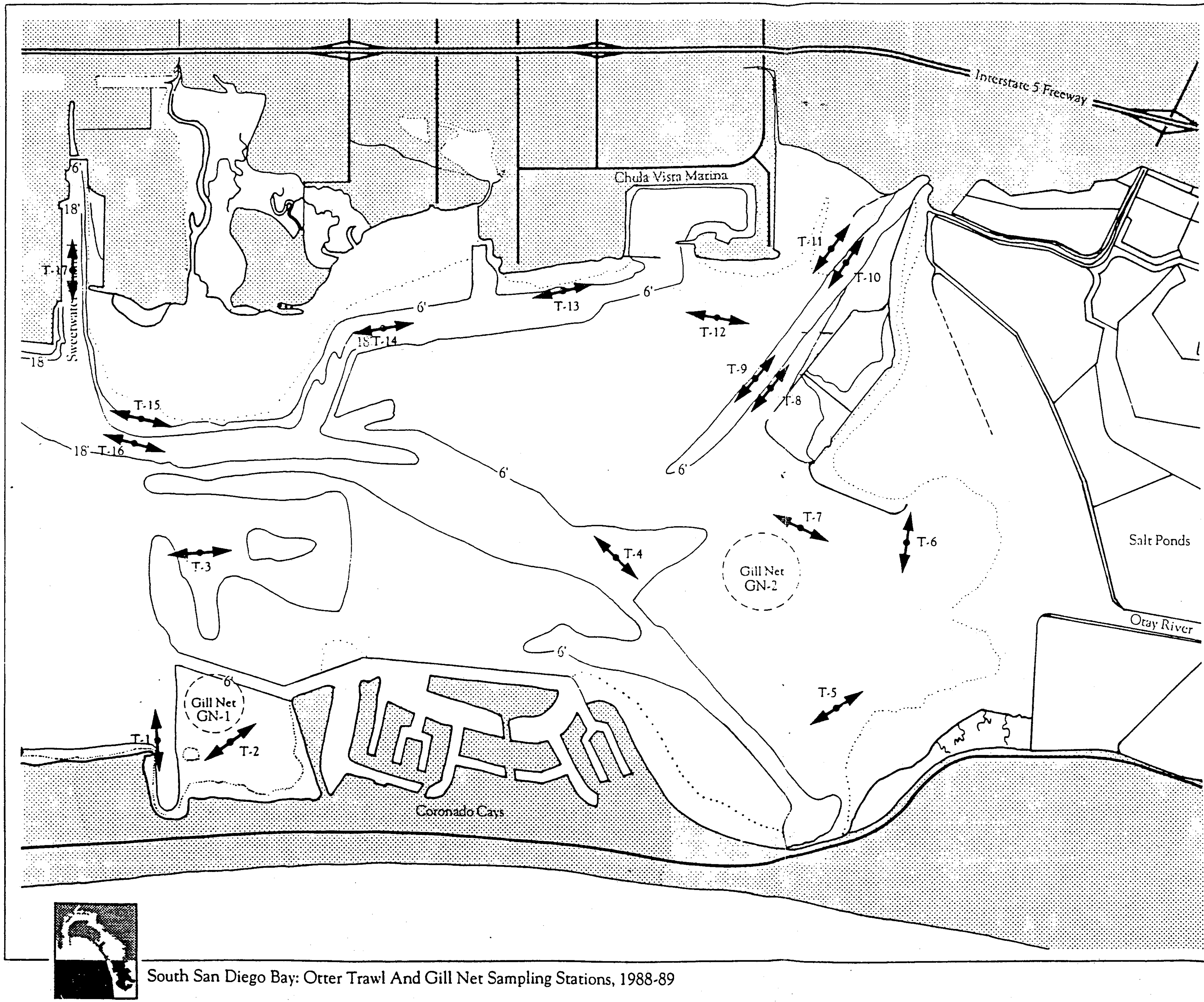
Figure No. 2

South San Diego Bay
Resources Atlas

## Sample Stations

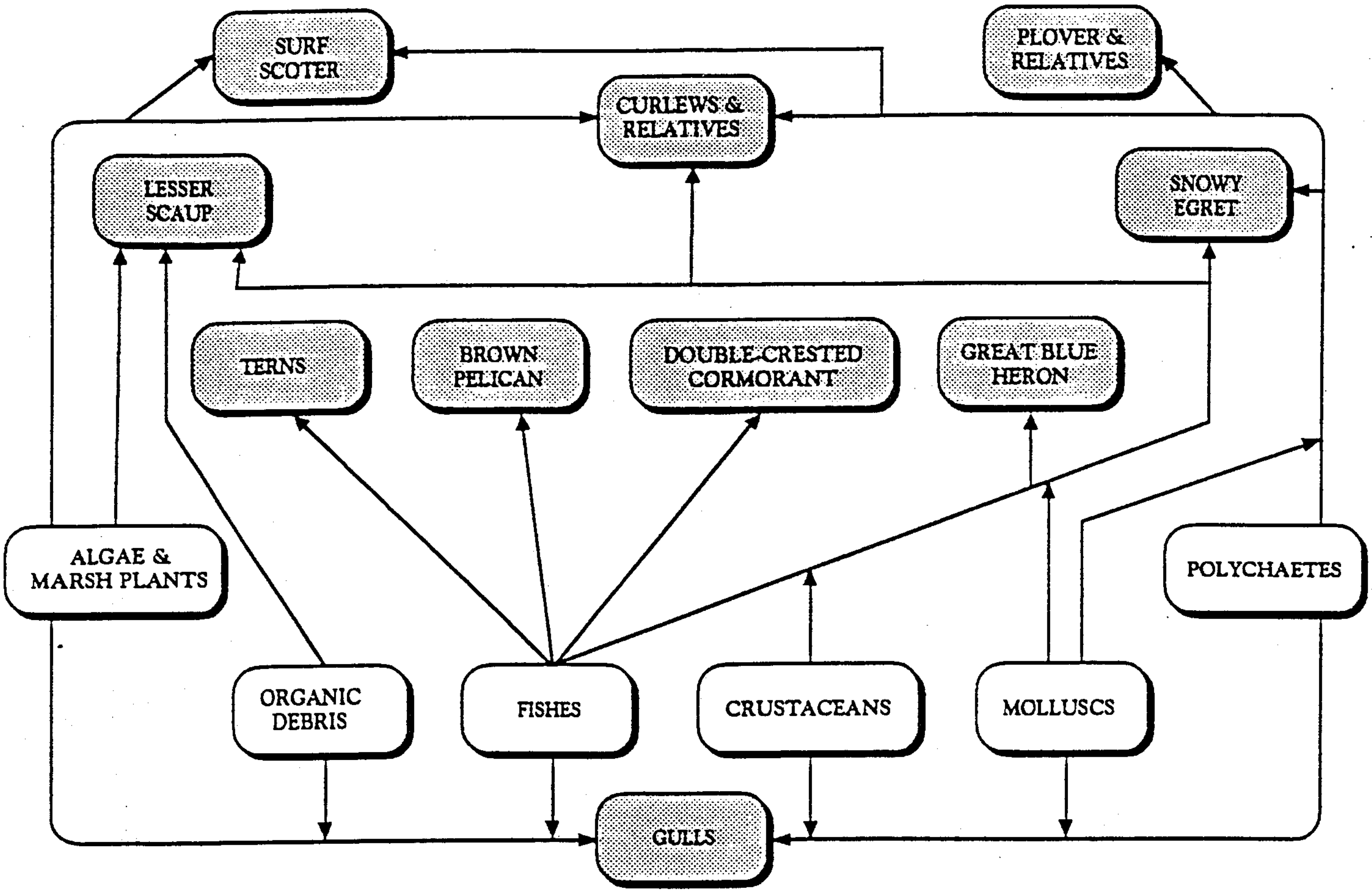
Locations of stations T-1 through T-17 at which otter trawl samples were taken during the period July 1988-May 1989. The two replicate hauls were taken in opposite directions from the station points, as shown.

Location of stations GN-1 and GN-2 at which replicate multiple panel gill net samples were taken during July 1988, and February 1989, and May 1989



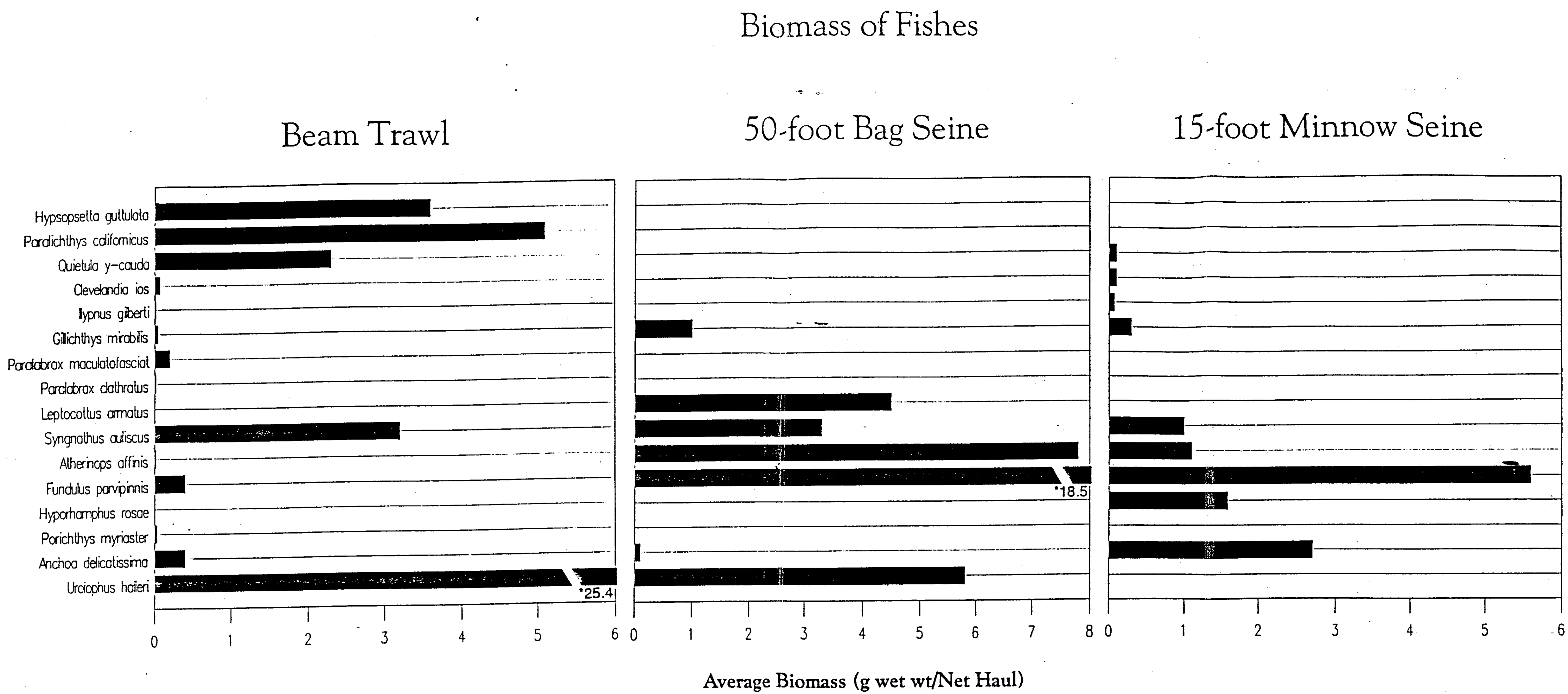

South San Diego Bay: Otter Trawl And Gill Net Sampling Stations, 1988-89

Figure No. 3




Generalized summer sub food web for major marine birds in South San Diego Bay, based on published data. The diagram reflects food of marine origin only. Direction of arrow indicates direction of food and energy. Birds are shaded. (Redrawn from Ford 1968.)

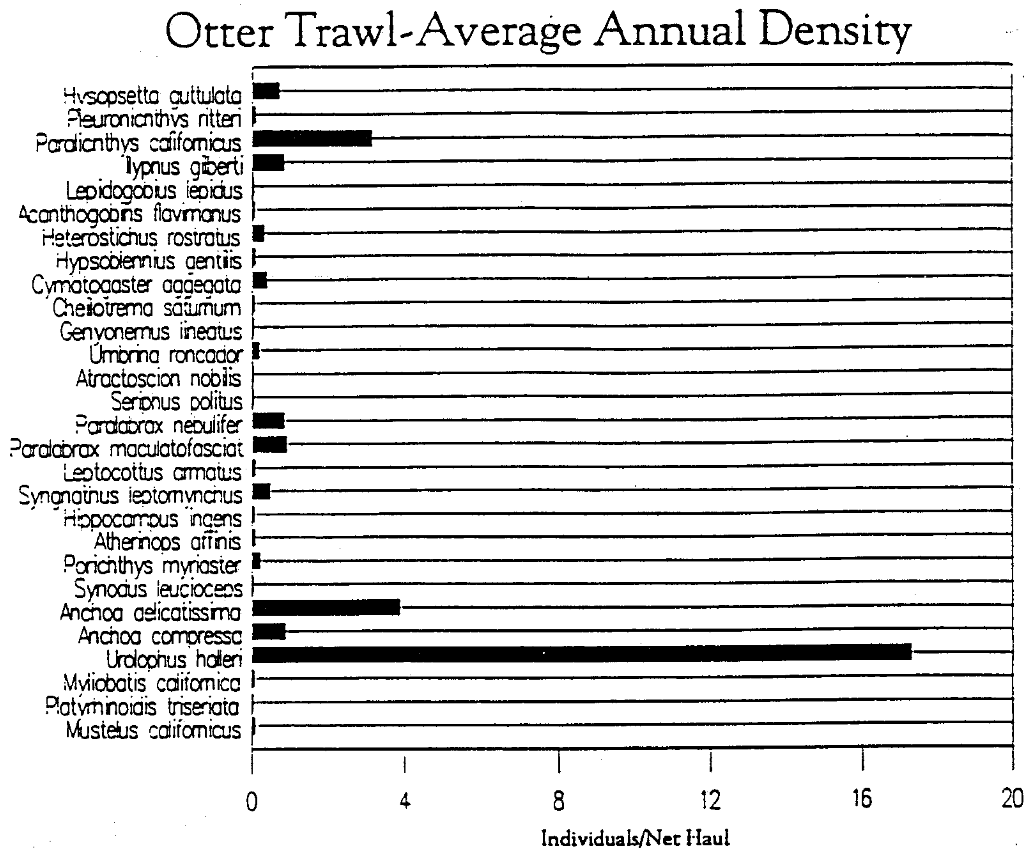
Figure No. 5

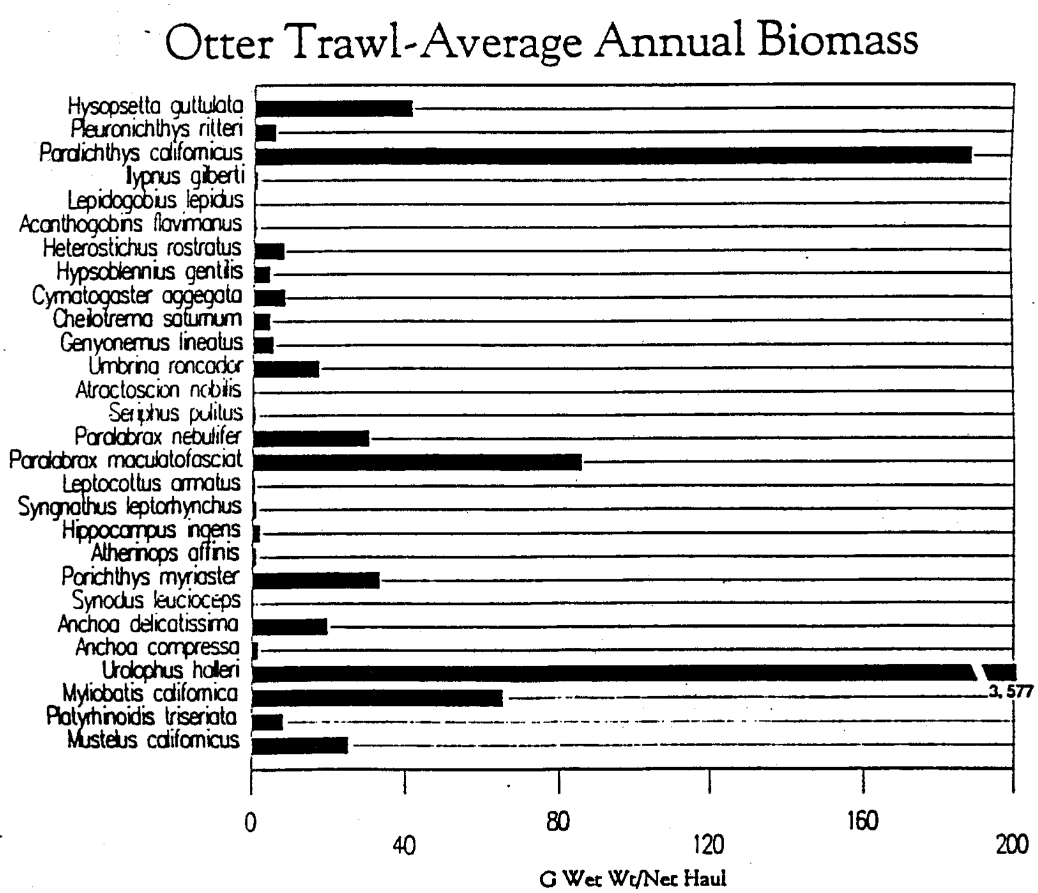



Source: Ford (1968); See Figure 20 For Sample Station Locations.

South San Diego Bay: Average Biomass Of Fish (Grams Wet Weight Per Replicate Net Haul) Collected in August 1968, Using Three Different Sampling Methods.

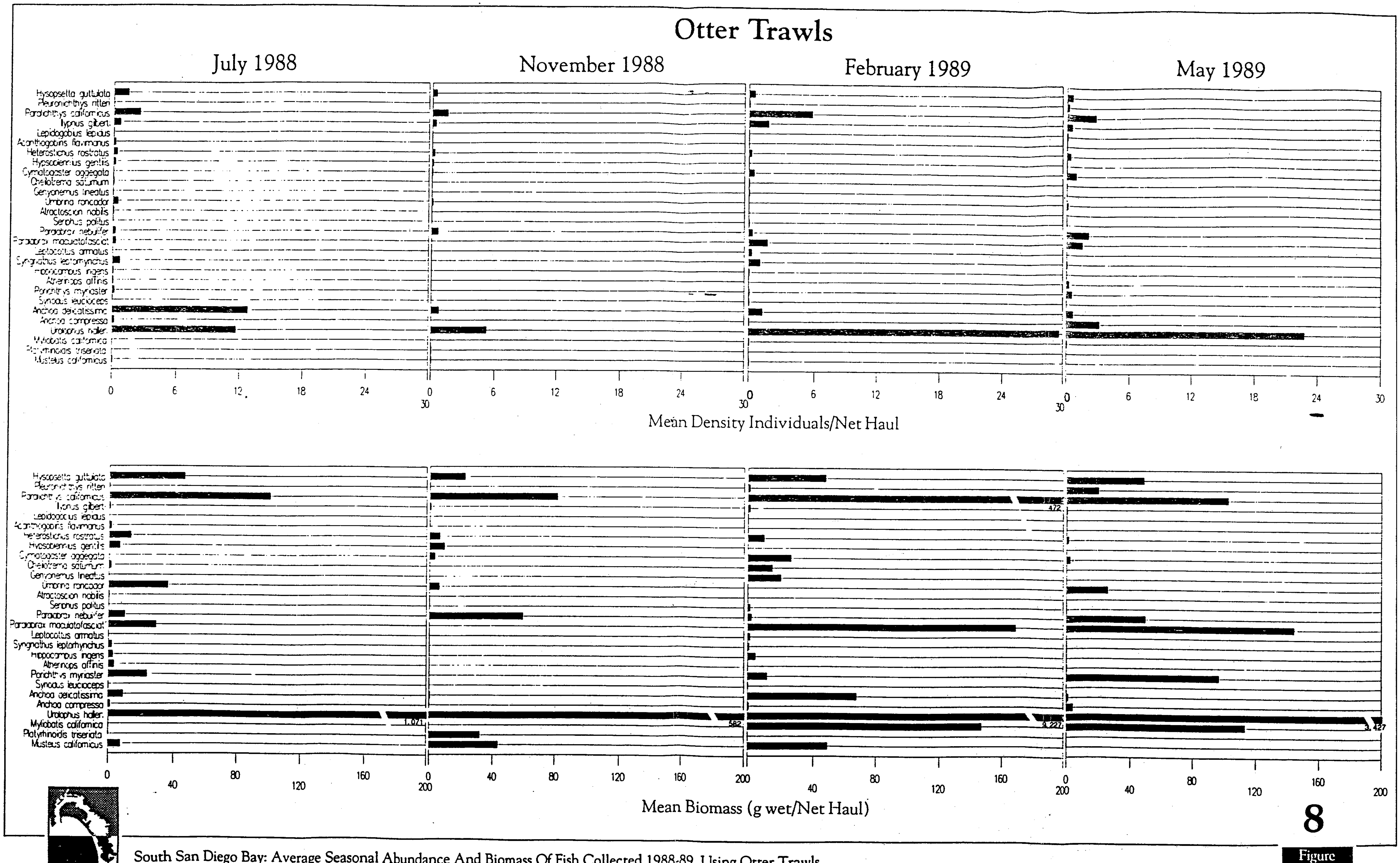
Figure No. 6




South San Diego Bay: Average Annual Abundance And Biomass Of Fish Collected 1988-89, Using Otter Trawls

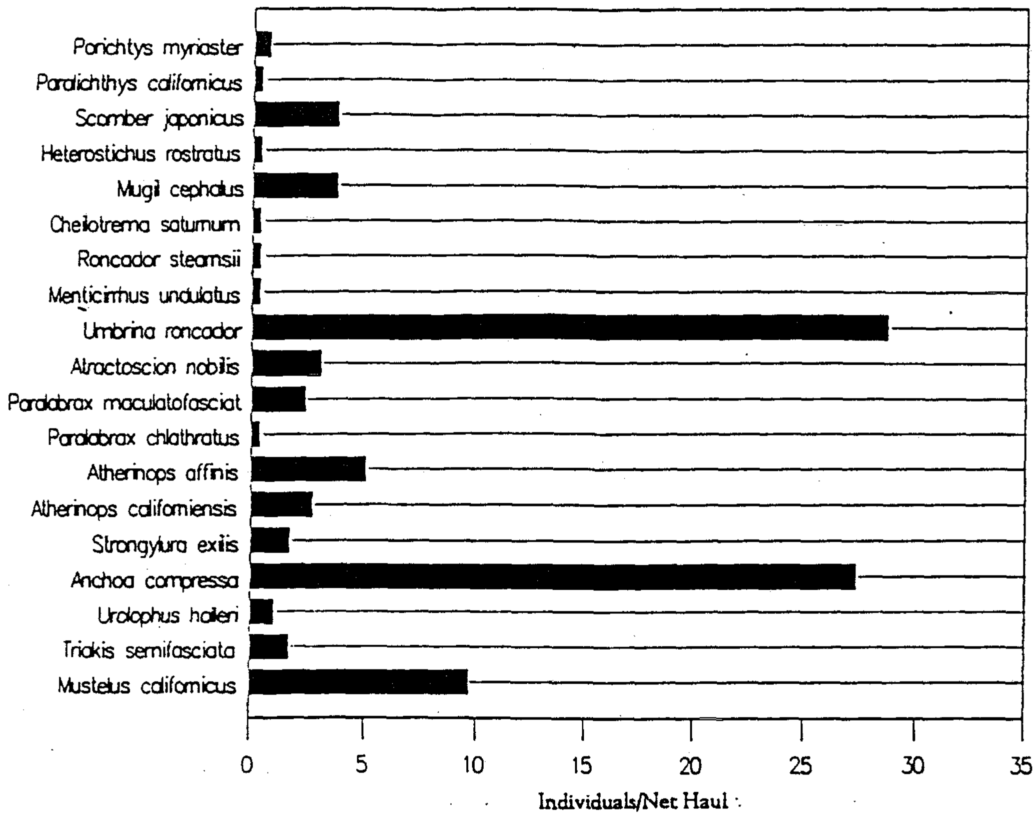
Figure No. 7



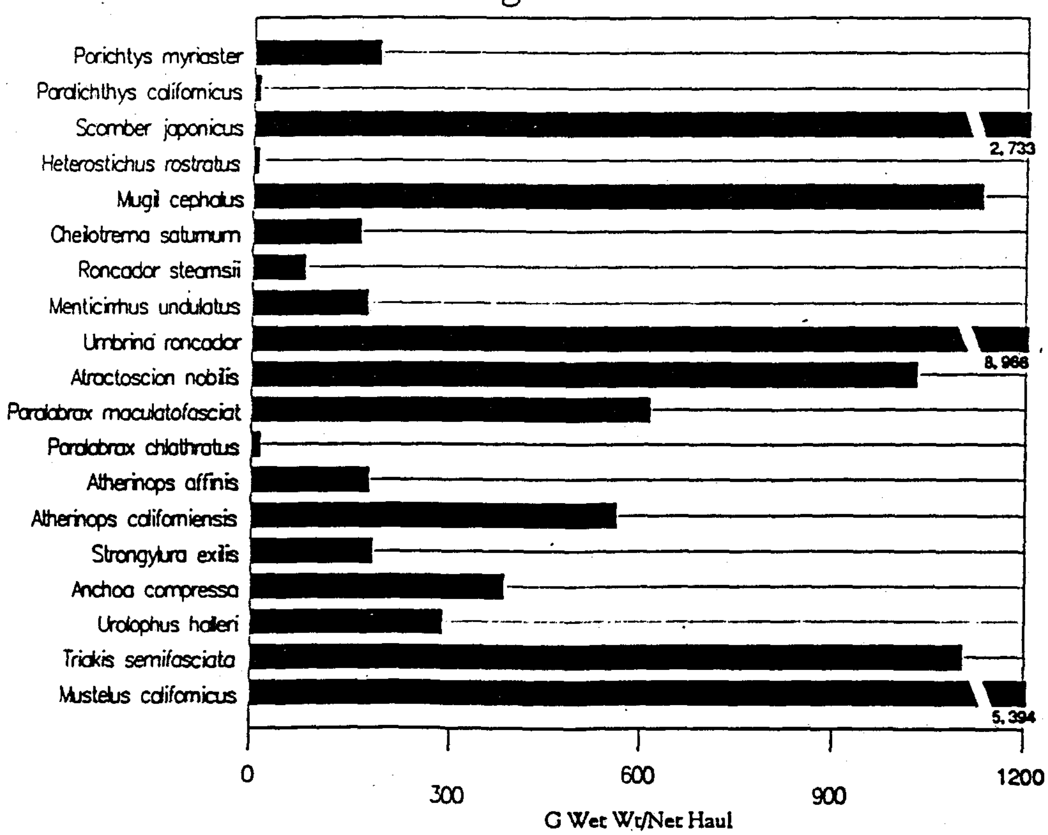

South San Diego Bay: Average Seasonal Abundance And Biomass Of Fish Collected 1988-89, Using Otter Trawls

Figure No. 8

# Gill Nets- Average Annual Density



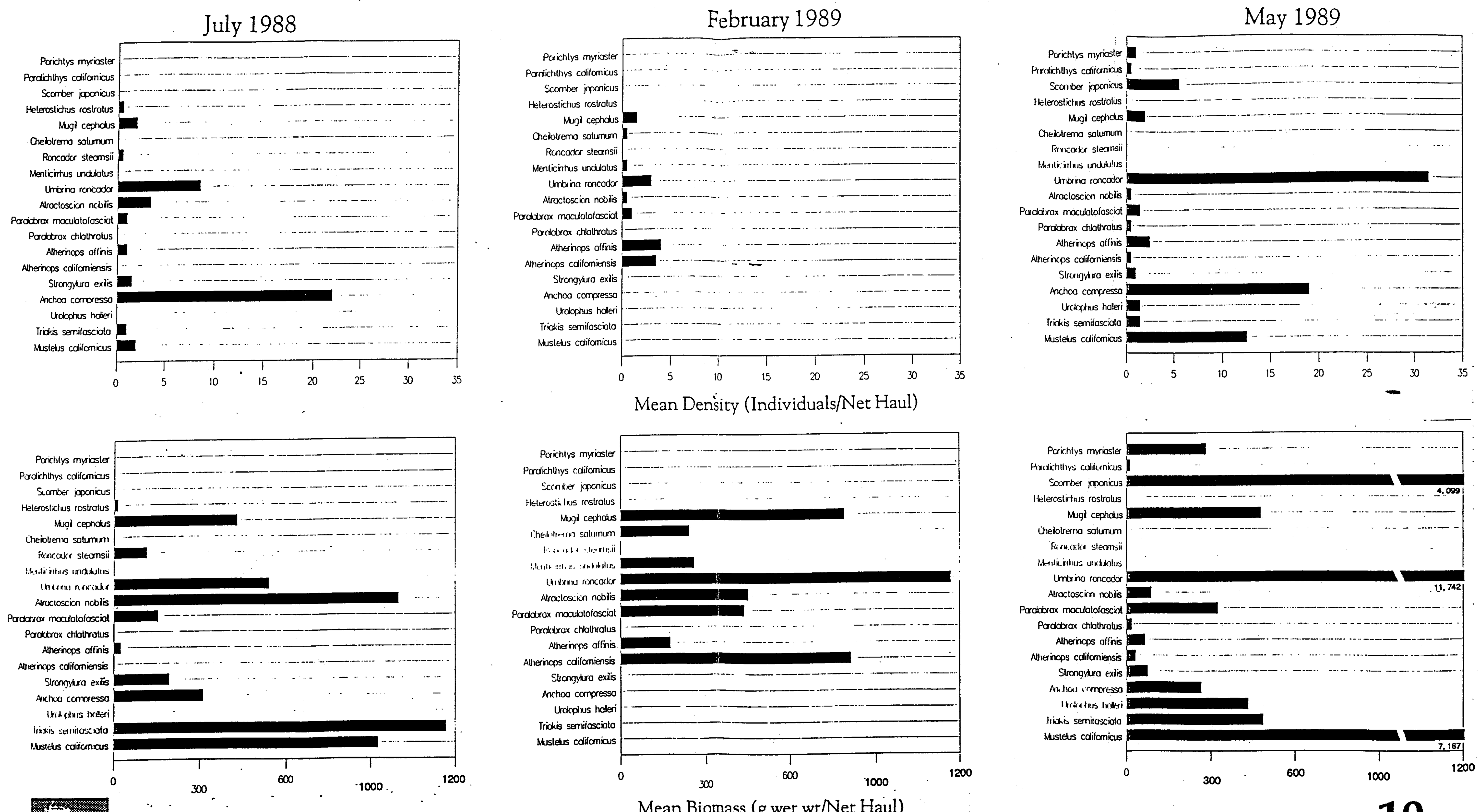

# Gill Nets-Average Annual Biomass




South San Diego Bay: Average Annual Abundance And Biomass Of Fish Collected 1988-89, Using Gill Nets

Figure No. 9

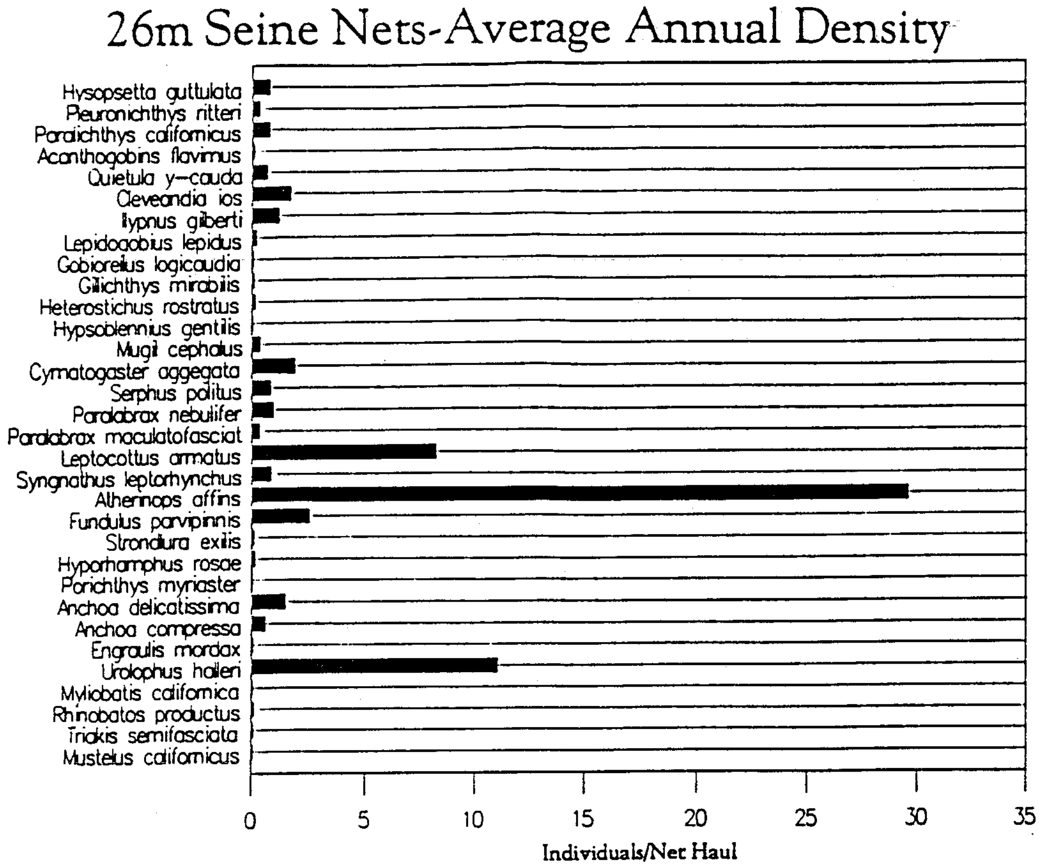
# Gill Nets

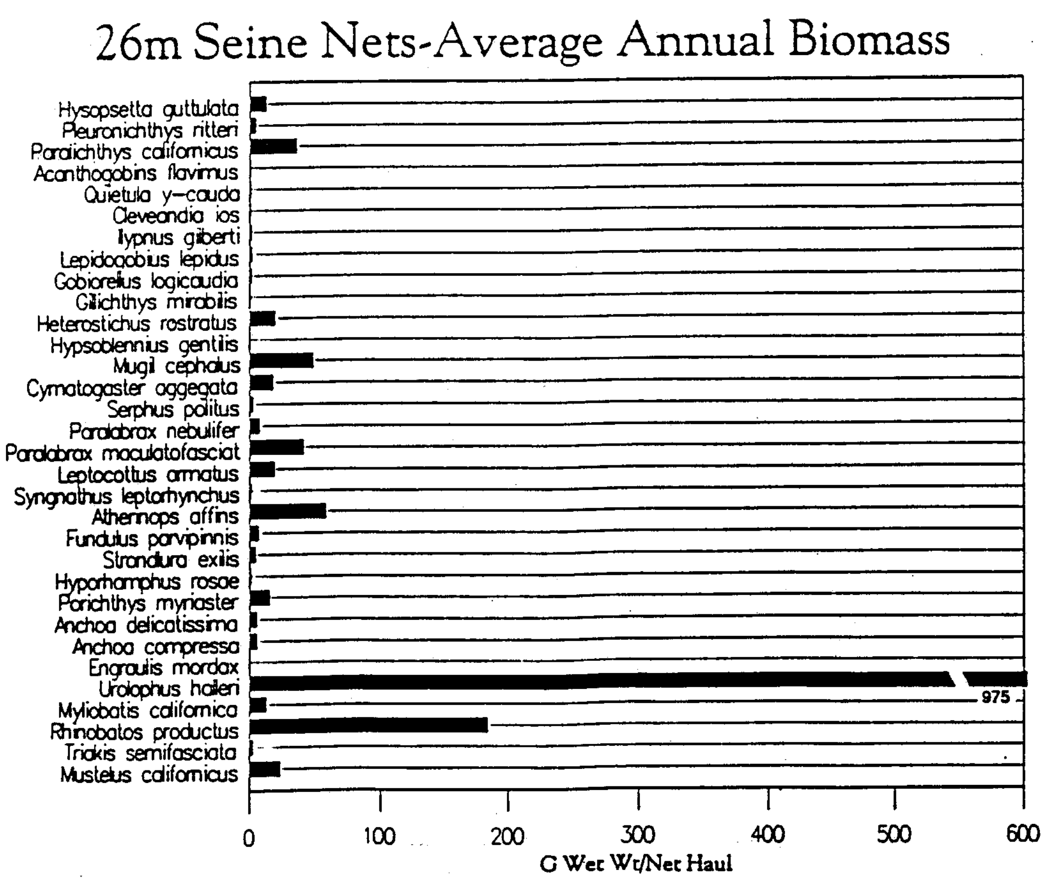



10

Figure No.

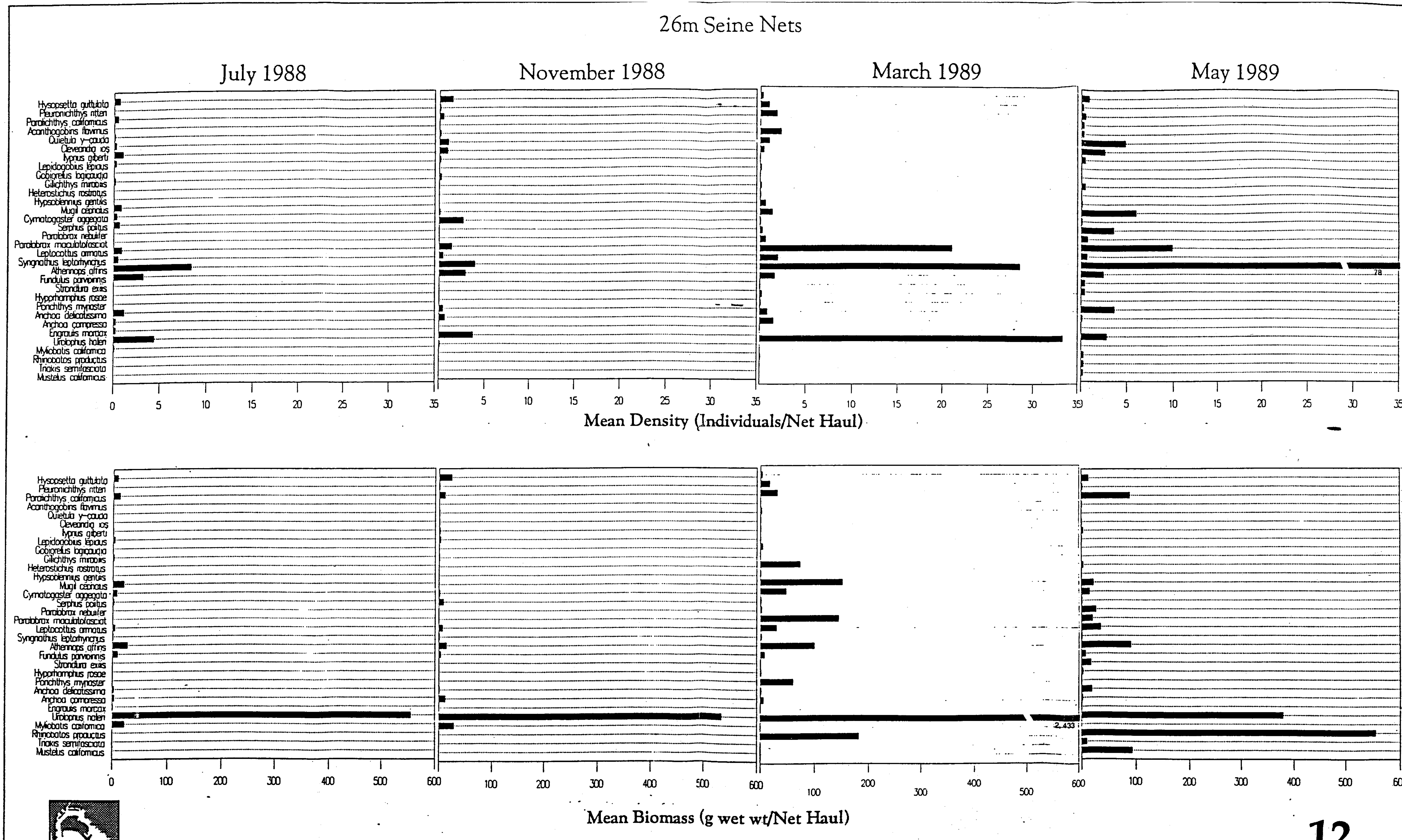
South San Diego Bay: Average Seasonal Abundance And Biomass Of Fish Collected 1988-89, Using Gill Nets




South San Diego Bay: Average Annual Abundance And Biomass Of Fish Collected 1988-89, Using 26m Seine Nets

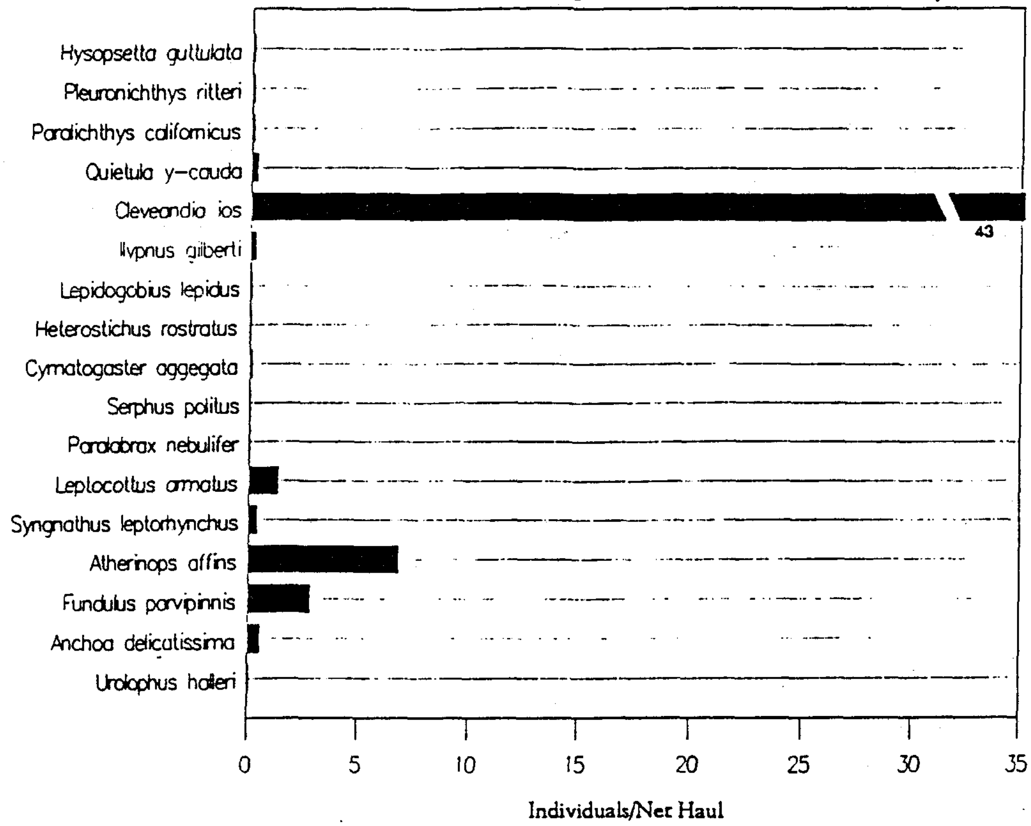
Figure No. 11



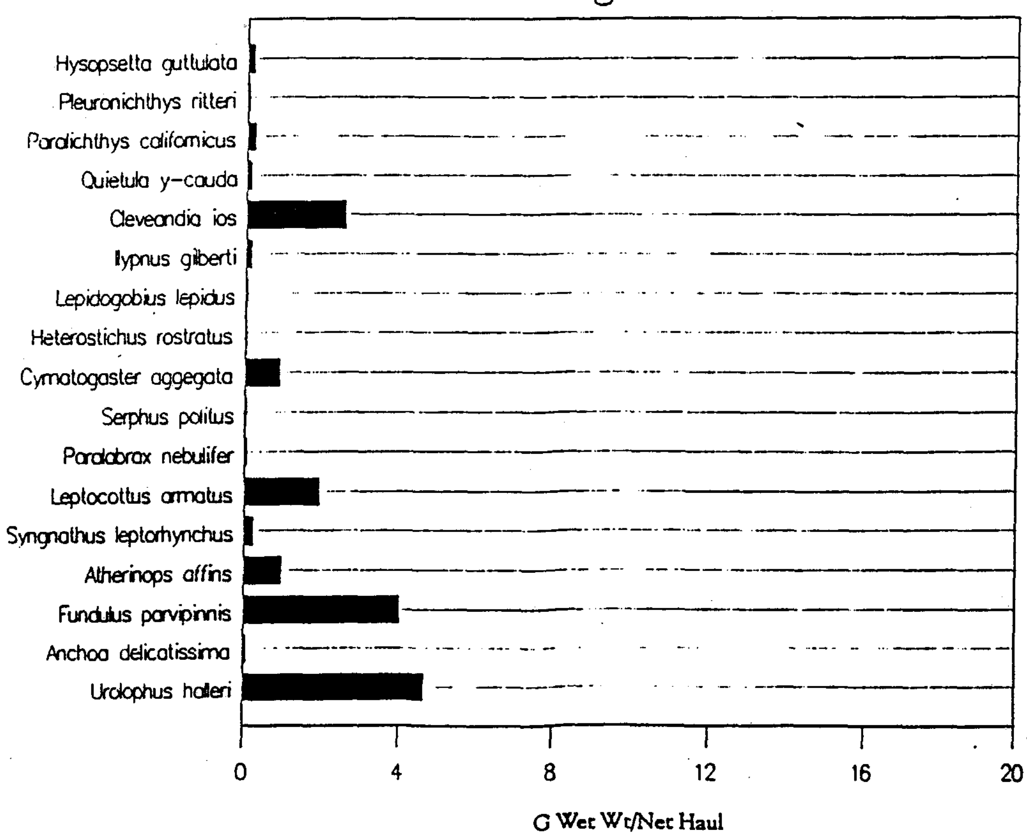

South San Diego Bay: Average Seasonal Abundance And Biomass Of Fish Collected 1988-89, Using 26m Seine Nets

Figure No. 12

# 5.2 Seine Nets-Average Annual Density

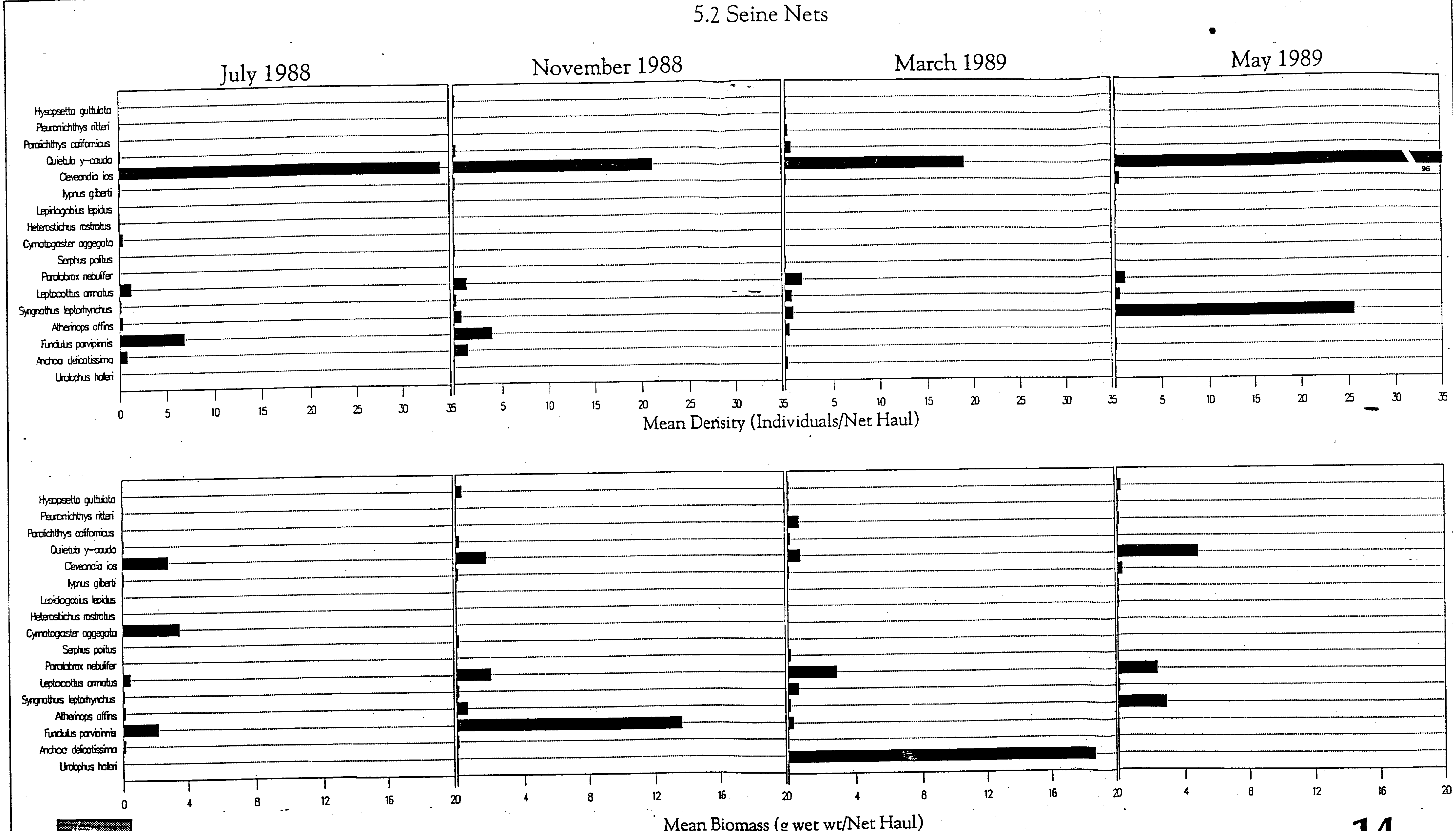



# 5.2m Seine Nets-Average Annual Biomass




South San Diego Bay: Average Seasonal Abundance And Biomass Of Fish Collected 1988-89, Using 5.2 Seine Nets

Figure No. 13

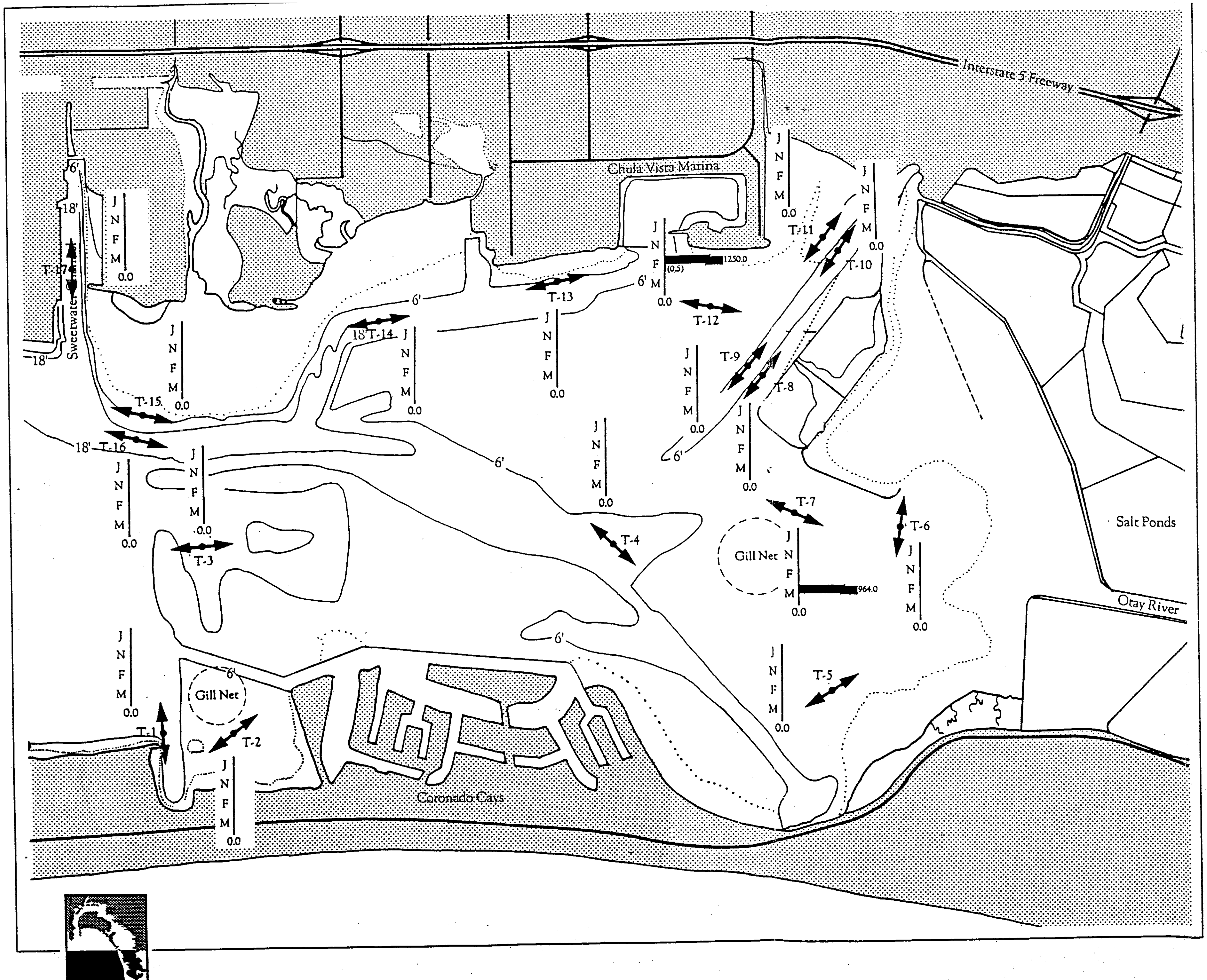


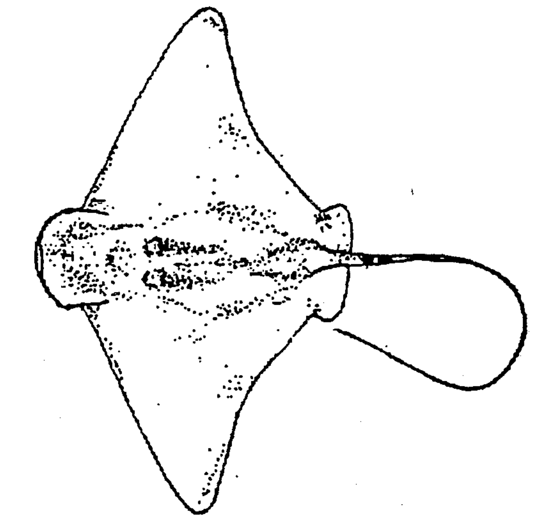

South San Diego Bay: Average Annual Abundance And Biomass Of Fish Collected 1988-89, Using 5.2 Seine Nets

Figure No. 14

# South San Diego Bay Resources Atlas

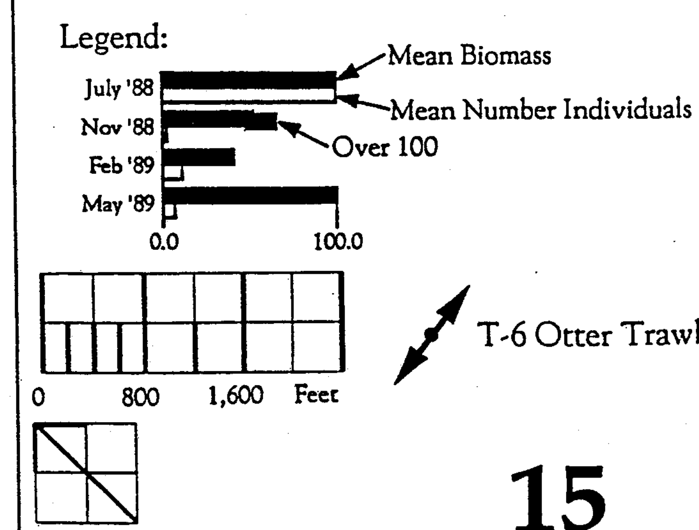
## Bat Ray
## *Myliobatis californica*

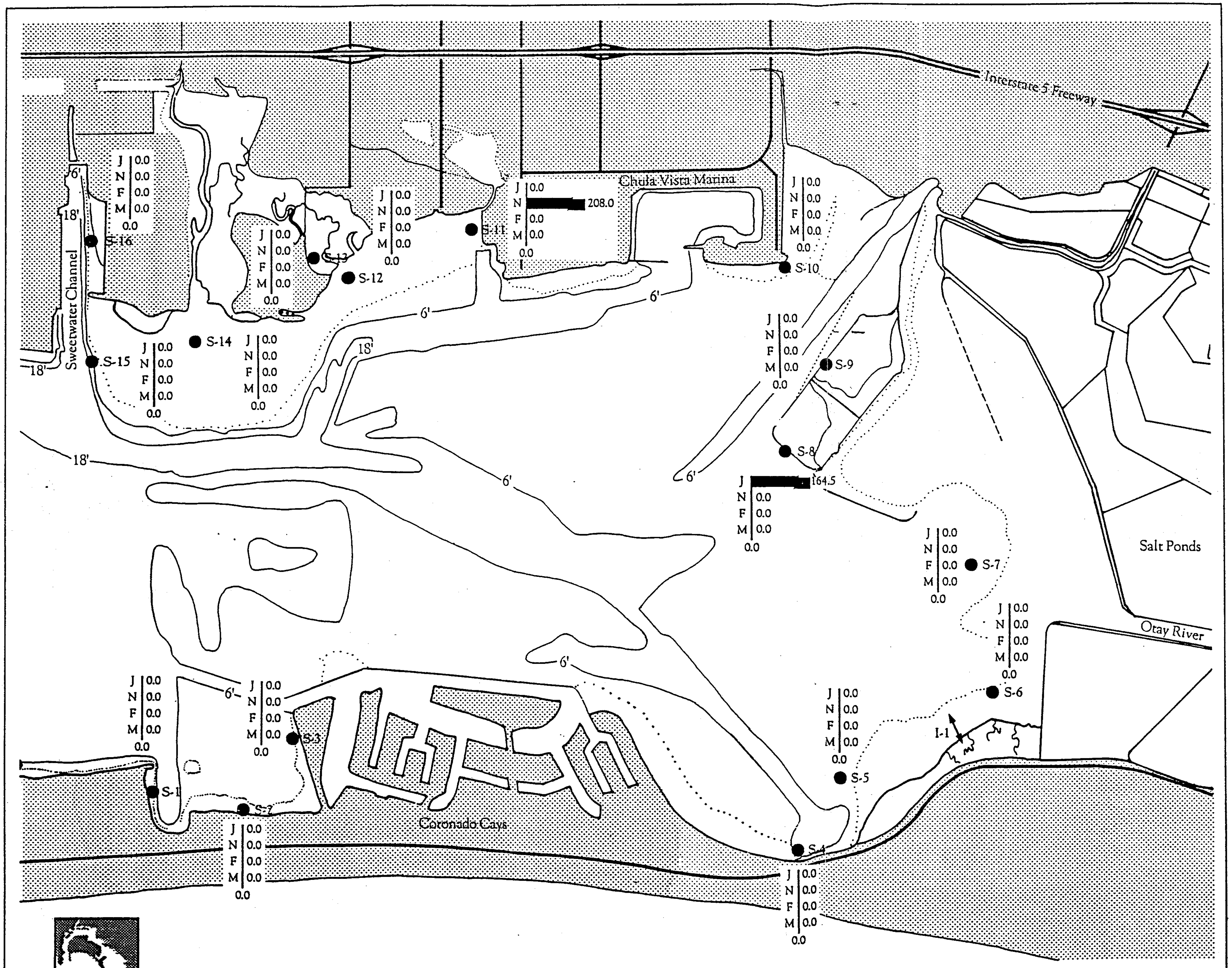


### Otter Trawls

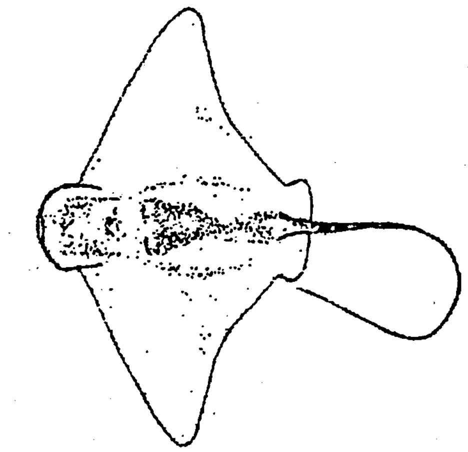
Location of stations T-1 through T-17 at which replicate otter trawl samples are taken during the period July 1988 through May 1989.






South San Diego Bay
Resources Atlas

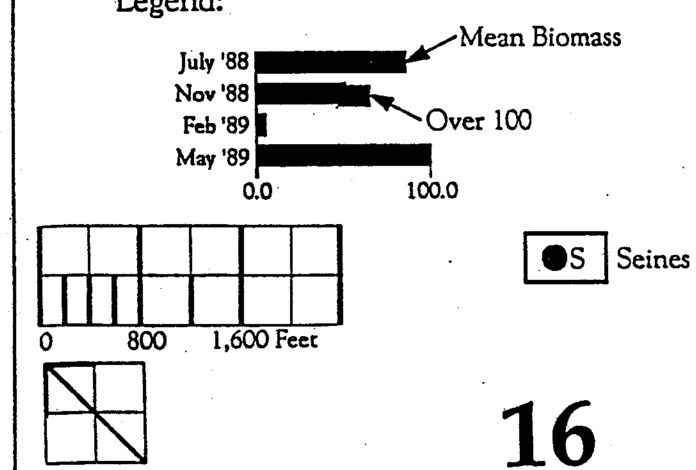
# Bat Ray
# *Myliobatis californica*



26m Bag Seines

Location of stations S-1 through S-15 at which replicate beach seine samples were taken across the intertidal and shallow subtidal shoreline. Sampling was conducted during the period July 1988 – May 1989.

Legend:

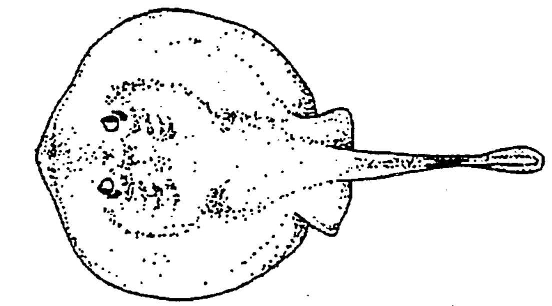


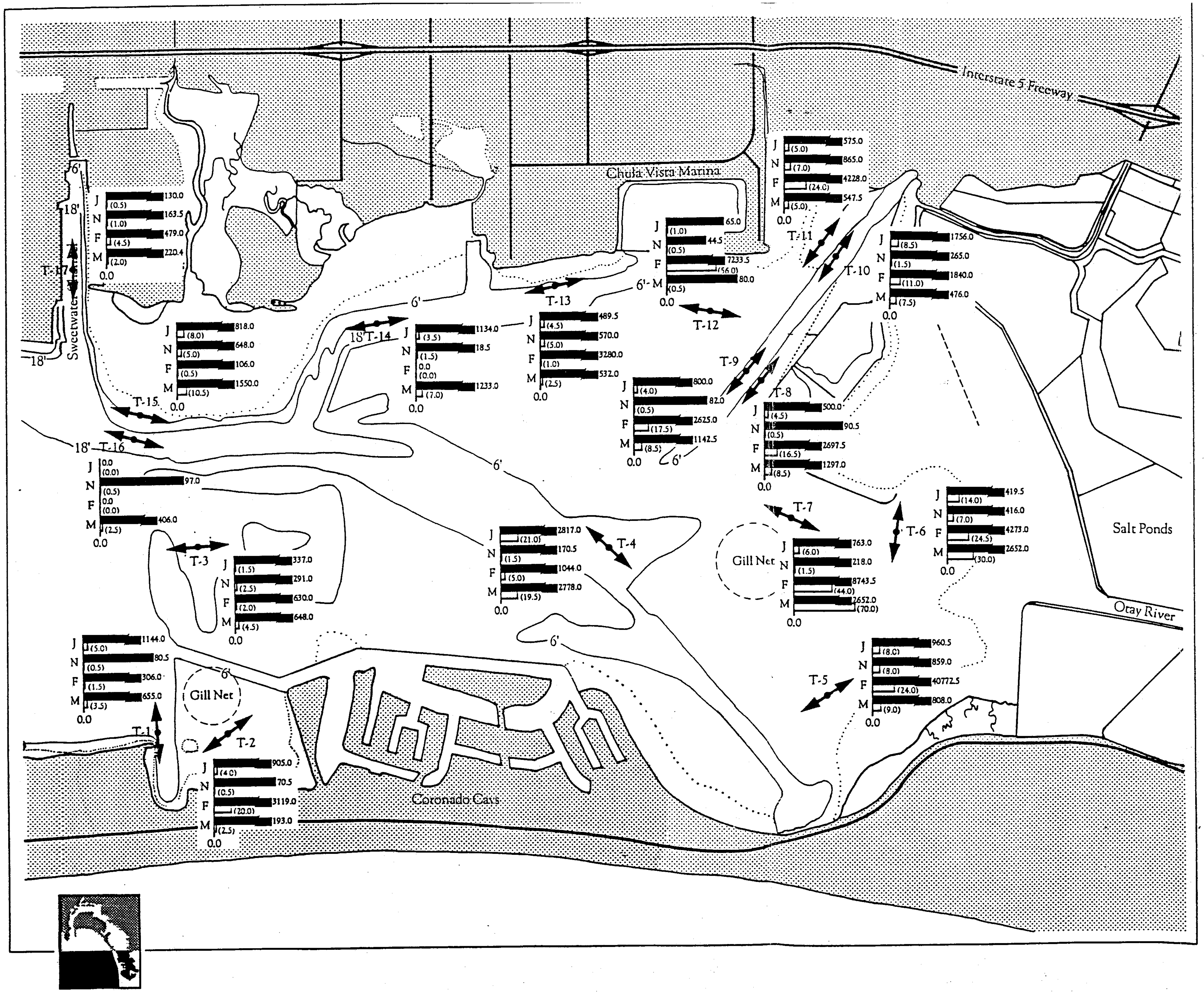

**16**

Figure No.

South San Diego Bay
Resources Atlas

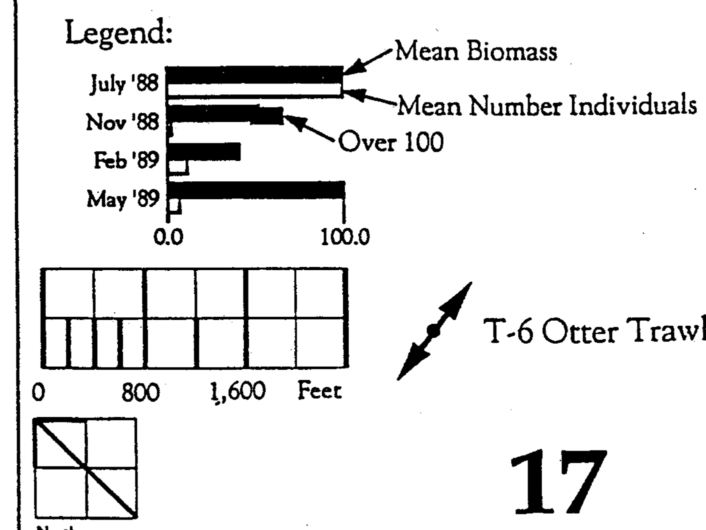
# Round Stingray
# *Urolophus halleri*






## Otter Trawls

Location of stations T-1 through T-17 at which replicate otter trawl samples are taken during the period July 1988 through May 1989.

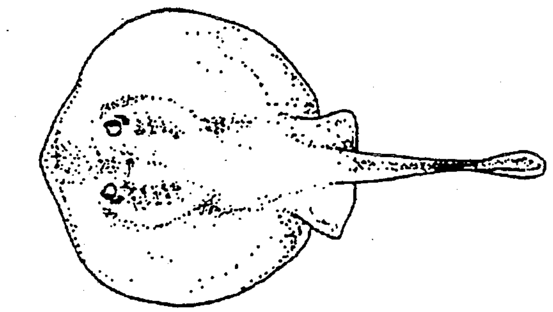


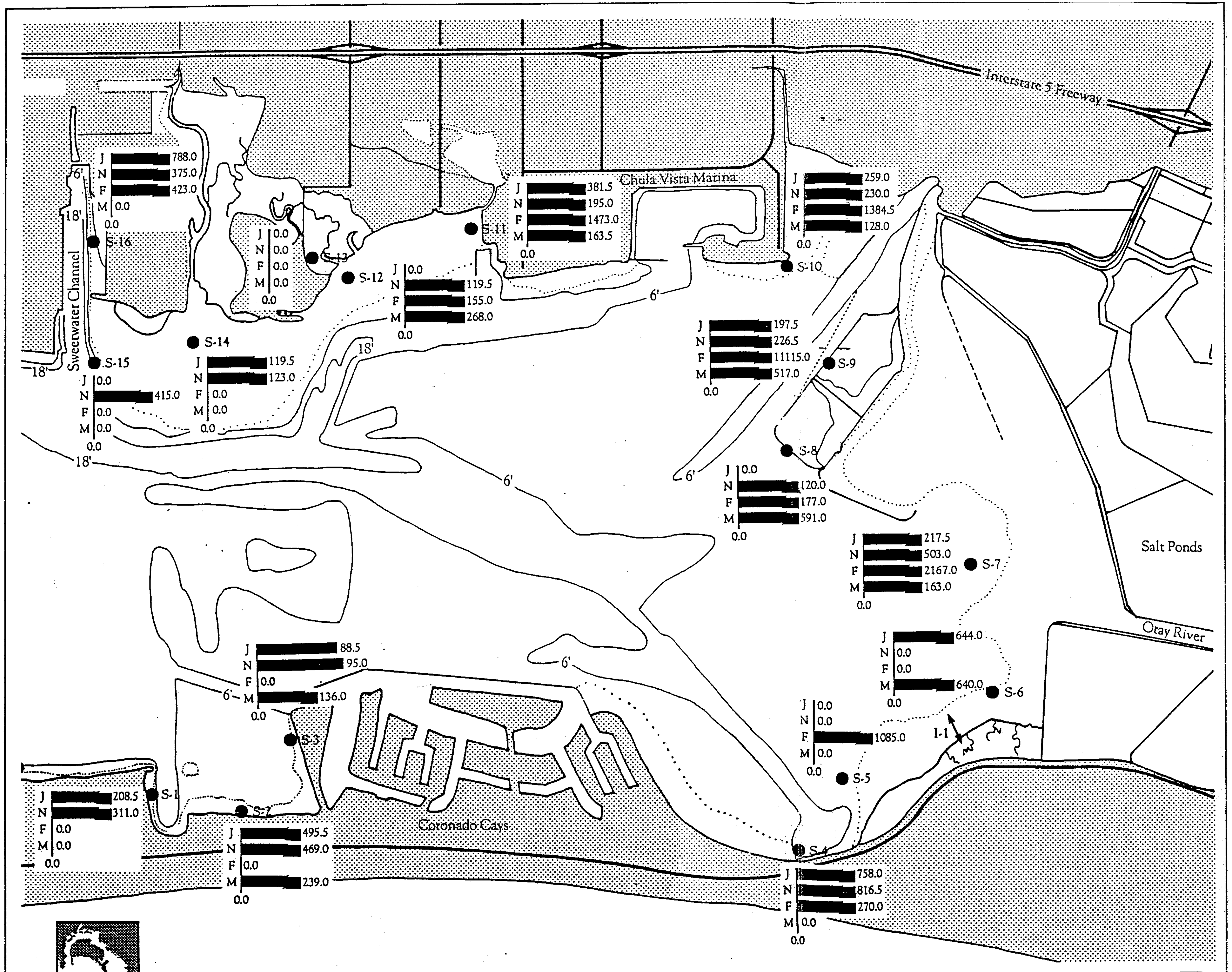

**17**

Figure No.

South San Diego Bay
Resources Atlas

# Round Stingray
# Urolophus halleri

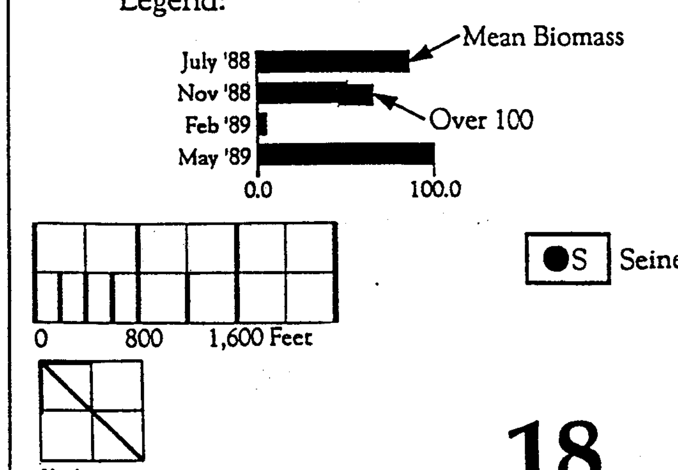





26m Bag Seines

Location of stations S-1 through S-15 at which replicate beach seine samples were taken across the intertidal and shallow subtidal shoreline. Sampling was conducted during the period July 1988 – May 1989.

Legend:

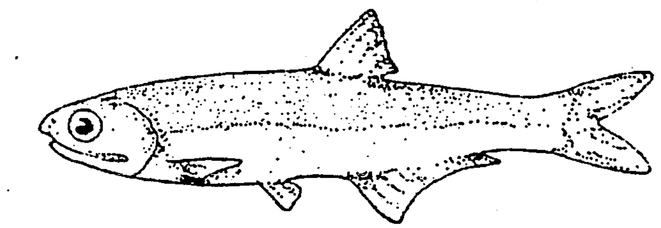


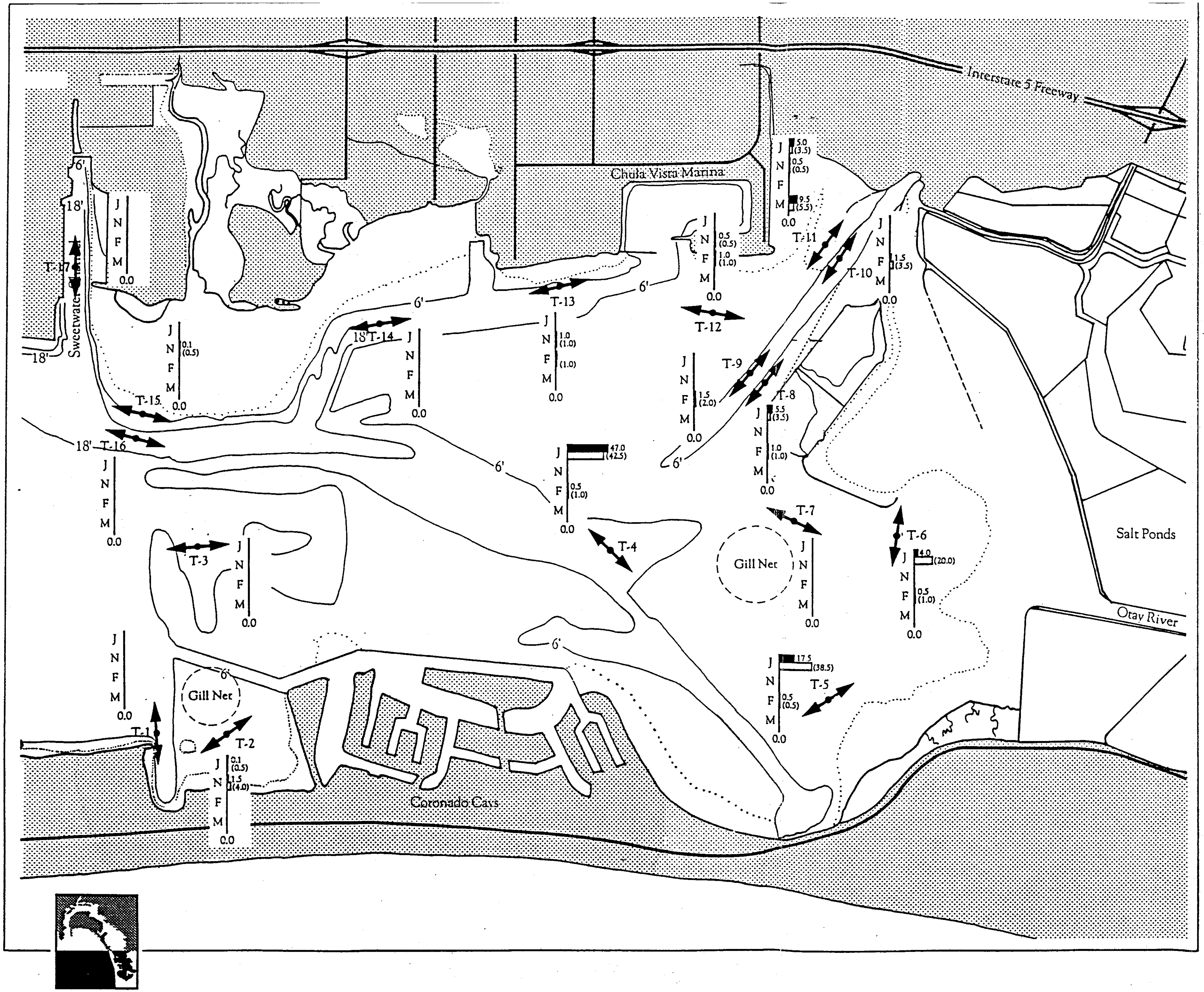

**18**

Figure No.

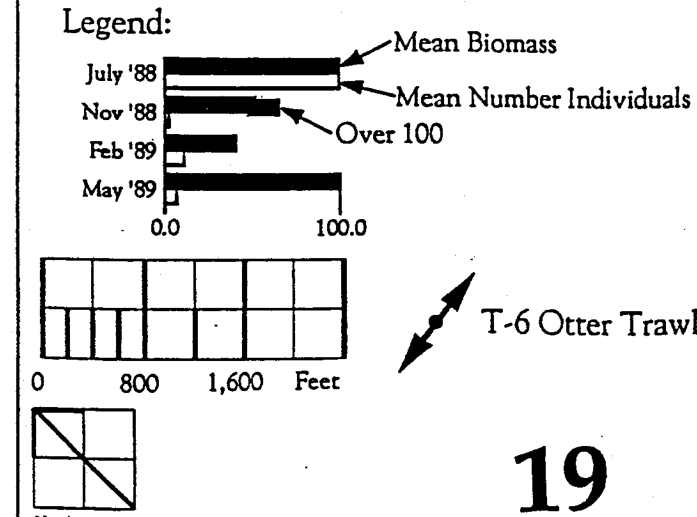
South San Diego Bay
Resources Atlas

# Slough Anchovy
# *Anchoa delicatissima*





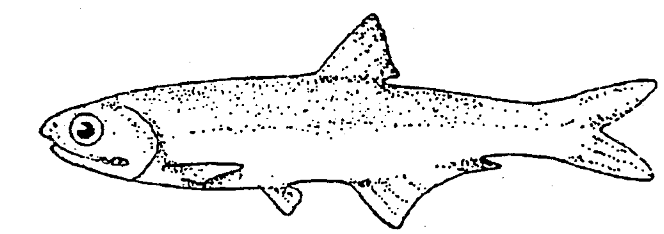

Otter Trawls
Location of stations T-1 through T-17 at which replicate otter trawl samples are taken during the period July 1988 through May 1989.

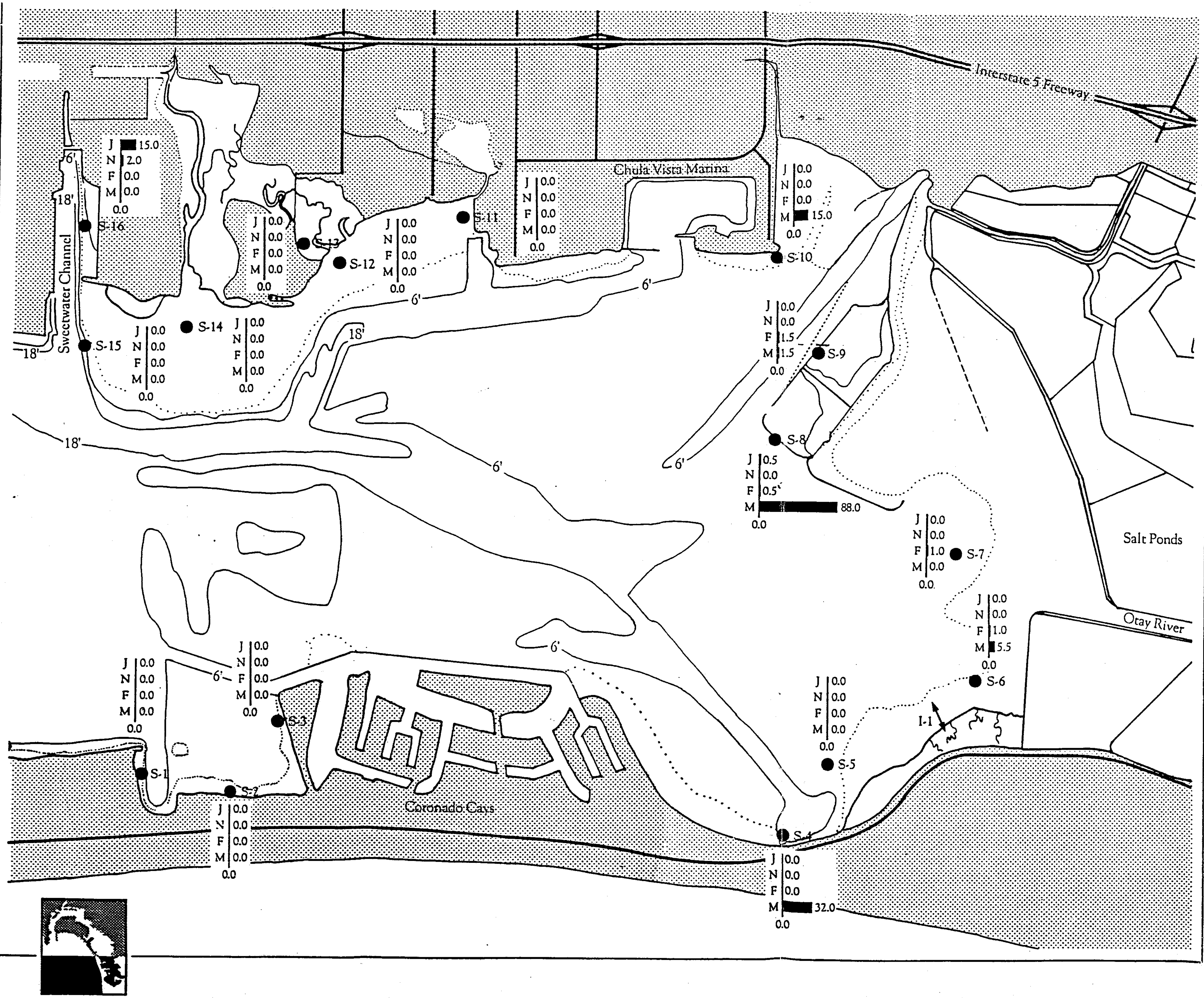



19
Figure No.

South San Diego Bay
Resources Atlas

# Slough Anchovy
# *Anchoa delicatissima*

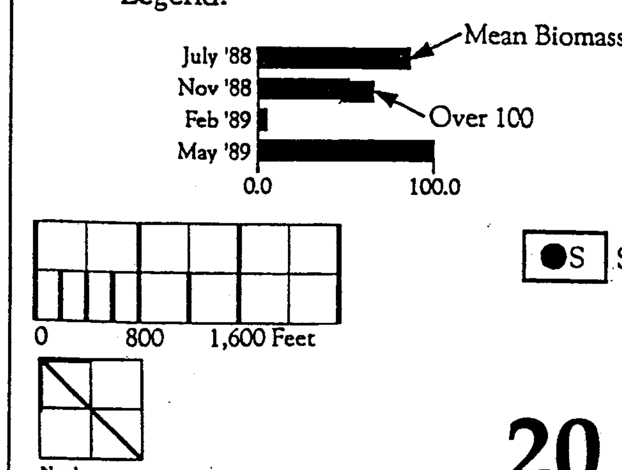





26m Bag Seines

Location of stations S-1 through S-15 at which replicate beach seine samples were taken across the intertidal and shallow subtidal shoreline. Sampling was conducted during the period July 1988 – May 1989.

Legend:

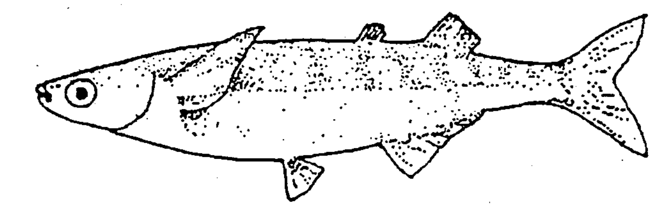


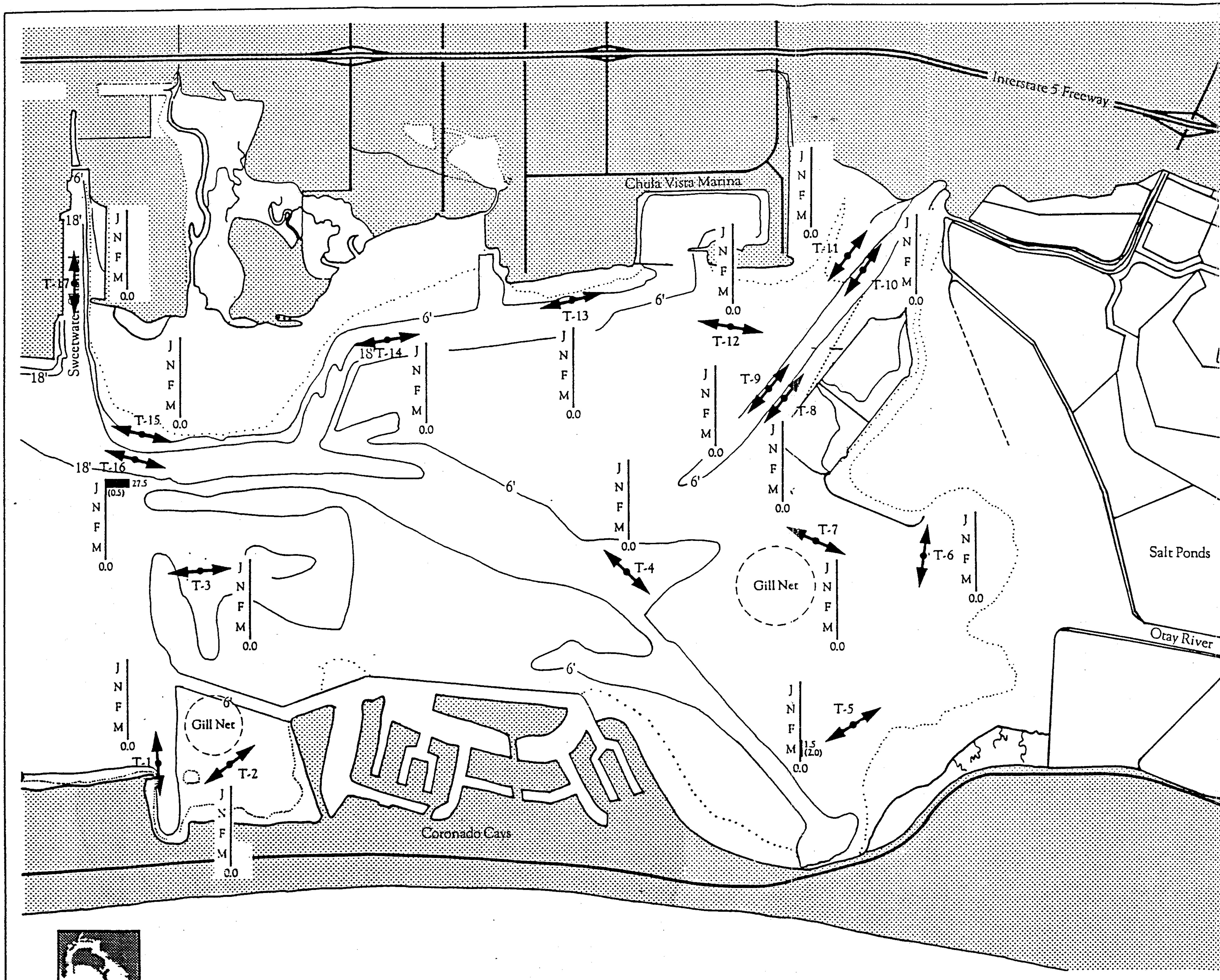

**20**

Figure No.

South San Diego Bay
Resources Atlas

# Topsmelt
# *Atherinops affinis*

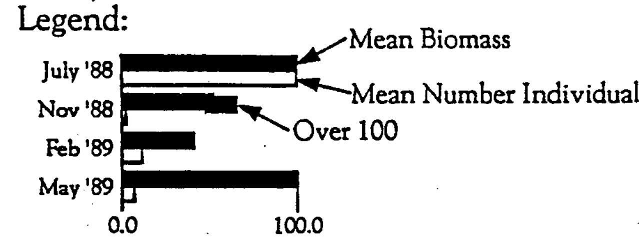





Otter Trawls

Location of stations T-1 through T-17 at which replicate otter trawl samples are taken during the period July 1988 through May 1989.

Legend:

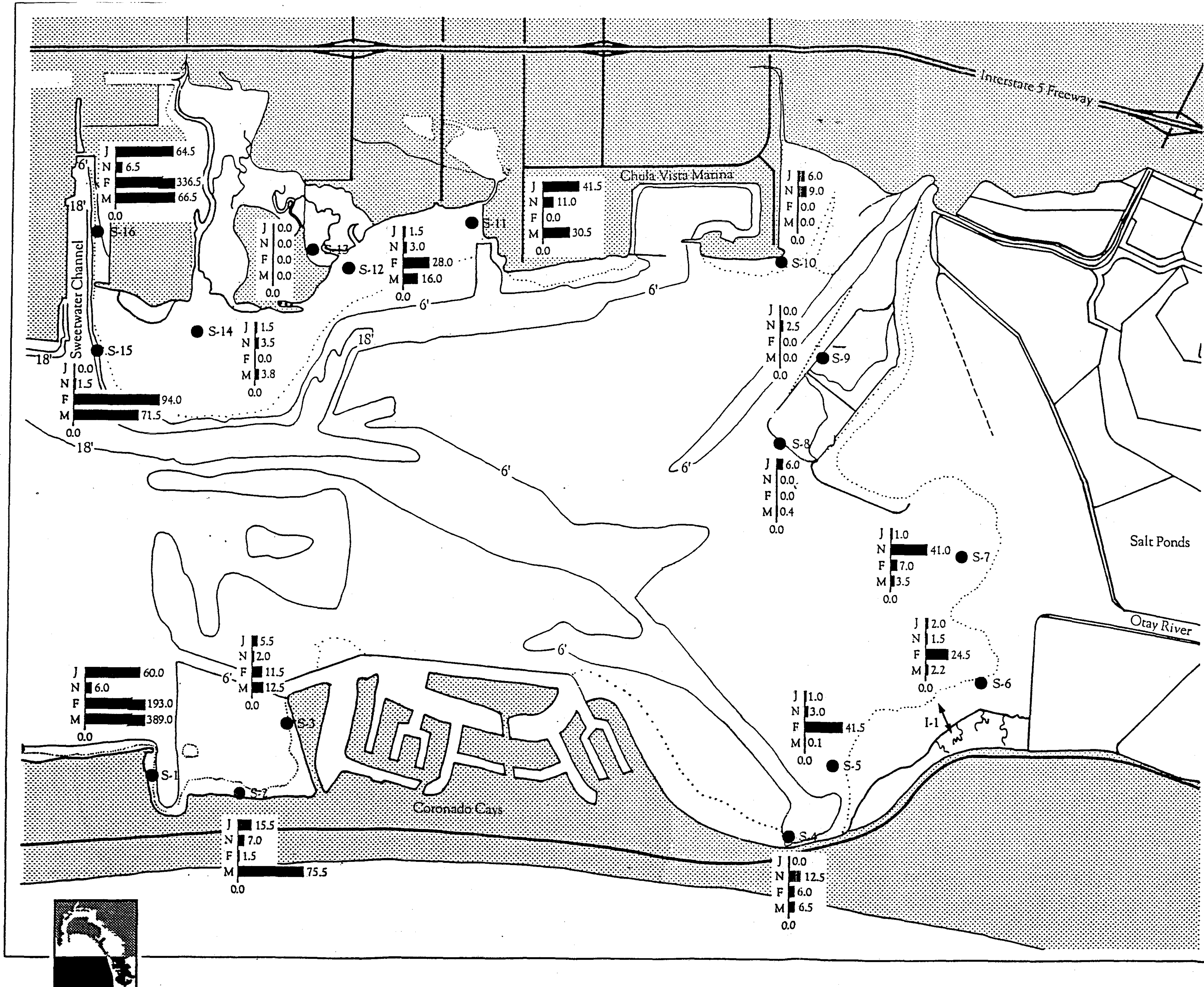



0 800 1,600 Feet

North

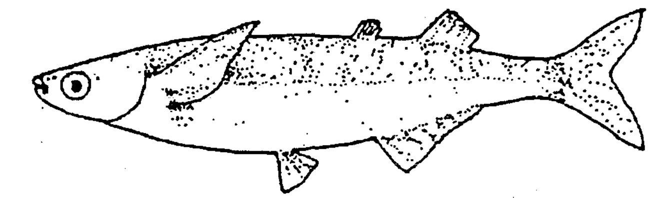
T-6 Otter Trawl

Figure No. 21




South San Diego Bay
Resources Atlas

# Topsmelt
# *Atherinops affinis*



26m Bag Seines

Location of stations S-1 through S-15 at which replicate beach seine samples were taken across the intertidal and shallow subtidal shoreline. Sampling was conducted during the period July 1988 – May 1989.

Legend:

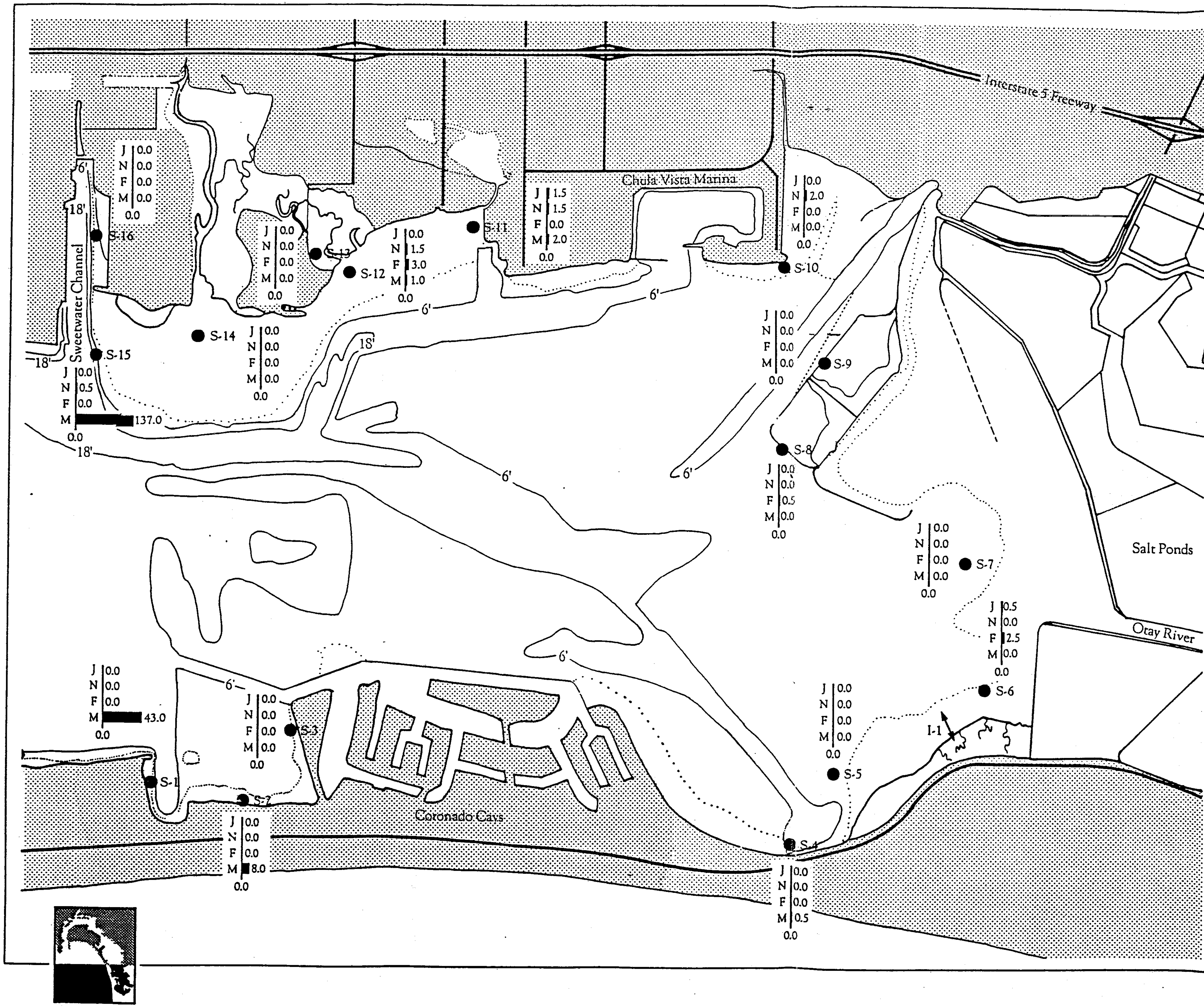
July '88 — Mean Biomass
Nov '88 — Over 100
Feb '89
May '89
0.0 — 100.0

S Seines

0 800 1,600 Feet

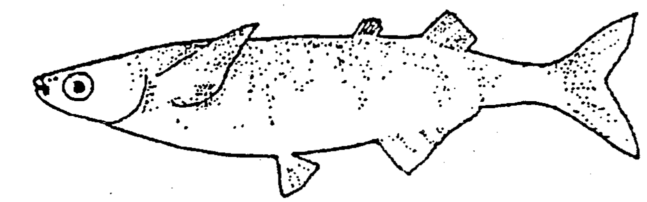
North

Figure No. 22




South San Diego Bay
Resources Atlas

# Topsmelt
# *Atherinops affinis*



5.2m Minnow Seines

Location of stations S-1 through S-15 at which replicate beach seine samples were taken across the intertidal and shallow subtidal shoreline. Sampling was conducted during the period July 1988 – May 1989.

Legend:

July '88 — Mean Number Individuals
Nov '88 — Over 100
Feb '89
May '89
0.0 100.0

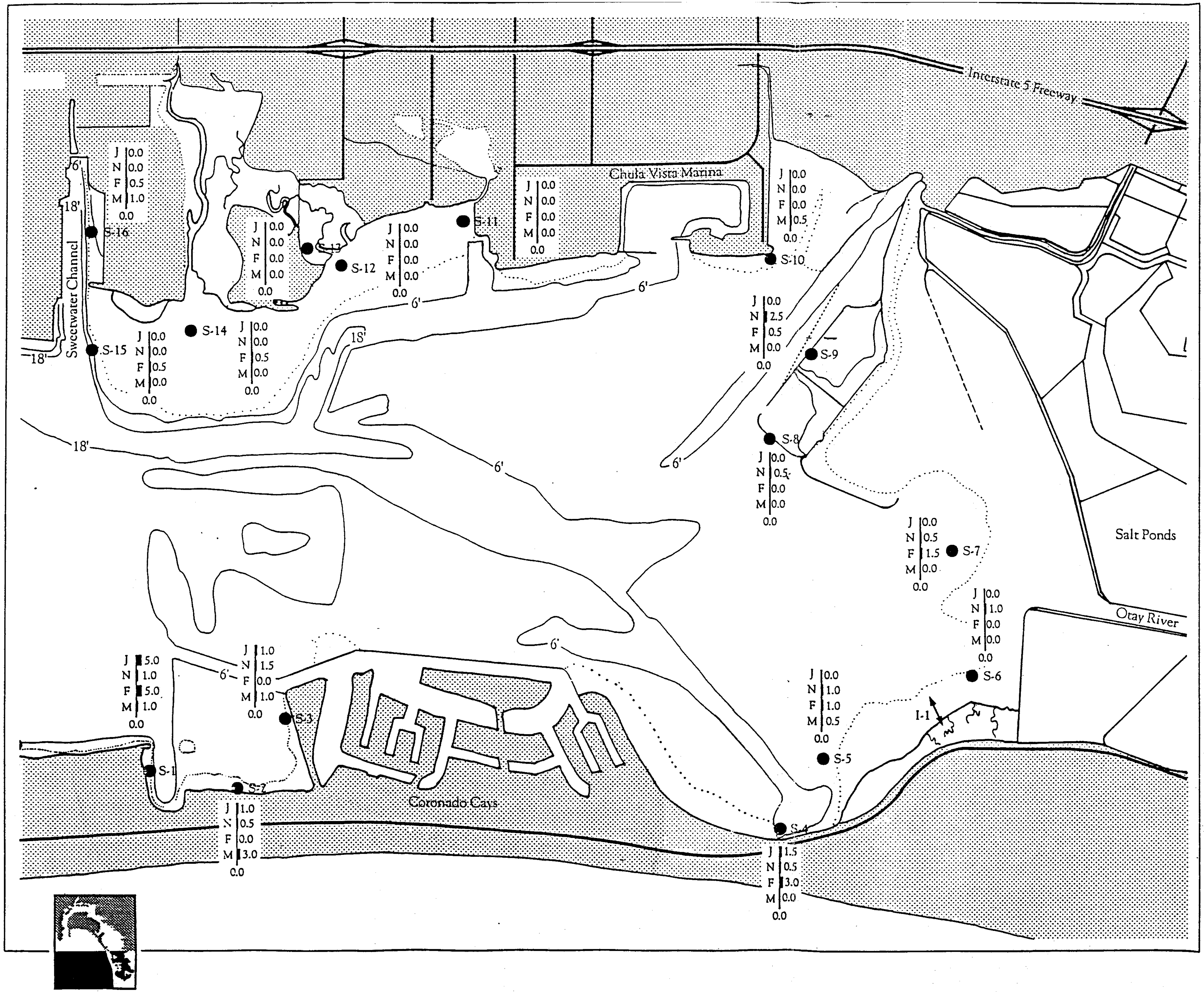
0 800 1,600 Feet

North

● S Seines

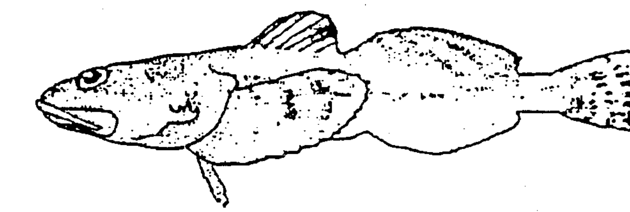
**23**

Figure No.




South San Diego Bay
Resources Atlas

# Pacific Staghorn Sculpin
## *Leptocottus armatus*



5.2m Minnow Seines

Location of stations S-1 through S-15 at which replicate beach seine samples were taken across the intertidal and shallow subtidal shoreline. Sampling was conducted during the period July 1988 – May 1989.

Legend:

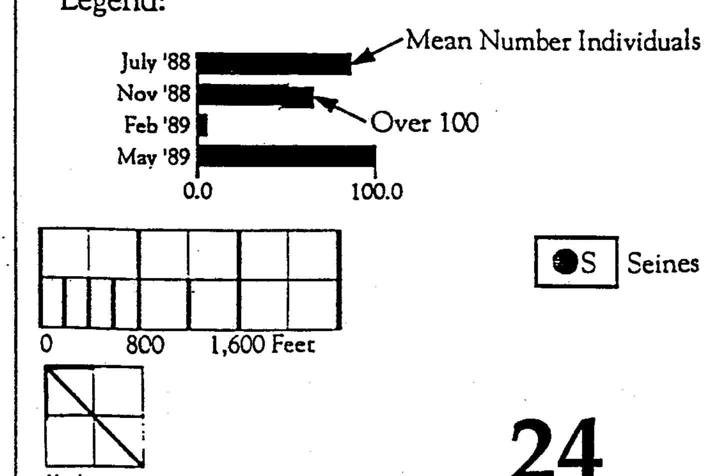



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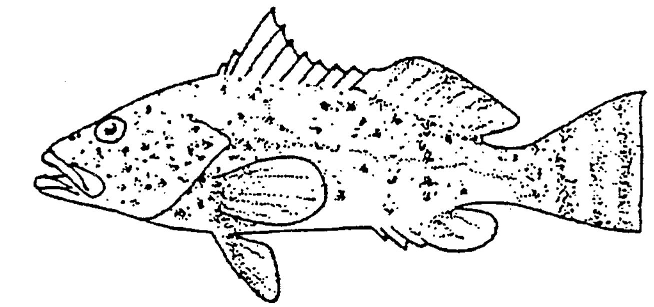
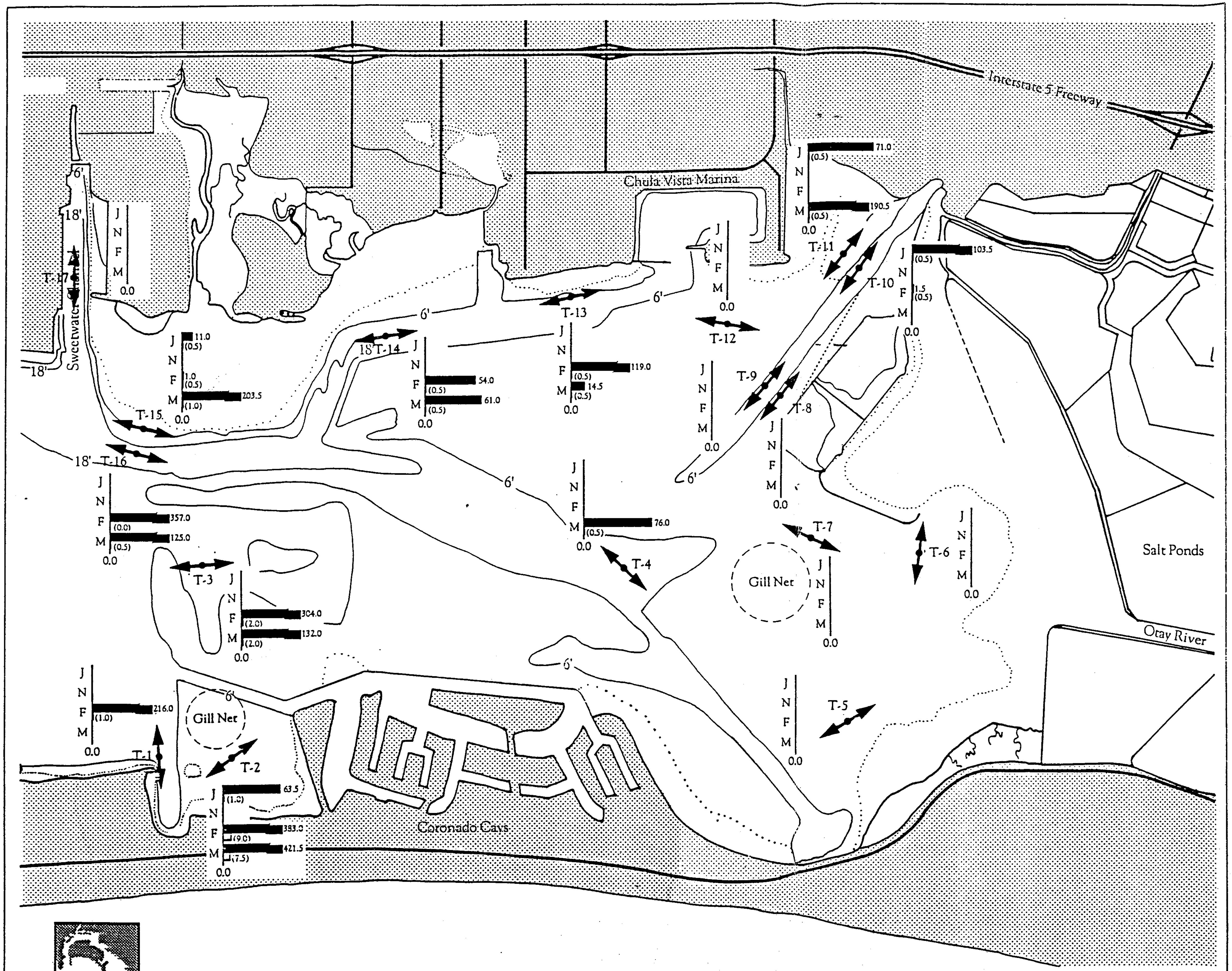
Figure No.

South San Diego Bay
Resources Atlas

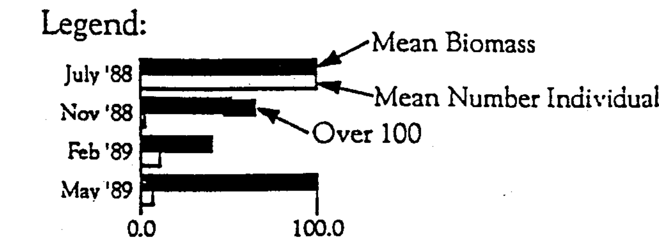
# Spotted Sand Bass
## *Paralabrax maculatofasciatus*

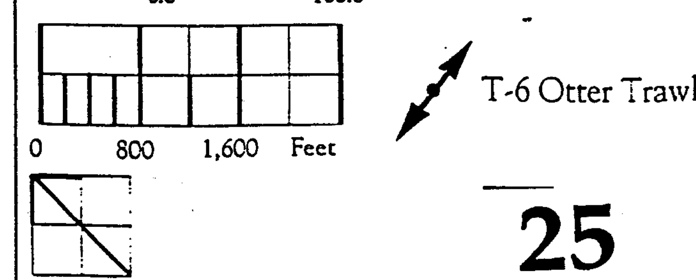


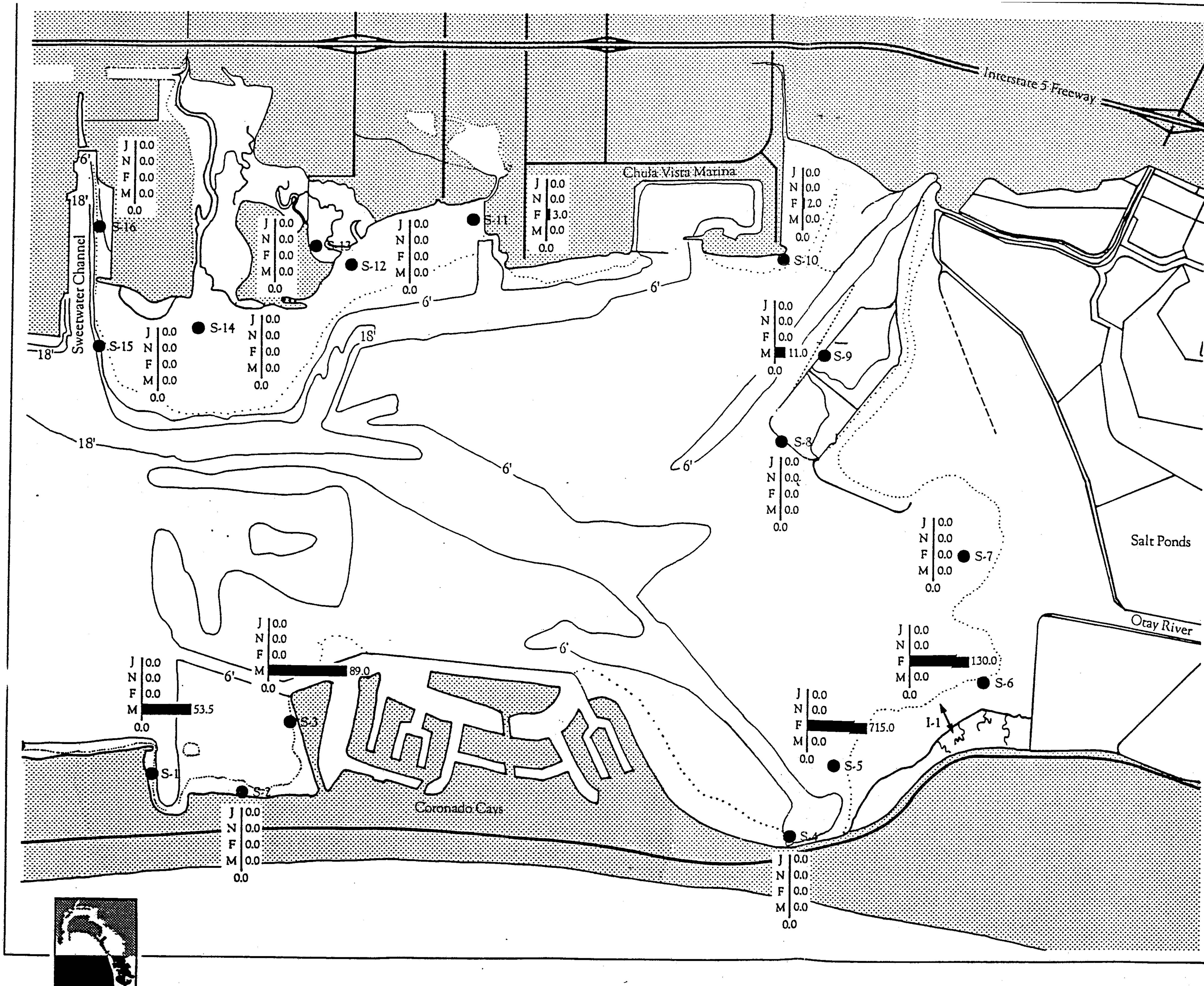



Otter Trawls
Location of stations T-1 through T-17 at which replicate otter trawl samples are taken during the period July 1988 through May 1989.

Legend:

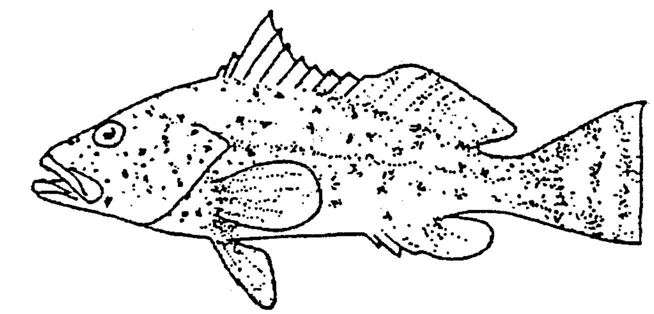





South San Diego Bay
Resources Atlas

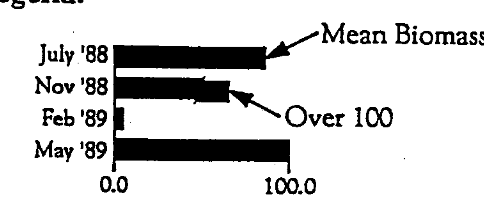
# Spotted Sand Bass
## *Paralabrax maculatofasciatus*



### 26m Bag Seines

Location of stations S-1 through S-15 at which replicate beach seine samples were taken across the intertidal and shallow subtidal shoreline. Sampling was conducted during the period July 1988 – May 1989.

Legend:




● S Seines

0 800 1,600 Feet

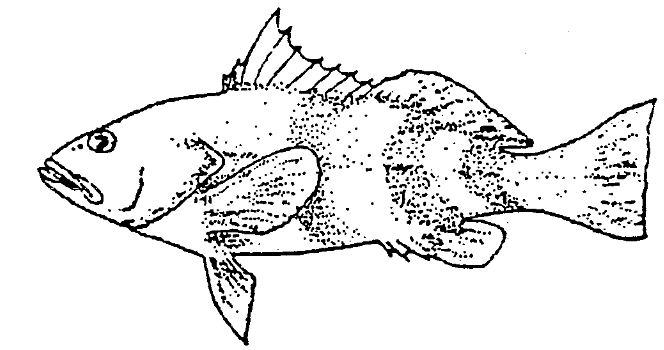
North

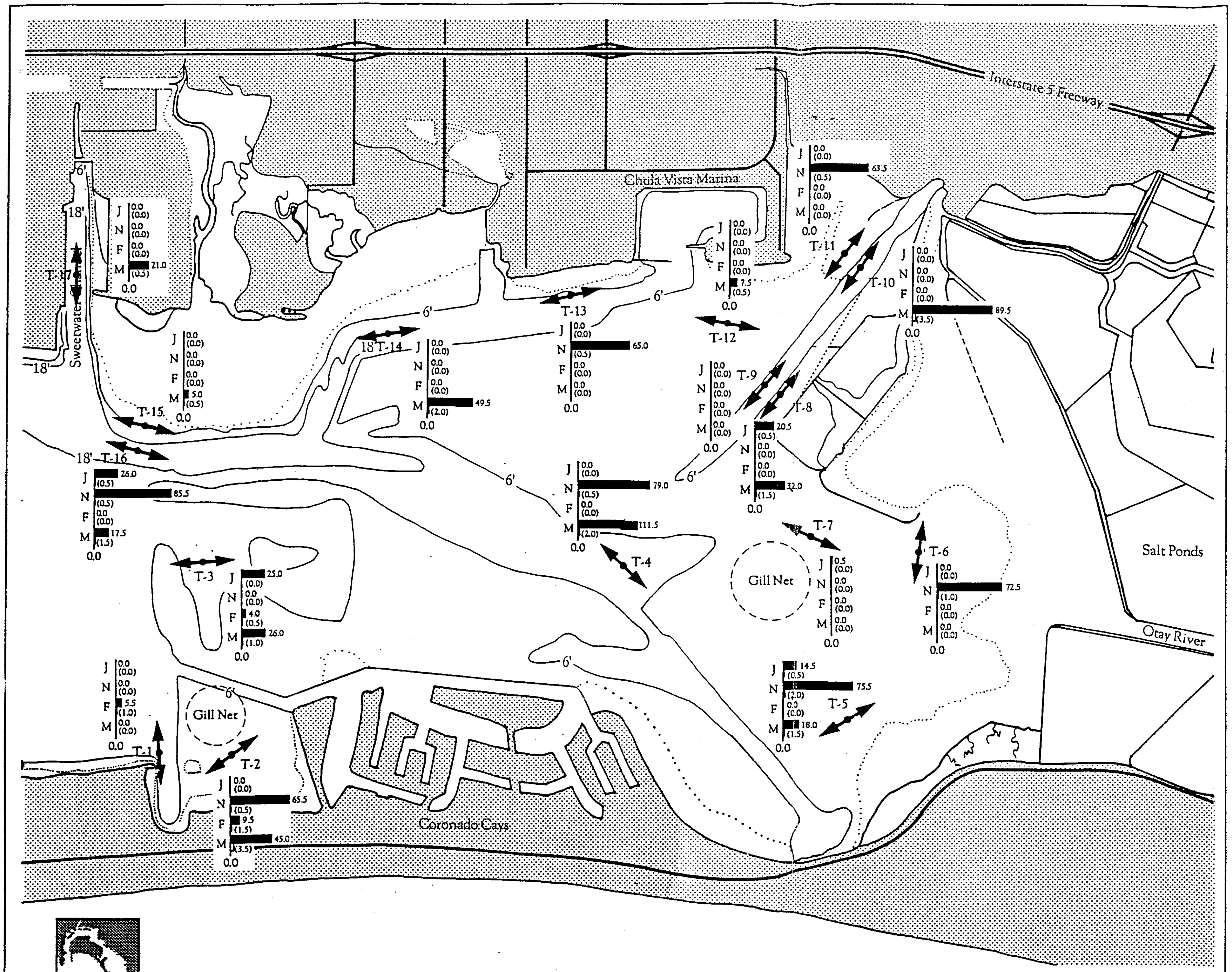
26

Figure No.

South San Diego Bay
Resources Atlas

# Barred Sand Bass
# Paralabrax nebulifer

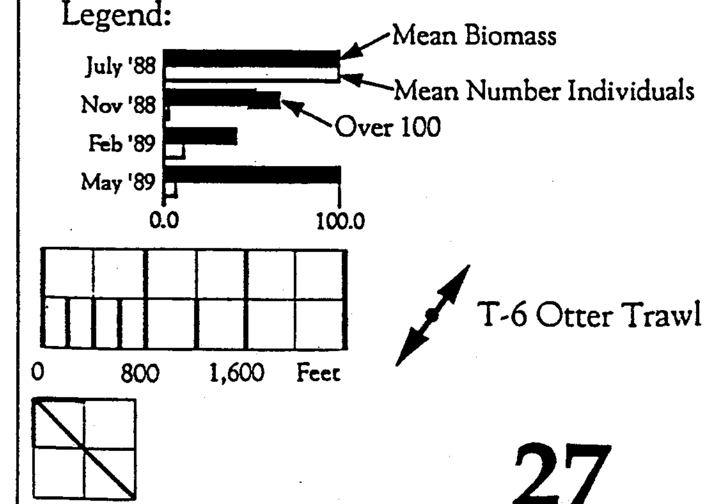





Otter Trawls

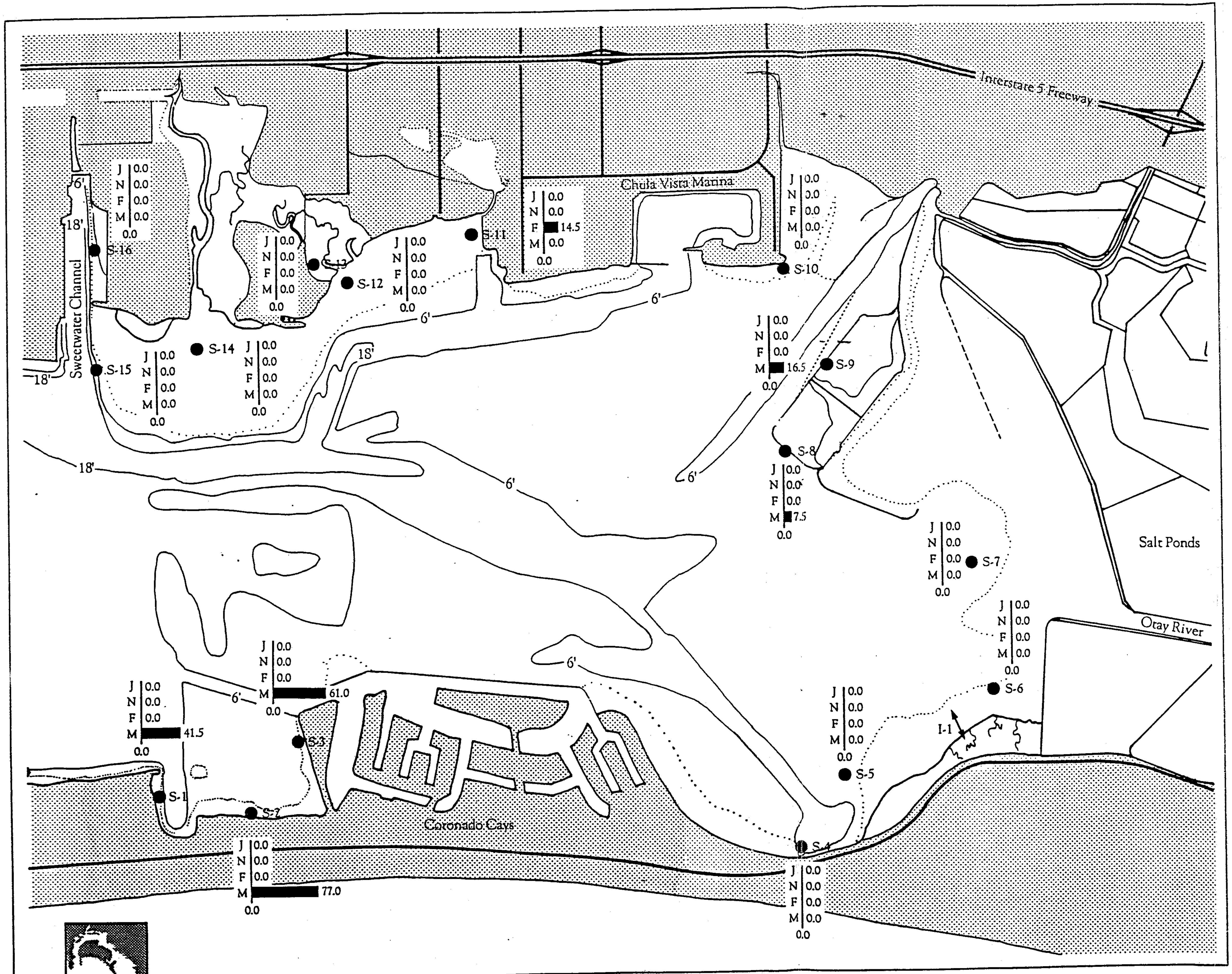
Location of stations T-1 through T-17 at which replicate otter trawl samples are taken during the period July 1988 through May 1989.

Legend:



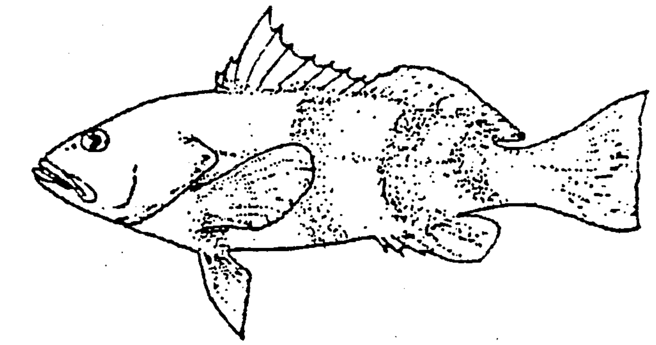

27

Figure No.




South San Diego Bay
Resources Atlas

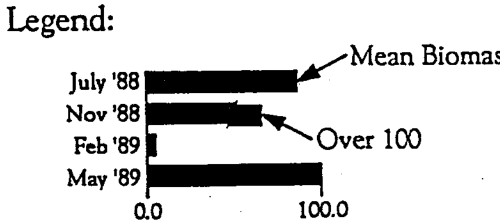
## Barred Sand Bass
## Paralabrax nebulifer



26m Bag Seines

Location of stations S-1 through S-15 at which replicate beach seine samples were taken across the intertidal and shallow subtidal shoreline. Sampling was conducted during the period July 1988 – May 1989.

Legend:




●S Seines

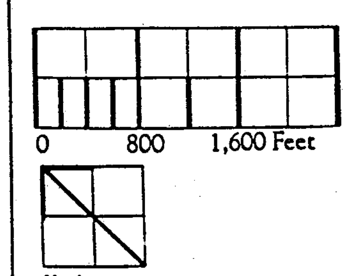



Figure No.
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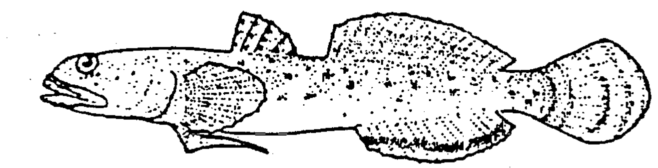
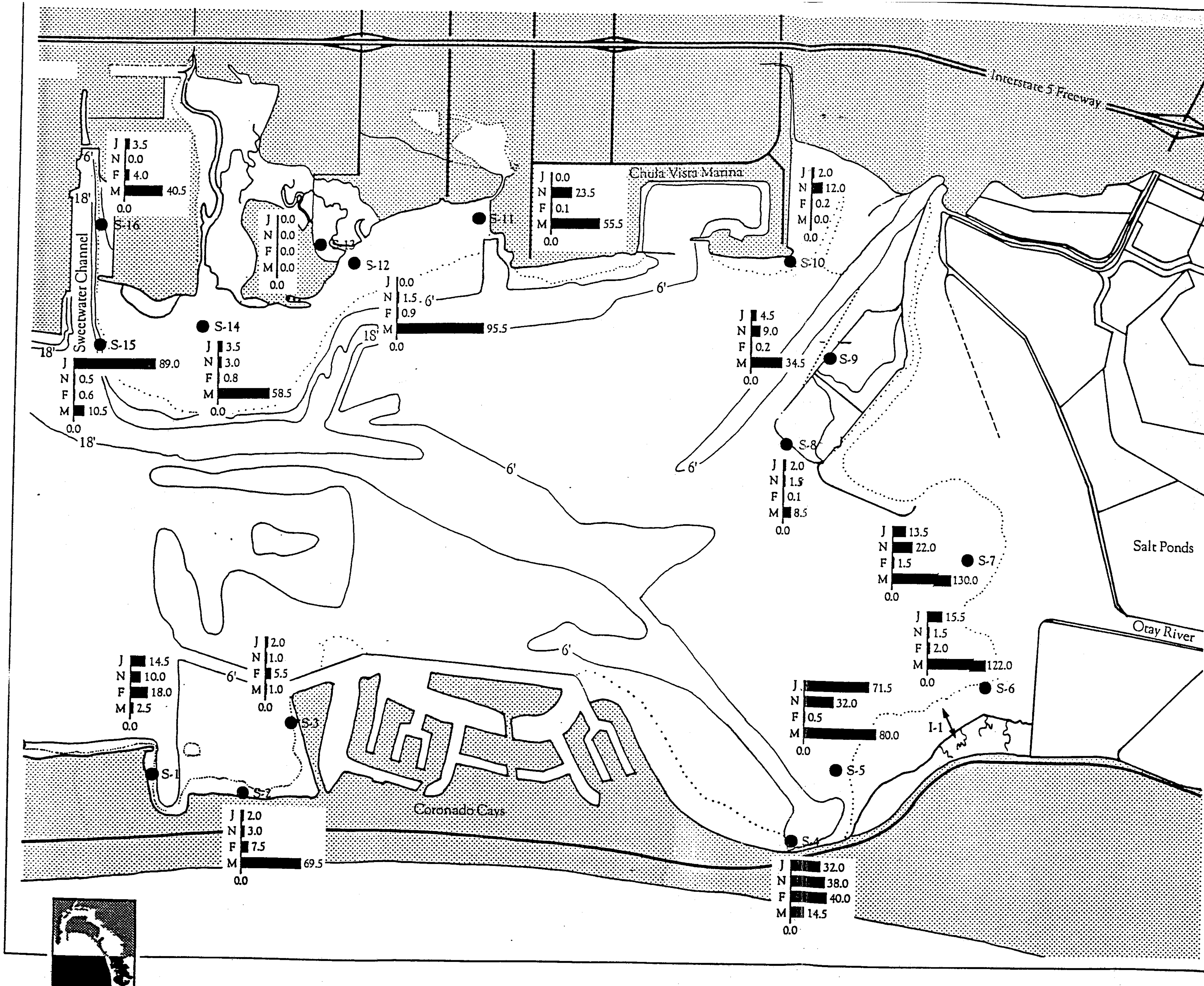
South San Diego Bay
Resources Atlas

# Arrow Goby
# Clevelandia ios

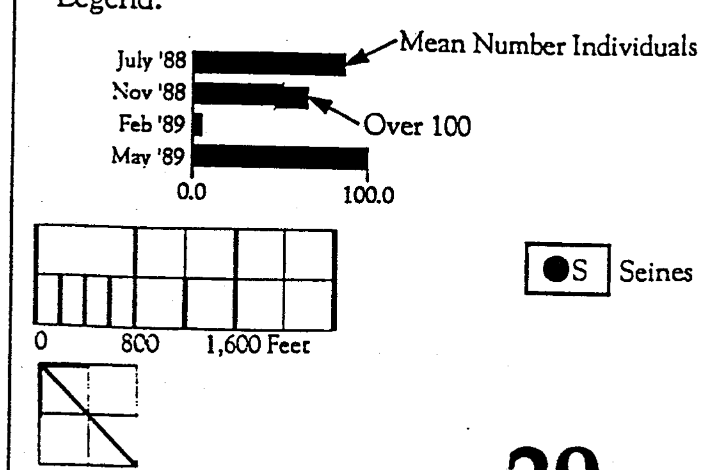





5.2m Minnow Seines

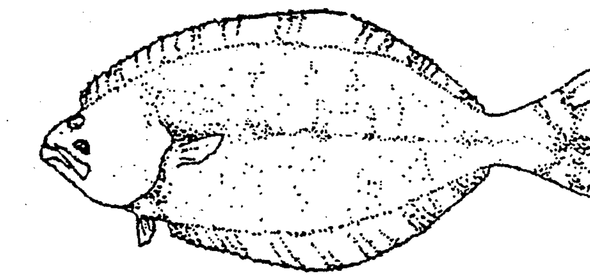
Location of stations S-1 through S-15 at which replicate beach seine samples were taken across the intertidal and shallow subtidal shoreline. Sampling was conducted during the period July 1988 – May 1989.

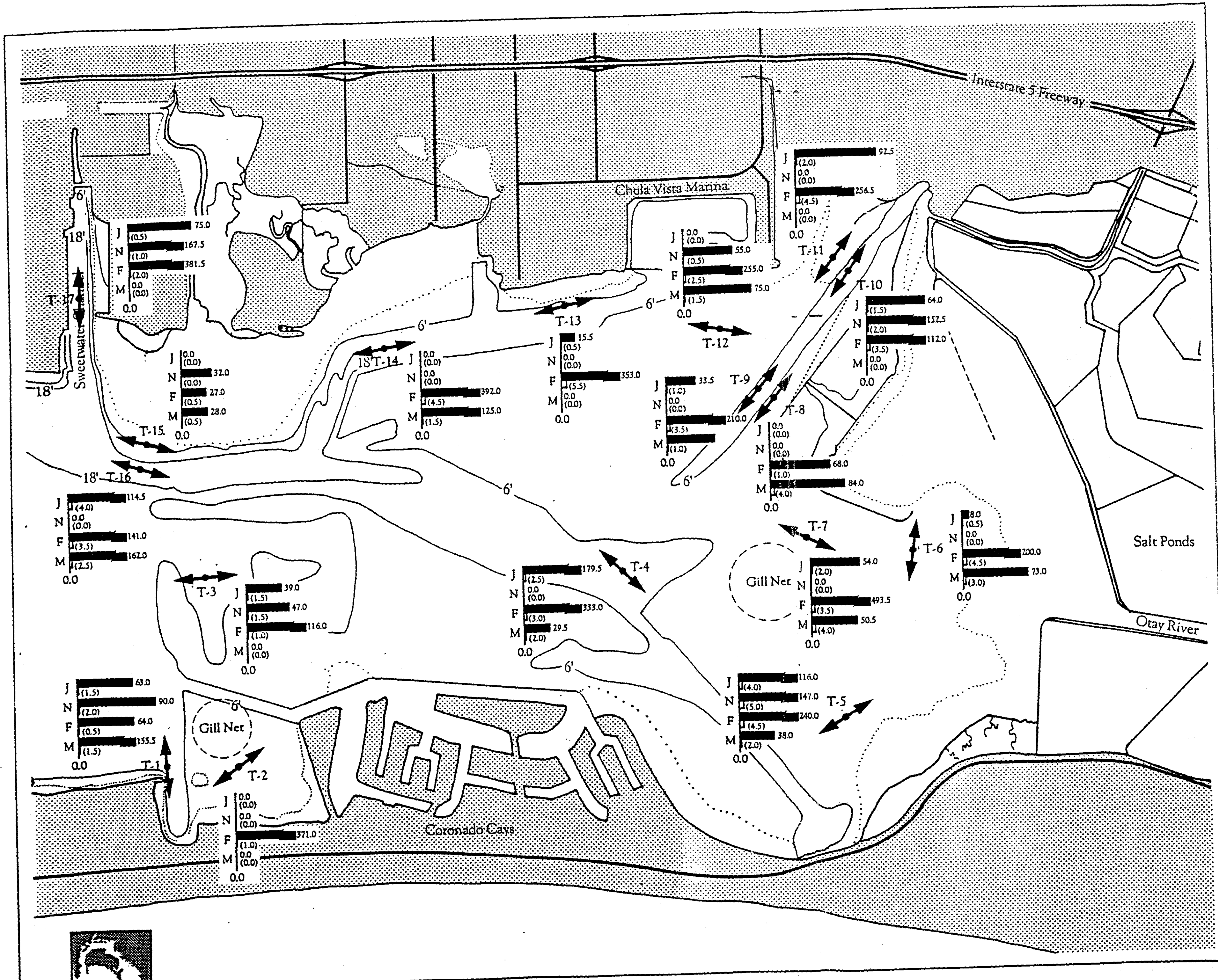
Legend:



South San Diego Bay
Resources Atlas

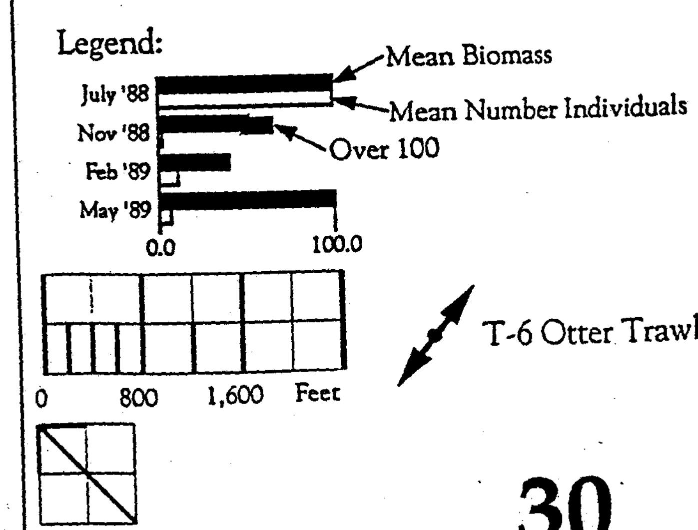
# California Halibut
## *Paralichthys californicus*





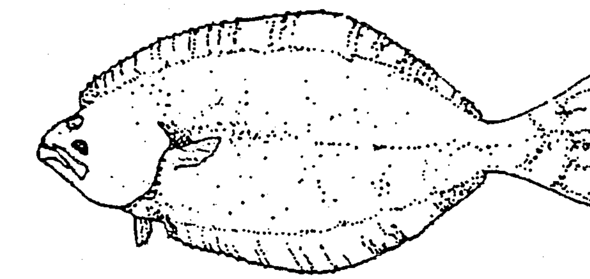

Otter Trawls

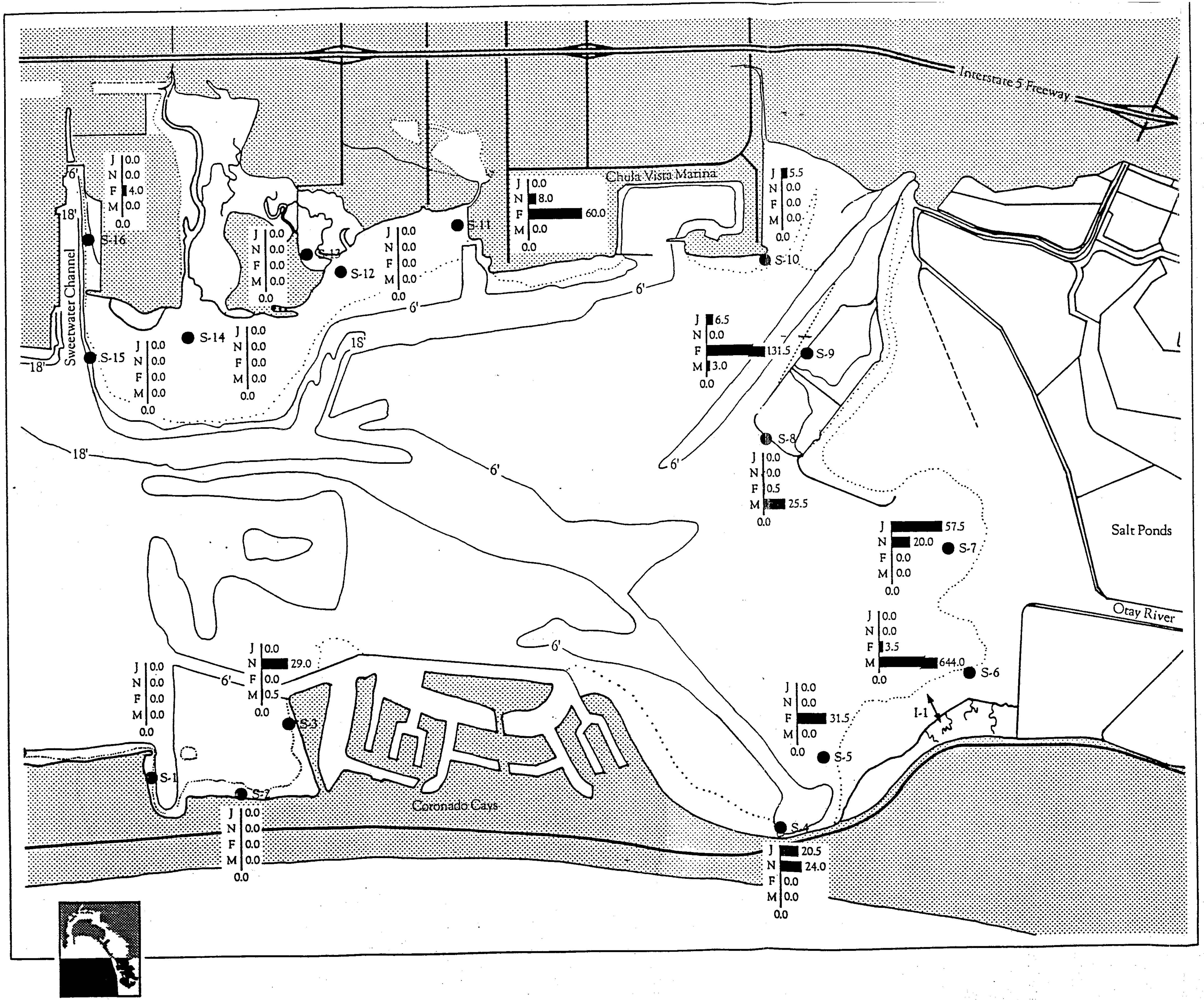
Location of stations T-1 through T-17 at which replicate otter trawl samples are taken during the period July 1988 through May 1989.



South San Diego Bay
Resources Atlas

# California Halibut
## *Paralichthys californicus*






26m Bag Seines

Location of stations S-1 through S-15 at which replicate beach seine samples were taken across the intertidal and shallow subtidal shoreline. Sampling was conducted during the period July 1988 – May 1989.

Legend:

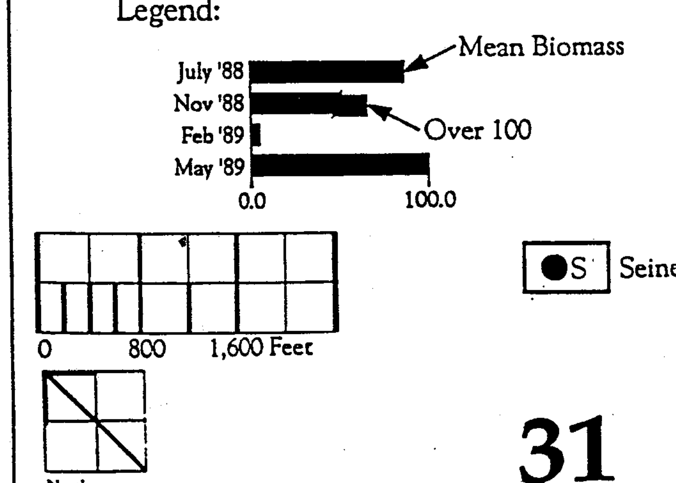



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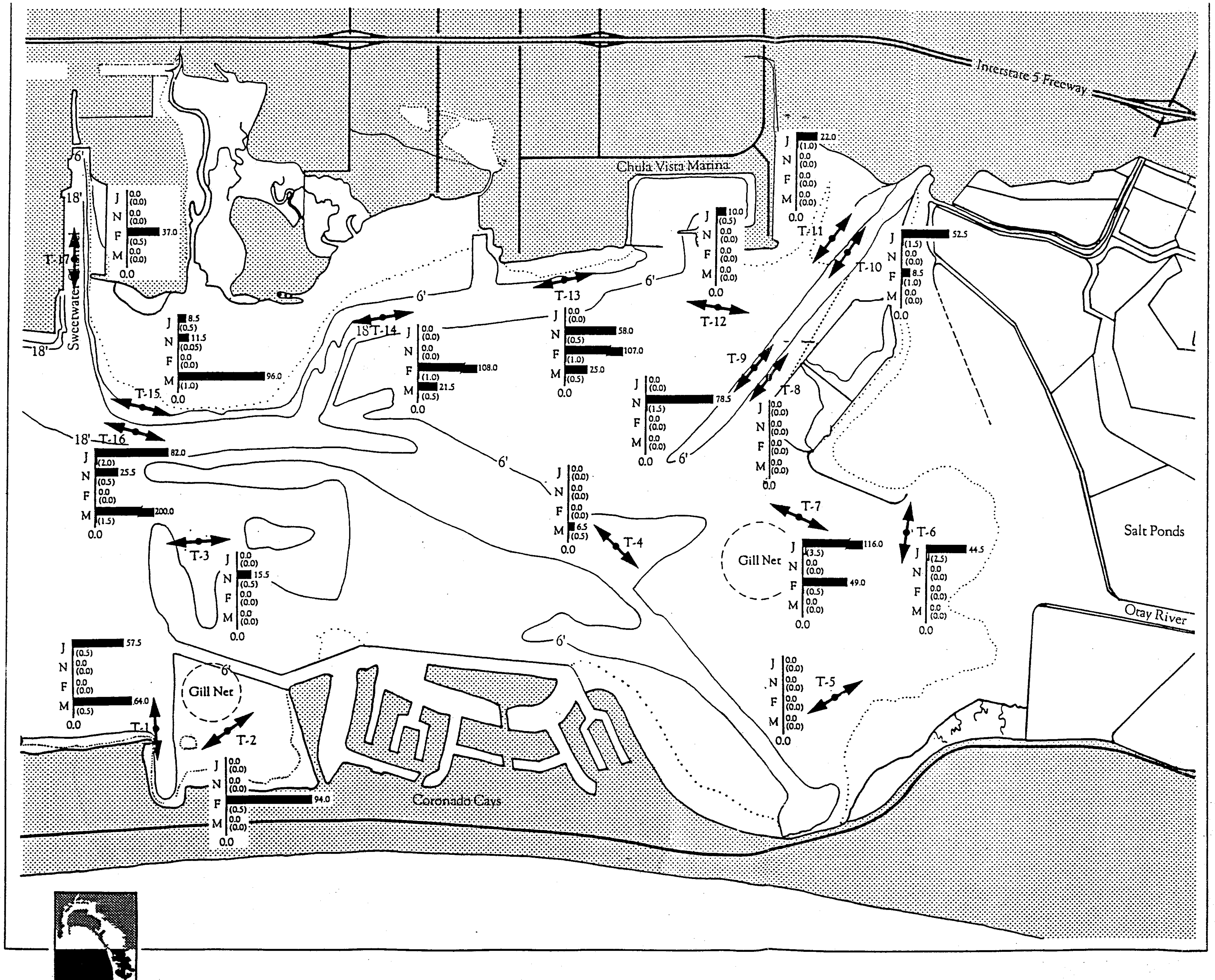
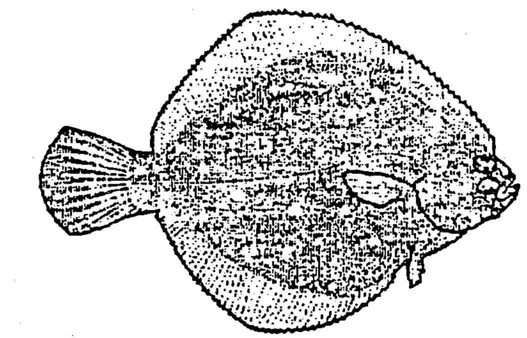
Figure No.




South San Diego Bay
Resources Atlas

# Diamond Turbot
## *Hypsopsetta guttulata*



Otter Trawls

Location of stations T-1 through T-17 at which replicate otter trawl samples are taken during the period July 1988 through May 1989.

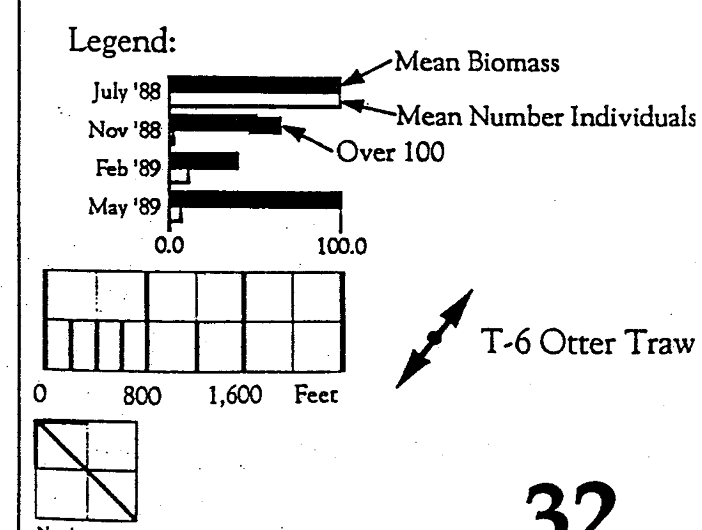



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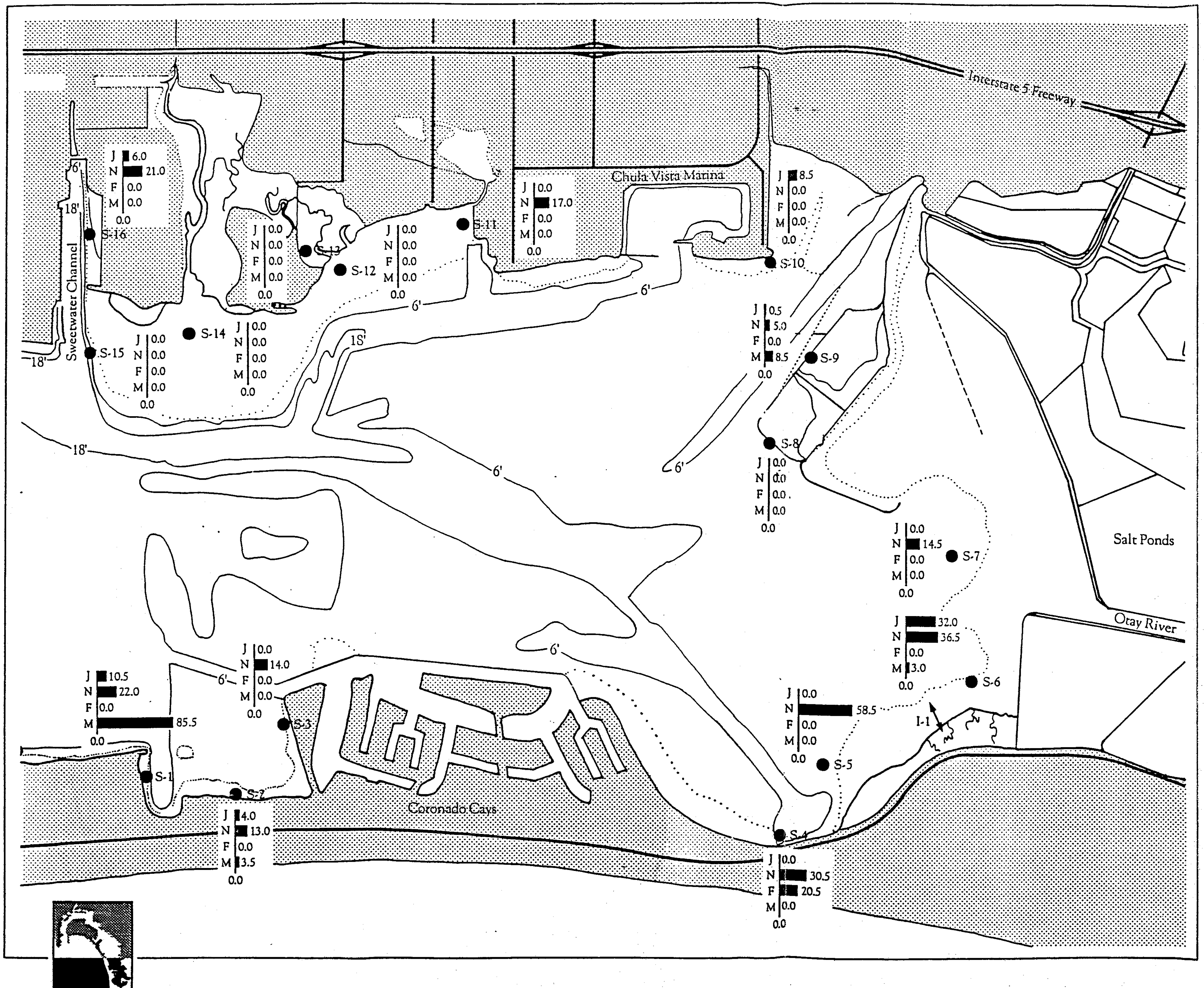
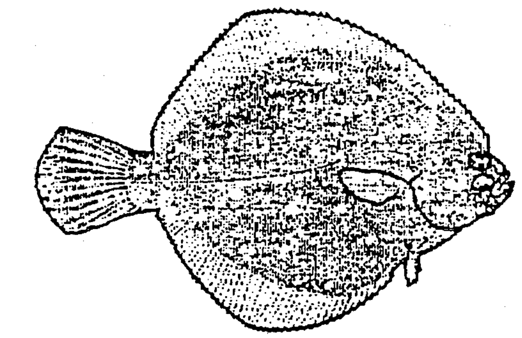
Figure No.




South San Diego Bay
Resources Atlas

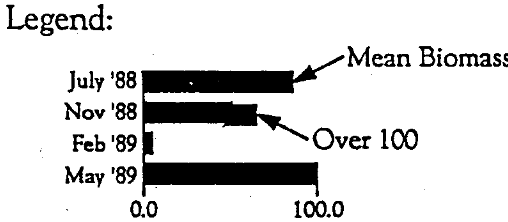
# Diamond Turbot
# Hypsopsetta guttulata



**26m Bag Seines**

Location of stations S-1 through S-15 at which replicate beach seine samples were taken across the intertidal and shallow subtidal shoreline. Sampling was conducted during the period July 1988 – May 1989.

Legend:




●S Seines

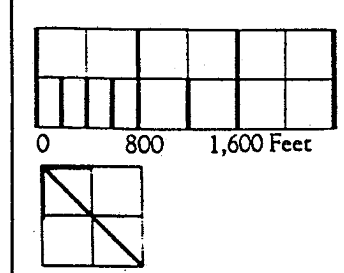



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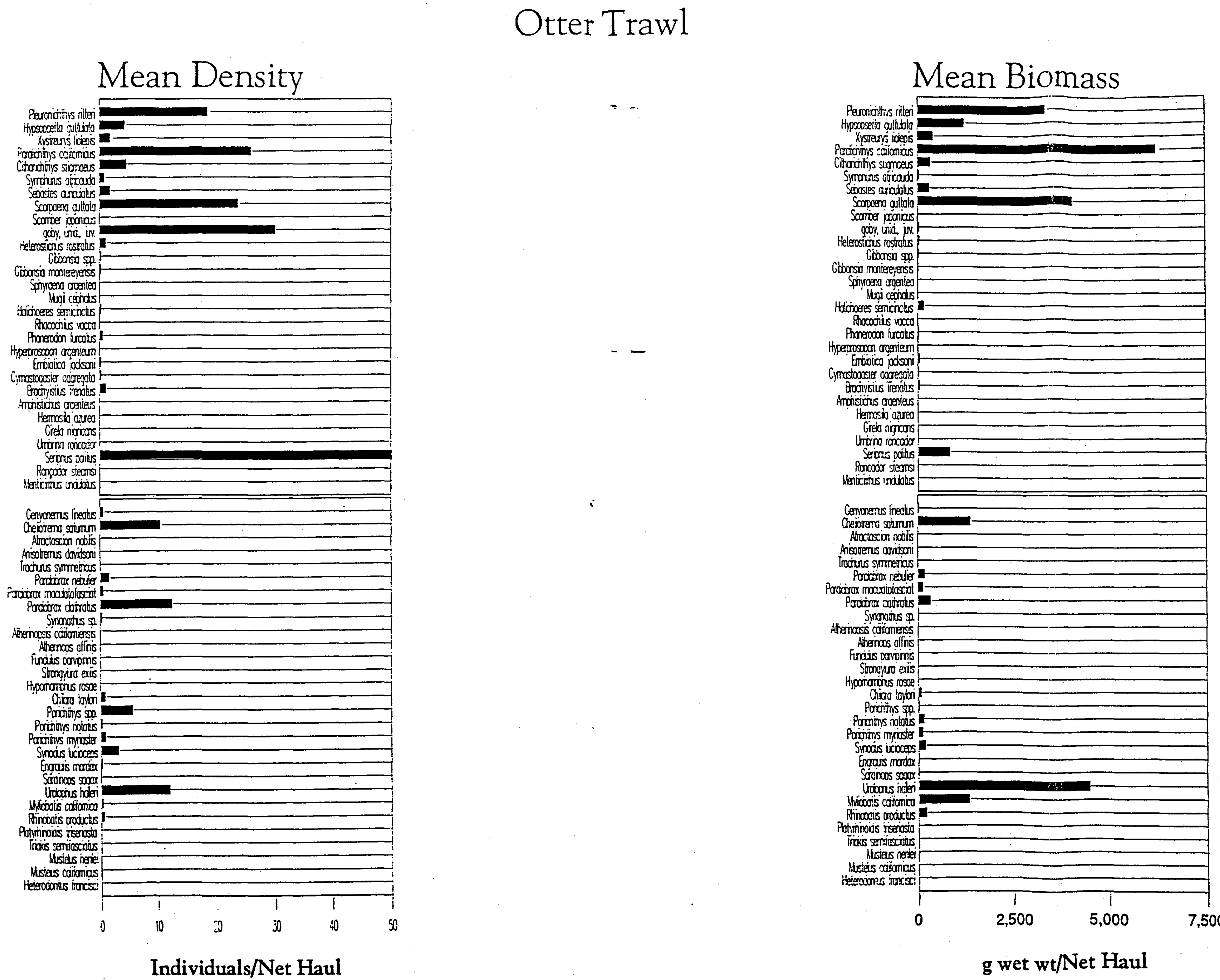
Figure No.



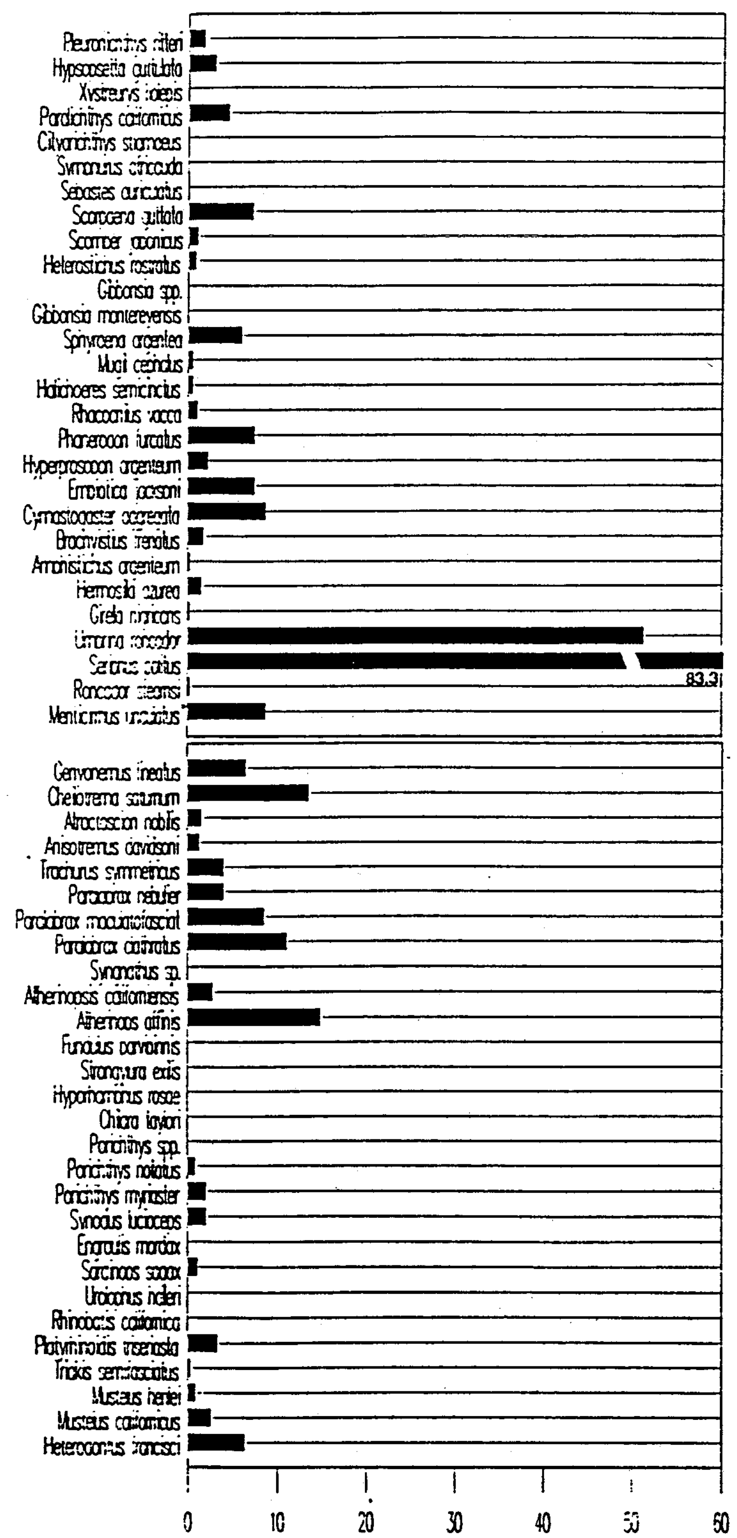

Sampling Conducted February, April, July and October 1988; See MBA (1989)
For Sample Locations (Arco Drydock Plus Control Area) and Additional Explanation.

Ballast Point, North San Diego Bay: Average Annual Abundance And Biomass Of Fish Collected 1988, Using Otter Trawls

Figure No. 34

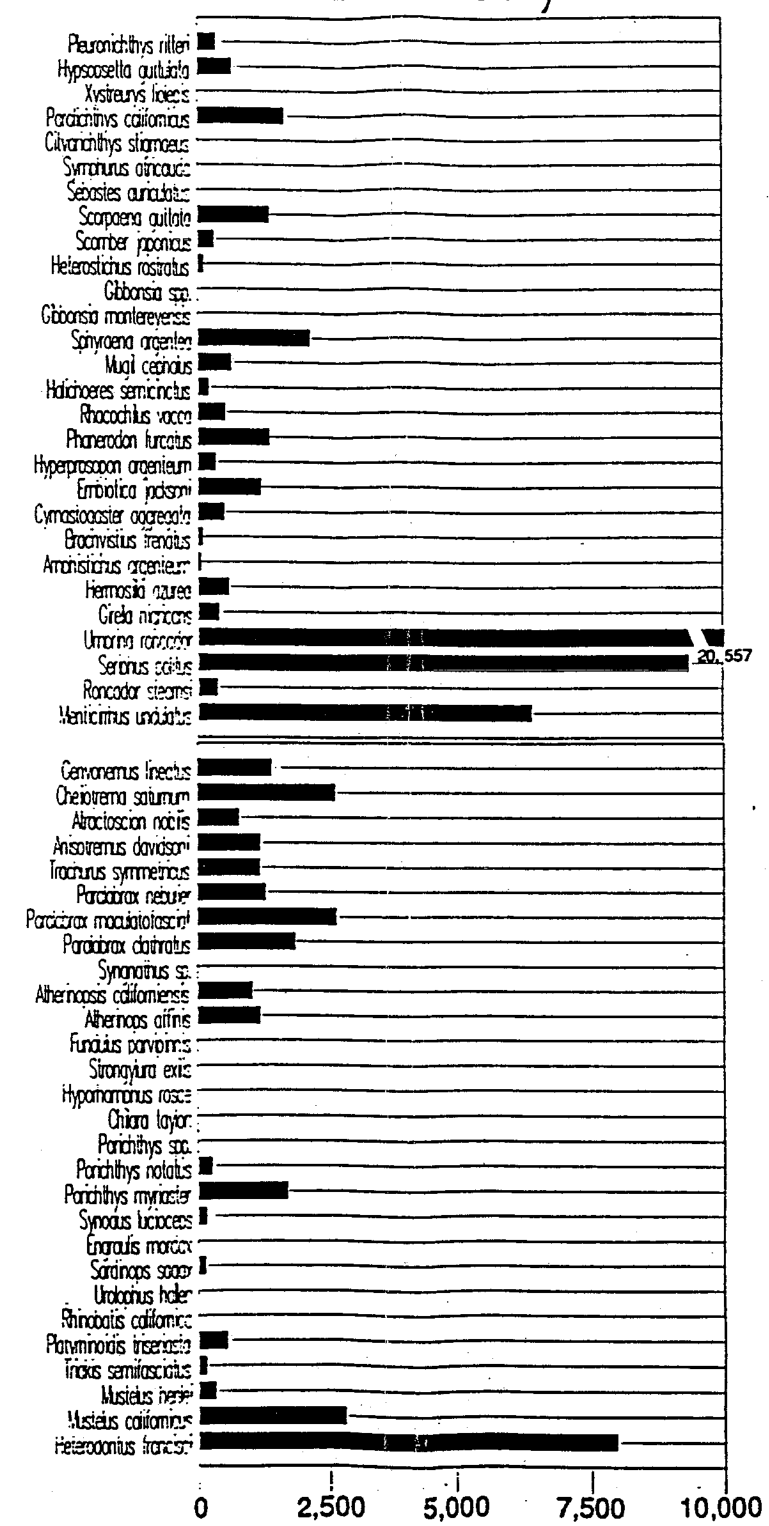
# Gill Net

## Mean Biomass




Individuals/Net Haul

## Mean Density




g wet wt/Net Haul

Sampling Conducted February, April, July and October 1988; See MBA (1989)
For Sample Locations (Arco Drydock Plus Control Area) and Additional Explanation.

Ballast Point, North San Diego Bay: Average Annual Abundance And Biomass Of Fish Collected 1988, Using Gill Nets

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Figure No.