ATTACHMENT 20

SOUTH BAY POWER PLANT
COOLING WATER DISCHARGE CHANNEL
FISH COMMUNITY CHARACTERIZATION STUDY

April 1997 through January 2000

FINAL REPORT

Prepared for:

Duke Energy South Bay LLC
and
California Regional Water Quality Control Board: San Diego Region

June 2000

Prepared by:

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FINAL REPORT

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EXECUTIVE SUMMARY

Duke Energy South Bay LLC recently renewed their National Pollution Discharge Elimination Systems (NPDES) permit for the South Bay Power Plant (SBPP). A condition of renewal, under San Diego Regional Water Quality Control Board (RWQCB) Order 96-05, required the completion of a fish use study within the power plant discharge channel. The purpose of this study was to characterize the fisheries beneficial uses within the discharge channel which existed on, or after, November 28, 1975. The study was designed to compliment the U.S. Navy fish study (*Fisheries Inventory and Utilization of San Diego Bay, San Diego, California*) which covered the larger bay ecoregions.

The three year study program included quarterly sampling at two stations; Station 1 occurred immediately west of the existing temperature monitoring buoy; Station 2 occurred farther to the west but still within the discharge channel. Both stations were located on the south side of the Chula Vista Wildlife Island and within the open waters of the discharge channel. Six different types of sampling gear were used at each station. This report constitutes the final monitoring report prepared for the study effort, covering sampling conducted quarterly from April 1997 through January 2000. The purpose of this report is to present all data collected during the three year study and to provide analyses of trends in fisheries resources within the South Bay Power Plant cooling water discharge channel.

During the three year survey, a total of thirty-eight species, represented by a combined total of 176,414 fish, were captured. Samples were dominated by slough anchovy (*Anchoa delicatissima*) which represented 91.4% of the total individuals caught during the survey. The next most abundant fish was deepbody anchovy (*Anchoa compressa*), comprising 1.4% of the total individuals caught during the study. Round stingray (*Urolophus halleri*) represented 1.1% of the total catch and topsmelt (*Atherinops affinis*) were only slightly less abundant, making up 1.0% of the total catch. Other commonly captured species included California killifish (*Fundulus parvipinnis*), cheekspot goby (*Ilypnus gilberti*), arrow and shadow gobies (*Clevlandia ios* and *Quietula y-cauda*), striped mullet (*Mugil cephalus*), bonefish (*Albula vulpes*), and California halfbeak (*Hyporhamphus rosae*).

The highest fish densities occurred in January 2000 at Station 1 (4.02 indiv./m^2) and in October 1997 at Station 2 (9.04 indiv./m^2). The mean density of fish captured for the three year study was considerably lower at Station 1 than Station 2 (0.75 indiv./m^2 and 1.95 indiv./m^2, respectively). For the most part, this difference was due to the larger numbers of anchovies caught at Station 2. The mean numerical fish density for the entire discharge channel as calculated over the total three year study period was 1.35 individuals/m^2. This density compared very favorably with the 1.36 indiv./m^2 mean numerical density reported for the remainder of San Diego Bay (Allen 1999).

The total weight of all individuals captured at both stations during the three year survey was 715.0 kilograms (478.1 kilograms at Station 1 and 236.9 kilograms at Station 2). The total weight of fish captured at each station varied between quarters and was highest at Station 1 in January 2000 (137.5

kg) and at Station 2 in January 1999 (99.2 kg). The lowest total weight of fish captured was in July 1997 at Station 1 (0.3 kg) and in October 1999 at Station 2 (1.7 kg).

Biomass at Station 1 ranged from a January 2000 high of 24.40 g/m^2 to a low of 0.05 g/m^2 in July 1997. Similarly the biomass at Station 2 ranged from a high of 17.47 g/m^2 in January 1999 to a low of 0.29 g/m^2 in October 1999. The mean biomass for the discharge channel during the course of the study was 5.48 g/m^2. This compares with the 2.03 g/m^2 for the remainder of San Diego Bay that has been reported from the U.S. Navy study (Allen 1999). Allen infers very high fish productivity rates for San Diego Bay based on the relatively large biomass determined for San Diego Bay. At 270% of the biomass recorded for the remainder of the bay, such productivity inferences would suggest even higher values for the South Bay Power Plant cooling water discharge channel.

A significant impetus on completing the fish community investigations within the discharge channel of the SBPP was to determine what the large number of birds that forage within the channel are consuming. From the present investigation, it is clearly suggested that the key species that could support the prolific foraging activities include slough anchovy and deepbody anchovy. Species of lesser importance to the avian forage base include topsmelt, California killifish, gobies, striped mullet, bonefish, and California halfbeak. It is interesting to note that the channel supports predominantly juvenile fish and is a nursery area for most forage species.

The 38 species collected during the three year study in the discharge channel can not be directly compared to the 78 species collected during the five year study of the entire bay that was completed by the Navy (Allen 1999). This is principally due to a number of factors including the fact that the Navy surveys sampled many more habitats than are represented within the discharge channel, extended for two years longer than the present study, and sampled over twelve times as much area than that sampled within the SBPP discharge channel. In the Navy's southern stations, the number of species collected began to approach the species richness levels represented by the discharge channel with 49 and 52 species being represented in the south-central and southern ecoregions of the bay. However, again the Navy study is favored by greater area of sampling, more habitat diversity, and larger sampling areas, all of which add to the potential for greater species richness. Data from the prior survey are not presented in a manner that allows ready extraction for comparison of species richness.

Of the 176,414 fish captured in this study, none exhibited abnormalities that can be attributed to either chemical or natural physical damage. Several of the round stingrays collected lacked tails or tail spines due to mechanical removal by wire cutters, pliers, or a knife. While unfortunate, such damage is rarely fatal to the ray and is a common occurrence where rays are regularly kept for display or caught by fishermen. Eight other fish hosted external parasites including leeches and isopods. The frequency of parasitism does not appear to be abnormal compared to other systems such as Batiquitos Lagoon, which was monitored during the same timeframe as the present study.

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND AND REGULATORY REQUIREMENTS

As part of the renewal process for the 1996 National Pollution Discharge Elimination Systems (NPDES) permit for the South Bay Power Plant, San Diego Gas & Electric (SDG&E) demonstrated the continued presence and protection of beneficial uses existing within the south San Diego Bay environment. SDG&E provided information which adequately documented the status of benthic organisms, avifauna, and endangered and threatened species within the south bay. Further, SDG&E demonstrated that no substantive changes have occurred relative to the plant operations subsequent to November 28, 1975, the baseline date for establishing beneficial uses under federal regulations (40 CFR 131) and the San Diego Basin Plan. However, while preparing and presenting information, it was recognized that additional baseline data was required to characterize the fish communities in proximity to the power plant discharge.

Numerous avian species including pelicans, terns, osprey, grebes, and mergansers, forage for fish in the discharge channel. However, it has not been clear what species of fish these birds are eating. The most recent comprehensive fish studies within the discharge channel were conducted prior to the 1975 date for establishing beneficial uses to be protected (Ford 1968). Further, these studies pre-date environmental changes including the construction of the San Diego Unified Port District's Chula Vista Wildlife Island, and the California Department of Fish and Game's authorization of an experimental mullet fishery within south San Diego Bay.

Recognizing the mutual benefits provided by a better understanding of the extent and function of the fish community in the overall ecosystem, an agreement was reached between interested state and federal resource agencies and SDG&E to conduct a one time study which documents the existing fish communities of the South Bay Power Plant discharge channel. This documentation will serve as baseline information for characterization of the fisheries beneficial uses which existed within the cooling water discharge channel on, or after, November 28, 1975. A formal requirement for the discharge channel fish study was incorporated into the NPDES renewal by the California Regional Water Quality Control Board, San Diego Region (Order 96-05) as follows:

> SDG&E shall conduct or fund a study for purposes of determining the species and abundance of fish in the discharge channel of the South Bay Power Plant. No later than three months after adoption of this Order, SDG&E shall submit a detailed study plan to the Executive Officer, USEPA, Department of Fish and Game (DFG), U.S. Fish and Wildlife Service (USFWS), and National Marine Fisheries Service (NMFS). The study plan shall be subject to the approval of the Executive Officer, in consultation with USEPA, DFG, USFWS, and NMFS, and shall be revised as directed by the Executive Officer. The study shall be initiated and the results submitted in accordance with a schedule specified by the Executive Officer.
>
> ***(Order 96-05; F. REPORTING REQUIREMENTS; No. 16)***

Effective April 23, 1999, the South Bay Power Plant was sold to the San Diego Unified Post District, and Duke Energy South Bay LLC became the Plant Operator.

1.2 FISH COMMUNITY STUDY PLAN

In accordance with Condition F.16. of Order 96-05, a study plan was developed to guide the implementation of a fisheries study within the power plant discharge channel (Merkel & Associates 1997). On February 8, 1997, the study plan was submitted to the San Diego Regional Water Quality

Control Board and reviewing agencies. On March 21, 1997, the Plan was approved for implementation by Mr. John Robertus, Executive Officer. The study was designed to compliment the 1994-1999 U.S. Navy fish study (*Fisheries Inventory and Utilization of San Diego Bay, San Diego, California*) which covered the larger bay ecoregions and was conducted through a cooperative effort between the U.S. Navy, San Diego Unified Port District, and National Marine Fisheries Service (Figure 1-1).

This document serves as the final report of the fish community characterization study in accordance with the authorized plan for the required fish study. It has been developed through adherence to the requirements of Order 96-05, and field reviews of the channel area for study site selection, conducted on January 23, 1997 by F. Jacobsen, SDG&E; M. Kenney, USFWS; L. Allen, California State University, Northridge; K. Merkel, Merkel & Associates (M&A); and M&A staff, H. Hanson and K. Cull. One minor change to the original study site selection was the shift of the near-field sampling from the south side of the discharge channel to a small beach on the north side of the discharge channel to resolve sampling problems inherent with work on the soft mudflats fringing the southern channel edge. This change has been previously reviewed with resource agency staff and has been employed in every sampling interval for consistency.

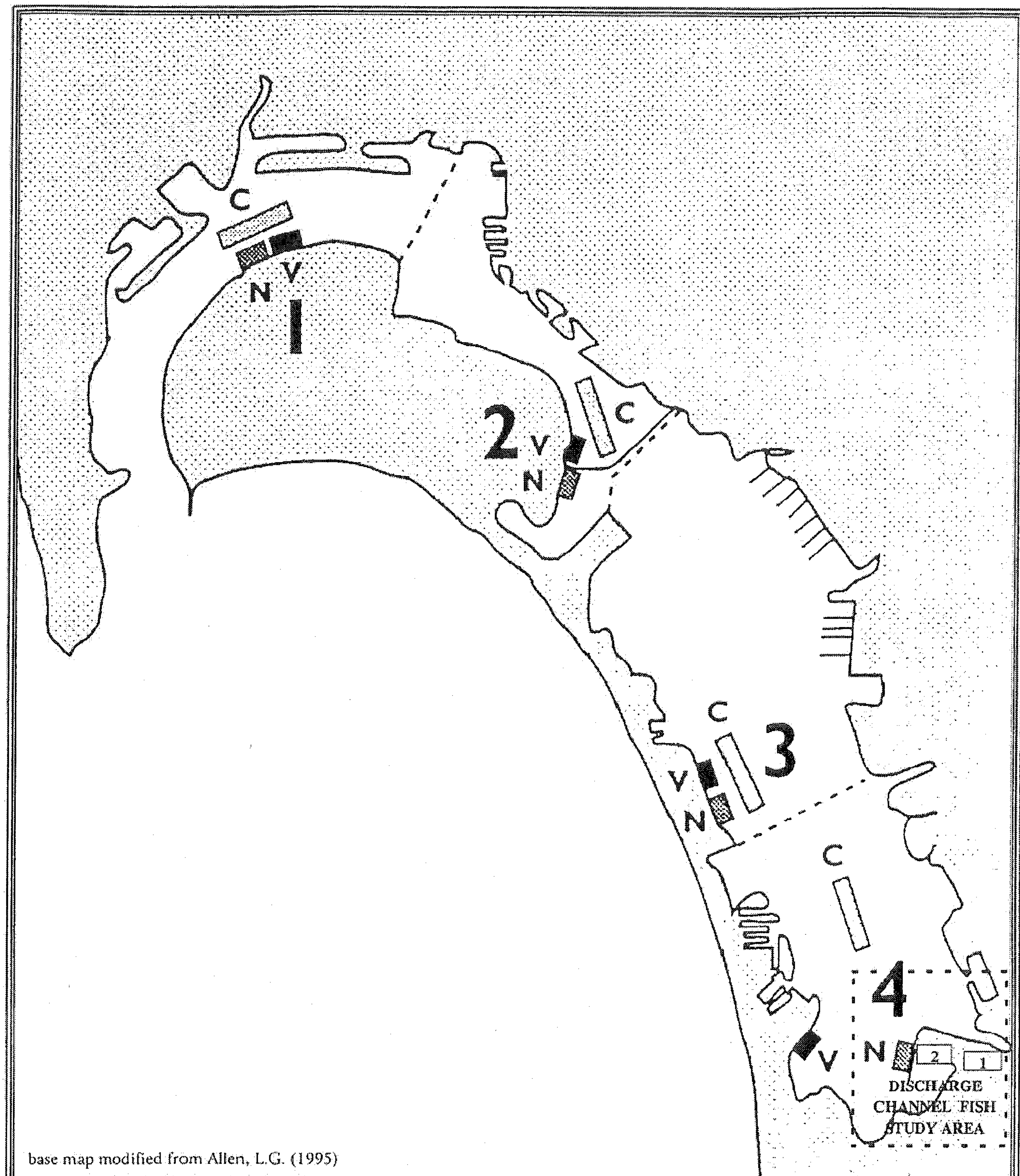
2.0 STUDY METHODS

2.1 SURVEY TECHNIQUES

2.1.1 Fisheries Studies

Study Approach

Fisheries survey techniques within southern California have not been well standardized. Recognizing the need for standardizing data collection methods and understanding the strengths and weaknesses of various sampling gear, the U.S. Navy, in cooperation with NMFS and the San Diego Unified Port District, conducted a multiple habitat, multiple gear sampling within San Diego Bay from 1994-1999. This U.S. Navy fish study was completed under the technical direction of Mr. Robert Hoffman of NMFS and Mr. Mitch Perdue of the Navy, and contracted to Dr. Larry Allen of CSU Northridge. The program has provided insight into ecological conditions of San Diego Bay, as well as provided a standard to which sampling programs can be developed and gear may be selected. This program borrowed much of its structure from past sampling programs including work in Upper Newport Bay, Alamitos Bay-Long Beach Harbor, and both Mission and San Diego Bays. To a great degree, the U.S. Navy fish study (from this point on referred to as the Navy study) linked common elements of other programs: quarterly sampling, replicated sampling and standardized coverage, and information on fish species, counts, biomass, standard length, and noted epidural abnormalities (Allen 1999). The South Bay Power Plant fisheries sampling program was structured similarly to the ongoing fish survey conducted by Merkel & Associates in Batiquitos Lagoon and the Navy study recently completed by Dr. Allen in San Diego Bay. This allows for future comparison between the studies and further characterization of the existing beneficial uses of south San Diego Bay. The data collection and sampling gear, station locations, study period and sampling frequency, statistical analyses, and reporting methods for the South Bay Power Plant Cooling Water Discharge Channel Fish Community Characterization Study are discussed in the following sections.



No Scale	San Diego Bay Fisheries Study Program Illustrating Relationship of Sampling Stations in Navy Fish Study to South Bay Power Plant Discharge Channel Study Area	Figure 1

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Station Locations

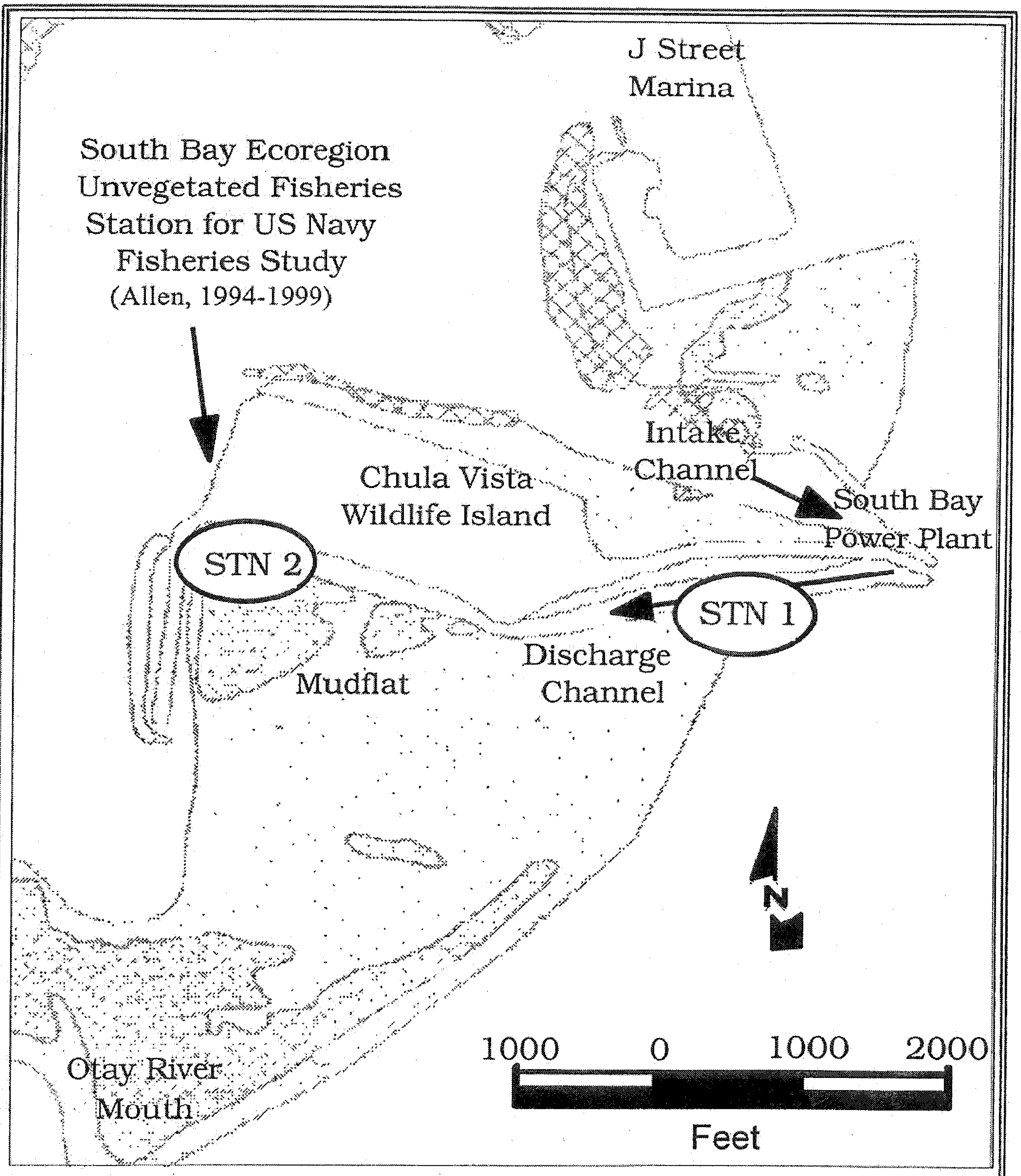
The South Bay Power Plant lies in the far southern end of San Diego Bay. Its cooling water system draws ambient bay waters into the power plant through an intake channel and discharges them into the bay through a cooling water discharge channel. The intake and discharge channels are separated by a 7,000 foot long earthen dike which forms the southern edge of the Chula Vista Wildlife Island. The 287 acre discharge channel consists of a shallow triangular area of the bay under marine tidal influence. The channel is geographically defined by the Chula Vista Wildlife Island to the north, the northern-most dikes of the Western Salt evaporator ponds to the south, and an extension of the southern arm of the intake/discharge dividing dike south to the mouth of the Otay River. Most of the discharge channel is an extensive intertidal mudflat extending northward from the dikes of the Western Saltworks. A deeper channel follows the southern edge of the Chula Vista Wildlife Island dike, which during low tides produces a narrow fringe beach along the northern channel edge. Because it was anticipated that the fish assemblage of the cooling water channel varies along a thermal gradient and also makes use of the channel in different ways over the course of a year, two stations were sampled to characterize the fish resources of the area. These stations consisted of one near-field station (Station 1) and one far-field station (Station 2).

Station 1 was located just west of the power plant's temperature monitoring buoy (Figure 2). Shore-based sampling at Station 1 was conducted on the beach along the northern edge of the channel. Sampling took place at low tide on a stretch of firm mudflat approximately 150 feet long and free of cobbles. Station 2 was located near the inside of the southerly arm of the original intake/discharge separator dike (Figure 2). Shore-based sampling at Station 2 was conducted at low tide over a stretch of cobble beach, also approximately 150 feet long. The area sampled by the shore-based gear at Station 2 had a cobblestone bottom at higher tidal elevations and a mud bottom at the lower tidal elevations.

Boat-based sampling was conducted adjacent to the onshore sampling stations within the deeper channel and flats of the discharge channel (Figure 2-1). A 250 meter transect was established at each offshore station and coordinates of the transect endpoints were recorded using a Leica 400 differential global positioning system (dGPS) set to projection WGS84, NAD83 (Table 2-1). During the survey, the endpoints of each transect were marked with temporary buoys; sampling replicates were completed along and to each side of the marked transects.

Table 2-1. Station coordinates for fish studies.

STATION	mE	mN
1, East Endpoint	490390	3608366
1, West Endpoint	490159	3608268
2, East Endpoint	489662	3608398
2, West Endpoint	489422	3608467



Location of Discharge Channel Fisheries Sampling Stations

Figure 2

Merkel & Associates,

Sampling Equipment and Methods

The fish study utilized a variety of sampling equipment in order to characterize the fish community of the area. The gear included large beach seine, small beach seine, square enclosure, beam trawl, purse seine, and otter trawl. Sampling involved three-fold replication at each station for each gear type. Equipment specifications and sampling techniques followed, to the maximum extent practical, the methods employed in the Navy study. Trawl tow lengths were shortened to one half of the length of those employed in the Navy study to accommodate the smaller sampling area available in the discharge channel. The trawl lengths were modified from timed tows to distance tows in order to standardize bottom area covered regardless of tow direction (with or against cooling water discharge flows). Data collected for fish caught in each haul included species and individual counts, individual standard lengths, and mass. One or more voucher specimens were collected for each new species of fish collected during the monitoring effort.

If more than 30 individuals of a species were caught in a replicate of any gear type, a batch sampling procedure was utilized. First, the standard length and weight was determined for 30 randomly selected individuals. Second, the batch weight was determined for 100 additional randomly selected individuals. Finally, the weight was taken of all the remaining, uncounted individuals caught in the replicate. The number of uncounted individuals was then estimated using the batch weight of the 100 randomly selected individuals.

Sampling gear types used, including design specifications, deployment techniques, and sampling areas, are discussed individually below. In addition, the target fish groups found to be best sampled with the various pieces of equipment are identified. The following six gear types were utilized:

Large Seine

The large seine is used to sample schooling fishes in the nearshore portion of a station. The seine consists of a 15.5m x 1.8m net fitted with a 1.8m x 1.8m x 1.8m bag; it has 1.2cm mesh in the main body and 0.6cm mesh in the bag. The seine is deployed in waters between 0m and 2m and is set parallel to shore. A shore crew then hauls the seine to shore with two nylon bridles attached to end poles of the seine. Throughout the study, an average area of 217 m^2 was sampled per haul.

Small Seine

The small seine is used to sample juvenile and adult fish in shallow, inshore habitat. The seine consists of a 4.6m x 1.2m net with 3mm mesh. It is typically deployed in shallow waters from 0m to 0.5m in depth. Two researchers walk the seine for 10m along the shoreline, then pivot and haul it inward. This creates a total sample area of 46m^2 for each haul.

Square Enclosure

The square enclosure is utilized to sample small, burrow inhabiting fish, such as gobies, and other small fish that occupy shallow waters and mudflats. The enclosure consists of a 1m x 1m x 1m frame enclosed on the sides by canvas. The enclosure is deployed at depths of 0.25-0.75m and the frame is pushed approximately 5cm into the substrate. The enclosed water column is then treated with 0.5 to 1 liter of 1% rotenone solution. A long-handled dip-net is then utilized to search the water column and collect fish over a 10 minute interval. The square enclosure samples a 1m^2 area.

Beam Trawl

The beam trawl is utilized to sample demersal (bottom-dwelling) species. A 1.6m beam trawl with 4mm mesh in the wings and 2mm mesh in the cod-end is pulled with a small skiff or other shallow draft vessel. Tows are made at an approximate speed of 1.5 to 2 knots along a 200 m long transect. Each replicate beam trawl samples an area of 400m^2.

Purse Seine

The purse seine is utilized to sample juvenile and adult fishes in the water column of the nearshore portions of each monitoring station. The purse seine also does an adequate job of characterizing demersal species assemblages when deployed in shallow water where the net reaches the bay bottom. A 66m x 6m seine with 1.2cm mesh in the wings and 0.6cm mesh in the bag is pulled with a small skiff or other larger shallow draft vessel. A maximum water volume of 2,080 m^3 is sampled during each seine. The area of coverage by the seine is 347m^2.

Otter Trawl

The semi-balloon otter trawl is utilized to sample juvenile and adult fish in the mid- to bottom-waters of each monitoring station. When used effectively, the otter trawl may also be used to sample demersal fish. A 3.2m otter trawl with 8mm mesh in cod-end is pulled with a small skiff or other larger shallow draft vessel. Tows are made at an approximate speed of 1.5 to 2 knots along a 200m long transect. Each otter trawl replicate samples a maximum area of 801m^2; however, a smaller area is typically sampled as a result of incomplete opening of the trawl mouth.

2.1.2 Water Quality Monitoring

Water quality monitoring surveys were conducted at the offshore fisheries survey locations. A Hydrolab Datasonde IV unit, calibrated in accordance with manufacturer specifications, was utilized to collect data on temperature, dissolved oxygen, turbidity, pH, and salinity. The Hydrolab was lowered to the bottom of the water column and raised to the surface in one-foot increments to obtain a complete vertical profile at each station.

2.2 SURVEY SCHEDULE AND STAFF

The fish community characterization study was conducted quarterly in April, July, October and January from April 1997 to January 2000, from about 0700 hours to 1700 hours on each date (Table 2-2). The monitoring consisted of fisheries and water quality surveys. The primary staff, comprised of M&A scientists and biological technicians, involved in the quarterly field investigations are listed in Table 2-3.

Table 2-2. Summary of survey dates for Years 1, 2, and 3.

Year 1 (April 1997-January 1998)	Year 2 (April 1998-January 1999)	Year 3 (April 1999-January 2000)
24,25 April 1997	10 April 1998	2 April 1999
3 July 1997	10 July 1998	6 July 1999
29 October 1997	2 October 1998	6 October 1999
22 January 1998	11 January 1999	25, 31 January 2000

Table 2-3. April 1997 through January 2000 sampling program primary participants.

STUDY ELEMENT	STAFF	RESPONSIBILITIES
Fish Studies	K. Merkel	PI, field surveys, taxonomy
	R. Woodfield	field surveys, taxonomy
	H. Hanson	field surveys, taxonomy
	K. Cull	field surveys, navigation
	A. Gutierrez	field surveys, taxonomy
	C. Moore	field surveys
	N. Jassal	field surveys
	R. Larios	field surveys
	S. Rink	field surveys
	A. Behle	field surveys
Water Quality	R. Woodfield	field surveys, data analysis
	H. Hanson	field surveys, data analysis
	K. Cull	field surveys, navigation
Data Management and Reporting	K. Merkel	PI, data analysis, author, editor, QA/QC leader
	R. Woodfield	data management, analysis, reporting, prime author
	H. Hanson	data management, analysis, author, editor
	A. Merkel	database design and development
	L. Allen	technical advisor, statistical advisor

2.3 Data Management and Analyses

All project data was initially recorded on hard copy original datasheets and then transferred in the laboratory to digital database files. IDS Ecological Survey©, an ecological information management program, developed by Integrated Data Systems, Inc., was used to manage relational data from the project surveys. Original raw data sheets were included with each quarterly report.

2.4 Limitations or Complications Encountered

The sampling program was designed to collect baseline information for the fish communities of the cooling water discharge channel in a manner which was efficient, repeatable, and had minimal impact on the natural resources of the area. Therefore, some sampling techniques, such as gill nets, were specifically omitted by both the Navy study and this program. These techniques were omitted to prevent potential damage to the green sea turtle population present at the study site and to avoid unnecessary mortality of fish. However, some species of fast-moving fish, such as large mullet, cannot be effectively sampled using the gear employed for this study. In lieu of utilizing gill nets to quantify such species, the less exhaustive but less destructive technique of noting species seen escaping over the float lines of seines was employed. This technique does not provide a representative measure of these larger fish.

The area sampled by the beach seines at Station 2 included a cobble beach. While the lead line of the seines typically guides the net smoothly along the bottom, the uneven nature of the cobble bottom at Station 2 could have allowed fish to escape under the net. This presented a possible problem for the small seine, which typically samples juvenile and demersal fish. These fish may have been able to hide under the cobbles or to escape under the uneven lead line, thus avoiding the net and inclusion in the sample. The large seine targets both small, demersal fish and larger pelagic fish. The larger fish are unlikely to escape under the net due to their tendency to stay in the water column rather than seek refuge in the bottom cobbles. The large seine also features a catch bag which collects the fish encountered by the net. The small fish targeted, however, may have avoided collection for the same reasons as those in the small seine. Sampling at Station 2 was therefore conducted at the lowest feasible tide in an attempt to sample the smooth mud bottom found at the base of the cobble slope.

During the study, a change was made in the field identification protocol. After extensive research and consultation with other fish taxonomists and fisheries biologists (R. Hoffman, R. Lea, D. Heilprin), it was concluded that it is difficult to conclusively distinguish between juvenile arrow goby (*Clevelandia ios*) and shadow goby (*Quietula y-cauda*) in the field. Because the majority of gobies captured during this study were juvenile, gobies that may have belonged to either species were identified as "arrow/shadow complex". These functionally similar species commonly co-occur and occupy the same niche in the demersal fish community. Other gobies were identified to the species level. This method is regularly employed in similar fish studies by fisheries biologists. All gobies identified in previous quarters of this study as arrow gobies should be considered to fall within this arrow/shadow goby complex.

A goatfish captured in April 1999 was identified in the field as a Mexican goatfish (*Mulloidichthys dentatus*). Following the issuance of the April 1999 report, this identification was countered by a final determination made by Robert Lea, CDFG fish taxonomist, who identified the fish as a bigscale goatfish (*Pseudupeneus grandisquamis*). A small goby that was captured during the October 1999 survey that was vouchered for definitive identification was also identified by R. Lea. What was recorded as an arrow/shadow goby was identified as a juvenile longjaw mudsucker (*Gillichthys mirabilis*), another member of the goby family (Gobiidae).

Additionally, submission of vouchered specimens to R. Lea resulted in a final determination that all corvina captured during this study were shortfin corvina (*Cynoscion parvipinnis*). The species description of shortfin corvina in the field guide primarily used for this study (Miller and Lea 1978) was based on adult specimens. The characteristics noted in the guide were not necessarily diagnostic of young of the species, which were often caught during this study, and identified as orangemouth corvina (*Cynoscion xanthulus*). Examination by R. Lea, however, determined them to be shortfin corvina. Therefore, the orangemouth corvina has been removed from the species list.

Preparation of the final report for this study has involved a final quality control review of collected data in order to include the most accurate data possible in the final presentation of the study results. The process involved the review of all raw data, quarterly reported data, and the data stored in the project database. This has resulted in a small number of corrections to the counts and weights contained in the dataset. Seventeen errors in individual fish entries were detected out of a total of 176,414 entries, resulting in a 0.01% error in the initially reported data. This is a notably small figure considering the large amount of data collected during this study. Other discrepancies between prior quarterly reports and this final report involve the finalization of species identifications as discussed above. All changes have been detailed in Appendix A.

3.0 RESULTS AND DISCUSSION

The following results and discussion provide information regarding the number of species, density, and biomass of fish collected during each quarterly monitoring interval and provides analyses of trends in fisheries data collected during the three year study. Water quality data for each interval of the study also presented and discussed.

3.1 FISHERIES STUDIES

3.1.1 Abundance and Density

A total of 176,414 fish was captured during this three year study (April 1997 through January 2000) (Tables 3-1 and 3-2). The total abundance (number of individuals) captured varied between quarters and stations (Figure 3-1). Total abundance is meaningful to look at because each survey sampled nearly the same amount of area, with only slight variations due to the large seine sample methods. During most surveys, total abundance fell within a range of 2,500 to 9,900 individuals captured at both stations together. Exceptions were seen in October 1997 and January 2000, when 53,186 and 54,134 total fish were captured, respectively. In July 1997, 13,233 fish were caught; during subsequent years, July surveys yielded much lower abundances. Abundance figures were generally driven by the number of slough anchovy (*Anchoa delicatissima*) captured and the spikes in abundance were due to marked increases in the capture of slough anchovy. In general, abundance was higher in the fall and winter samplings and lower during the spring and summer samplings.

Throughout the survey, slough anchovy dominated most samples, representing between 14.4 to 99.4% of the total individuals caught during each quarter (Figure 3-2). Overall, slough anchovy accounted for 91.4% of all fish captured over the three sampling years. Aside from anchovy larvae, which were found in high numbers in July 1999 (5,987), the next most abundant fish was deepbody anchovy (*Anchoa compressa*), comprising 1.4% of the total individuals caught during the study. This species occurred in high numbers during January and April, but was infrequently captured during summer and fall months. Round stingray (*Urolophus halleri*) represented 1.1% of the total catch and were common throughout the survey with notably high abundances during January surveys. Topsmelt (*Atherinops affinis*) were only slightly less abundant, making up 1.0% of the total catch and also occurring in a sporadic manner.

Other species making up more than 0.1% of the total catch were California killifish (*Fundulus parvipinnis*), cheekspot goby (*Ilypnus gilberti*), arrow/shadow gobies, striped mullet (*Mugil cephalus*), and bonefish (*Albula vulpes*). California halfbeak (*Hyporhamphus rosae*) were captured every quarter, peaking in October 1998 when 43 individuals were captured. California needlefish (*Strongylura exilis*), which were generally captured during cooler months of the year, were also captured during a majority of the surveys (Appendix B).

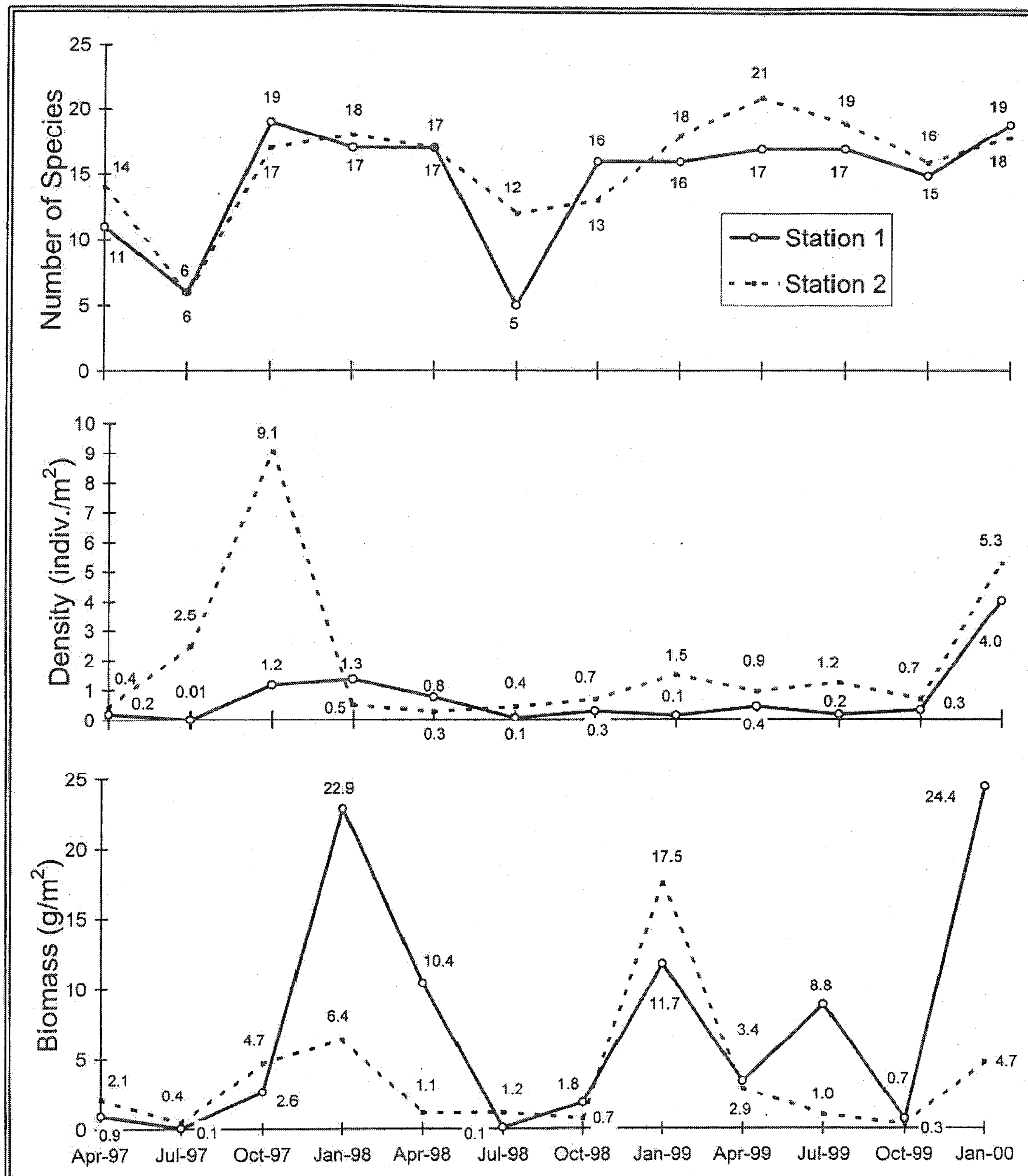
Several additional species were captured in low numbers over the three year survey period. Bat rays (*Myliobatis californica*) were occasionally captured with a high catch of seventy-one captured in January 1999. California halibut (*Paralichthys californicus*) and diamond turbot (*Hypsopsetta guttulata*) were regularly caught in small numbers, as were shortfin corvina and barred pipefish (*Syngnathus auliscus*). Less frequently captured were staghorn sculpin (*Leptocotus armatus*), yellowfin goby (*Acanthogobius flavimanus*), and spotted sand bass (*Paralabrax maculatofasciatus*). Five juvenile white seabass (*Atractoscion nobilis*) were captured in October 1997 and three were captured in April 1998. Gray smoothhound (*Mustelus californicus*), California butterfly ray (*Gymnura marmorata*), shovelnose guitarfish (*Rhinobatos productus*), and diamond stingray (*Dasyatis dipterura*) were the remaining sharks and rays captured during the study. Also caught were specklefin midshipman

Table 3-1. Total number (individuals) and density (individuals/m^2) of fish caught at Station 1 (April 1997 through January 2000).

	STATION 1												
SPECIES	Apr-97	Jul-97	Oct-97	Jan-98	Apr-98	Jul-98	Oct-98	Jan-99	Apr-99	Jul-99	Oct-99	Jan-00	TOTAL
Shovelnose guitarfish					1					5			6
Gray smoothhound				1	2								3
Bat ray			5		6			2	2			3	18
Round stingray	34	2	38	543	87		49	454	22	39	20	279	1,587
California butterfly ray								2					2
Diamond stingray												1	1
Bonefish			1	1	45	11	24	18	3	1	1		105
Threadfin shad													0
Pacific sardine				2									2
Slough anchovy	631	19	5,929	6,656	1,929	289	1,011	9	1,797	549	1,651	22,099	42,569
Deepbody anchovy	73		5	2	1,665		3		30	20		109	1,907
Anchovy, unidentified larvae										68			68
Specklefin midshipman													0
California halfbeak	20	2	1			2	38	1	3	2	6	11	86
California needlefish			1		6		2	28	39		1	4	81
California killifish		27	37	17	21	8	292	93	2		29	29	655
Topsmelt	264	2	58	69	91			27	208	237	1	52	1,009
Barred pipefish			1				2			1	4	1	9
Bay pipefish	2												2
Staghorn sculpin												5	5
Spotted sand bass	1		2	2	1		1	1			1	1	10
Barred sand bass									1				1
Bigscale goatfish													0
Lookdown													0
Shortfin corvina				9	9		9		3	2	6	2	40
White seabass			5		3								8
Yellowfin croaker					1					1			2
Spotfin croaker													0
Shiner surfperch								3					3
Striped mullet			5	49	21	3	3	60	31	1		1	174
Blue bobo				1									1
Longtail goby													0
Longjaw mudsucker													0
Yellowfin goby	13	1	2				1			1			18
Cheekspot goby			8	8	6			5	44	13	23	36	143
Arrow/Shadow goby	49		4	4			6	8	40	2	4	6	123
Goby, unidentified larvae	1												1
California halibut			4	2			5	10	2	1	1	1	28
Diamond turbot	4		3	1	4		9		2	6	5	12	46
TOTAL ABUNDANCE	1,092	53	6,109	7,367	3,898	313	1,455	721	2,229	949	1,753	22,652	48,591
Area Sampled (m^2)	5,559	5,513	5,282	5,463	5,220	5,421	5,266	5,230	5,173	5,607	5,584	5,636	64,974
Density (#/m^2)	0.20	0.01	1.16	1.34	0.75	0.06	0.28	0.14	0.43	0.17	0.31	4.02	0.75
Species Count	11	6	19	17	17	5	16	16	17	17	15	19	[illegible]

Table 3-2. Total number (individuals) and density (individuals/m^2) of fish caught at Station 2 (April 1997 through January 2000).

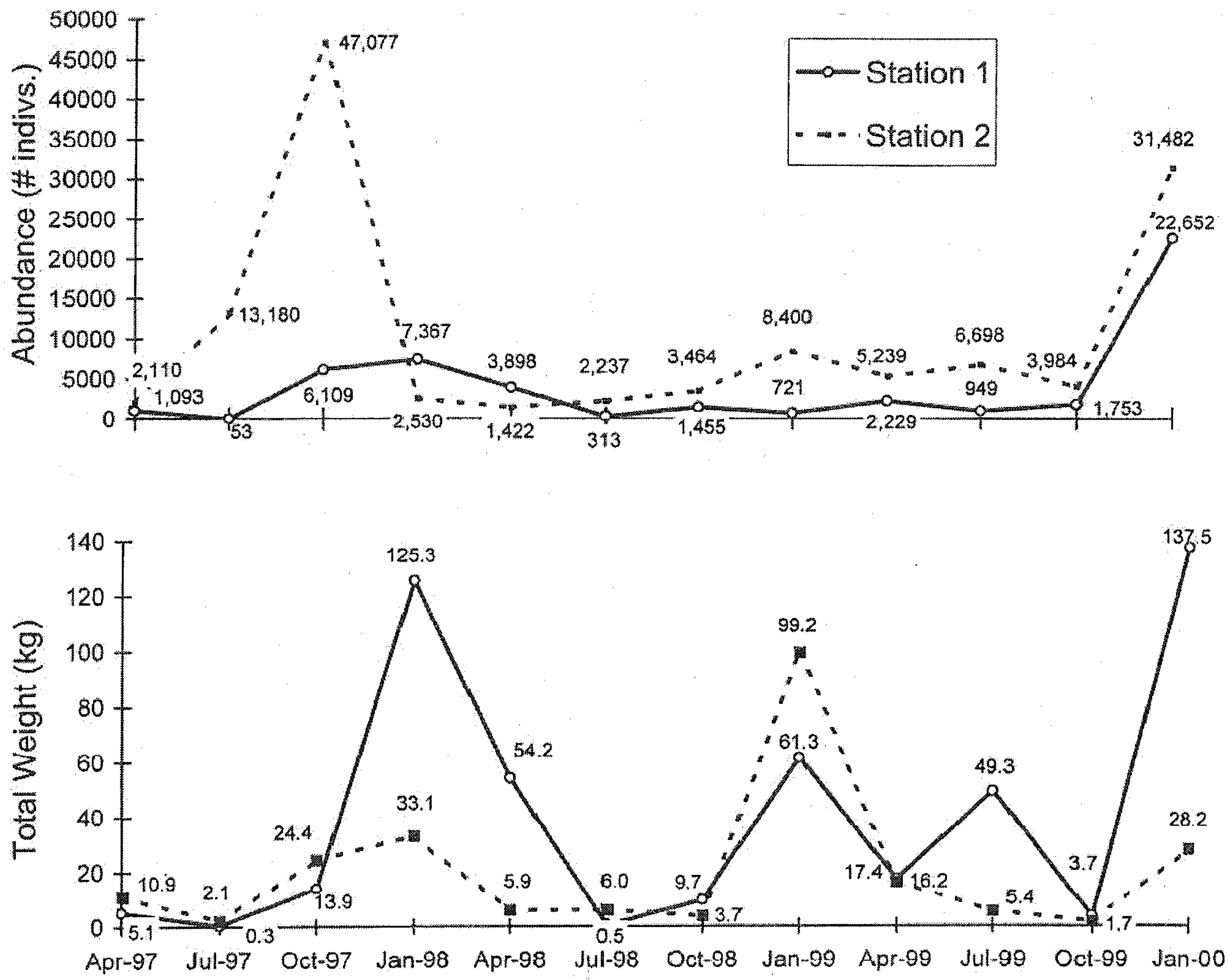
	STATION 2												
SPECIES	Apr-97	Jul-97	Oct-97	Jan-98	Apr-98	Jul-98	Oct-98	Jan-99	Apr-99	Jul-99	Oct-99	Jan-00	TOTAL
Shovelnose guitarfish													0
Gray smoothhound	4		1	1	1				2			1	10
Bat ray			2	1				69	3				75
Round stingray	2		18	99	21	20	7	68	37	16	3	40	331
California butterfly ray							1	1	2	1		2	7
Diamond stingray												1	1
Bonefish					27	70		1		2			100
Threadfin shad				1									1
Pacific sardine			1										1
Slough anchovy	1,267	13,141	46,895	2,086	1,179	2,097	3,384	8,120	5,013	547	3,859	31,029	118,617
Deepbody anchovy	437		72	28	13	3	10	11	47	12	2	10	645
larvae										5,919			5,919
Specklefin midshipman									6	1			7
California halfbeak	5	11	13	2	2	3	5	4	9		12	11	77
California needlefish	4		4				21	11	5	1		1	47
California killifish	2	4	21	32	2	1	2	11	1	2	5	45	128
Topsmelt	354	19	1	107	162	11	3	24	16	104	10	3	814
Barred pipefish			7	5		3	3		1	3	3	3	28
Bay pipefish	1	4								2			7
Staghorn sculpin					6				1			13	20
Spotted sand bass			2		3						1		6
Barred sand bass									1				1
Bigscale goatfish									1				1
Lookdown				1									1
Shortfin corvina		1			1		13	1		2	2	3	23
White seabass													0
Yellowfin croaker				1	1								2
Spotfin croaker			1										1
Shiner surfperch								1					1
Striped mullet				45	1	1		1	5	3			56
Blue bobo													0
Longtail goby											2		2
Longjaw mudsucker											1		1
Yellowfin goby	2							1		1	1		6
Cheekspot goby			15	66	1			49	54	32	72	213	502
Arrow/Shadow goby	27		16	44	1	26	13	17	27	42	10	101	324
Goby, unidentified larvae	3												3
California halibut	1		8	9	1		2	10	5	2		2	40
Diamond turbot	1			2		2			3	6	1	4	19
TOTAL ABUNDANCE	2,110	13,180	47,077	2,530	1,422	2,237	3,464	8,400	5,239	6,698	3,984	31,482	127,823
Area Sampled (m^2)	5,249	5,309	5,205	5,173	5,258	5,219	5,241	5,678	5,686	5,522	5,996	5,967	65,503
Density (#/m^2)	0.40	2.48	9.04	0.49	0.27	0.43	0.66	1.48	0.92	1.21	0.66	5.28	1.95
Species Count	14	6	17	18	17	12	13	18	21	19	16	18	[illegible]



Temporal Trends in Number of Fish Species, Density, Biomass, Abundance, and Total Weight April 1997 to January 1999

Figure 3-1

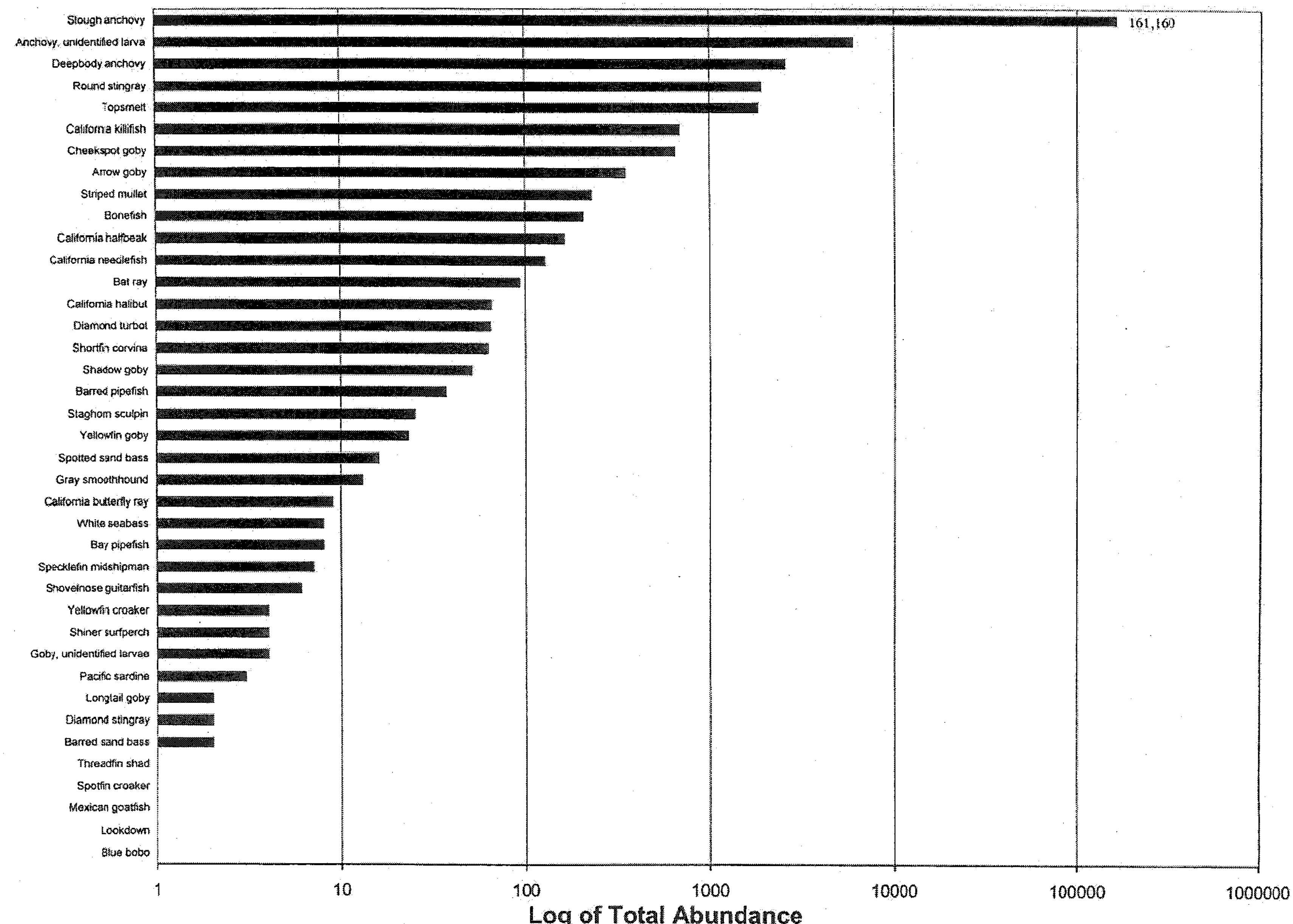
Merkel & Associates, Inc.



Temporal Trends in Number of Fish Species, Density, Biomass, Abundance, and Total Weight April 1997 to January 1999

Figure 3-1 (cont.)

Merkel & Associates, Inc.



Log of Total Abundance By Species
April 1997 through January 2000
(Note Count Extension for Slough Anchovy)

Figure
3-2

Merkel & Associates, Inc.

(*Porichthys myriaster*), bay pipefish (*Syngnathus leptorhynchus*), yellowfin croaker (*Umbrina roncador*), and Pacific sardine (*Clupea harengus*). Some species were captured in small numbers during only one quarter, including barred sand bass (*Paralabrax nebulifer*), longtail goby (*Gobionellus sagitulla*), and shiner surfperch (*Cymatogaster aggregata*). Species caught in only one sampling and represented by only one individual were spotfin croaker (*Umbrina stearnsii*), threadfin shad (*Dorosoma petenense*), lookdown (*Selene vomer*), blue bobo (*Polydactylus approximans*), bigscale goatfish (*Pseudupeneus grandisquamis*), and longjaw mudsucker.

Throughout the study, samples at both stations were dominated by either slough anchovy or anchovy larvae (together these species represented 88% and 97% of total individuals at Station 1 and 2, respectively). Mean densities of the most abundant groups of fish captured during each quarter of the sampling year are compared in Figures 3-3a through 3-3c. Although the majority of fish captured were slough anchovy, during a few samplings deepbody anchovy, topsmelt, California killifish, and rays accounted for higher proportions of the total density.

Fish density (individuals/m^2) trends throughout the study are presented in Figure 3-1 and closely mirror trends in total abundance due to consistency in sampling effort between quarters. Highest densities occurred in January 2000 at Station 1 (4.02 indiv./m^2) and in October 1997 at Station 2 (9.04 indiv./m^2). These high densities were attributable to the large number of anchovies caught. The lowest density at Station 1 was found in July 1997 (0.01 indiv./m^2) and the lowest at Station 2 was found in April 1998 (0.27 indiv./m^2). Differences in density between stations and quarters is almost entirely driven by the number of anchovies captured.

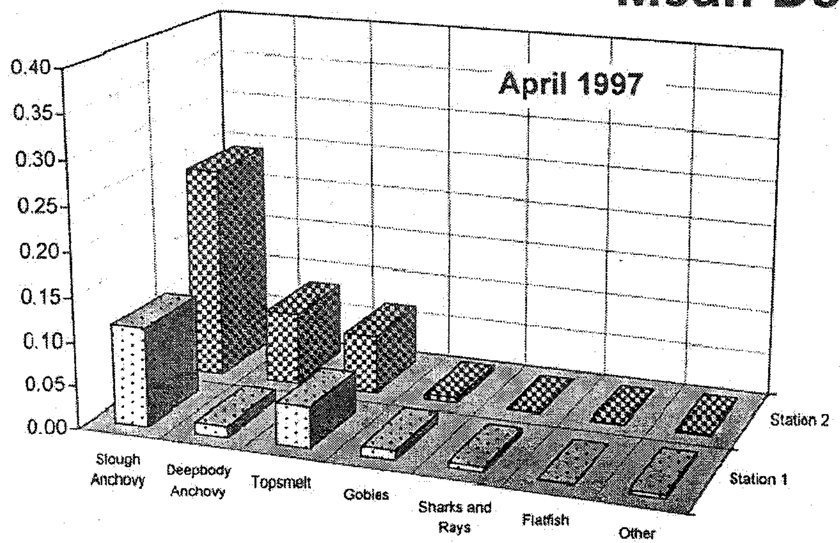
The total density of fish captured for the three year study was considerably lower at Station 1 than Station 2 (0.75 indiv./m^2 and 1.95 indiv./m^2, respectively). For the most part, this difference was due to the larger numbers of anchovies caught at Station 2. Other species were more often captured at one station than the other. Many more round stingray, deepbody anchovy, California killifish, striped mullet and diamond turbot were captured at Station 1 than 2. At Station 2, notably more bat rays, butterfly rays, slough anchovy, barred pipefish, California halibut, and cheekspot, arrow and shadow gobies were captured.

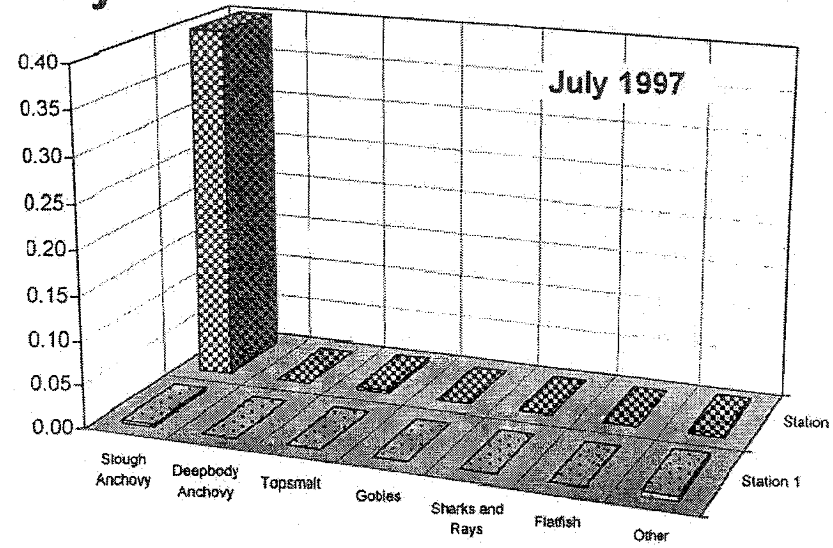
The mean density of both stations across the multiple year study was 1.35 indiv./m^2 (0.75 indiv./m^2 and 1.95 indiv./m^2 at Stations 1 and 2, respectively). This density measurement was calculated as number of fish captured per area sampled. The mean density of fish captured during the Navy study, conducted throughout San Diego Bay (See Figure 1-1 for Navy study station locations) was highly comparable to that found in the SBPP discharge channel at 1.36 indiv./m^2 (Allen 1999).

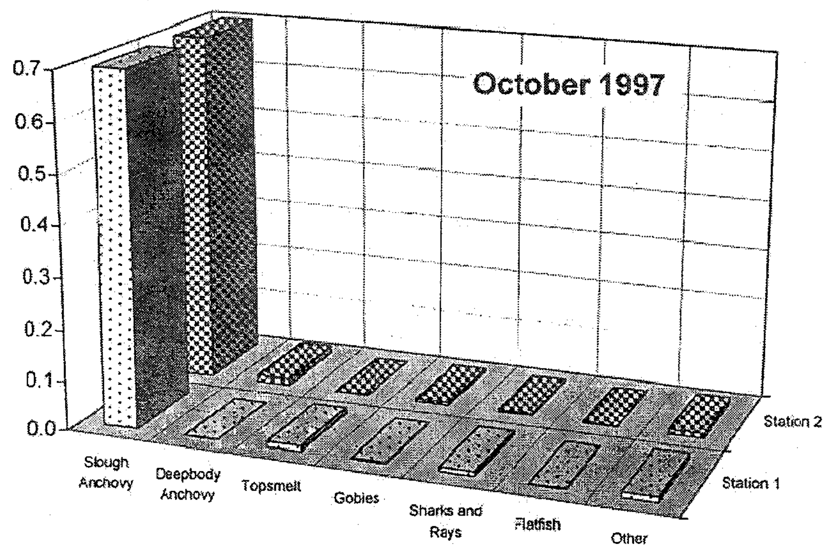
This density comparison is based on an unweighted method which Allen (1999) argues could underestimate the actual density due to gear inefficiencies and species specific selectivity. Because Allen elected to analyze his data in a weighted format, but did not report the weighting factors, it is not possible to make direct comparisons between data sets from the two studies. However, while unweighted, the more conservative densities calculated for this study are quite similar to the weighted densities calculated for the Navy study. The Navy study calculated a weighted mean density of 2.03, 1.93, 0.81, and 1.15 indiv./m^2 at North, Central, South-Central, and Southern Ecoregion stations, respectively. Because the calculated numbers used in this study are always lower estimates than the weighted estimates, this indicates densities within the SBPP discharge channel are generally comparable to those found outside of the discharge channel and in many instances higher than, those found in the Navy study.

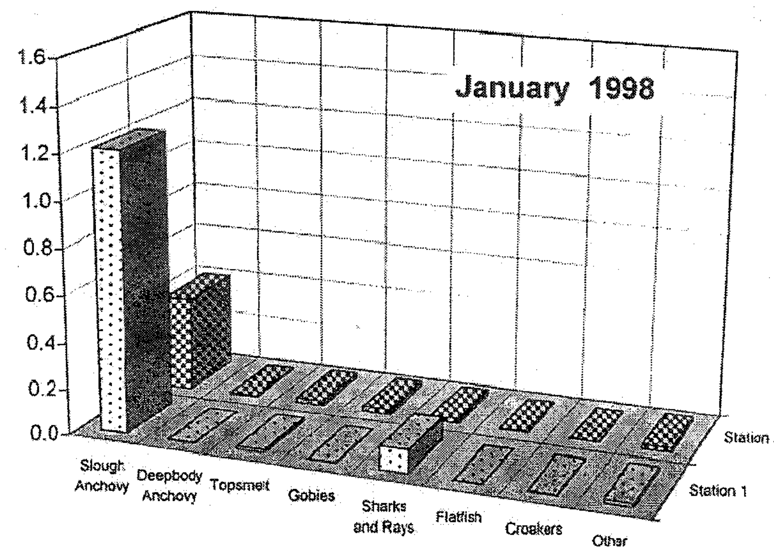
Further examination of density data from the Navy study also indicates that slough anchovy are more concentrated in the discharge channel than in any other areas of San Diego Bay. Slough anchovy were

Mean Density





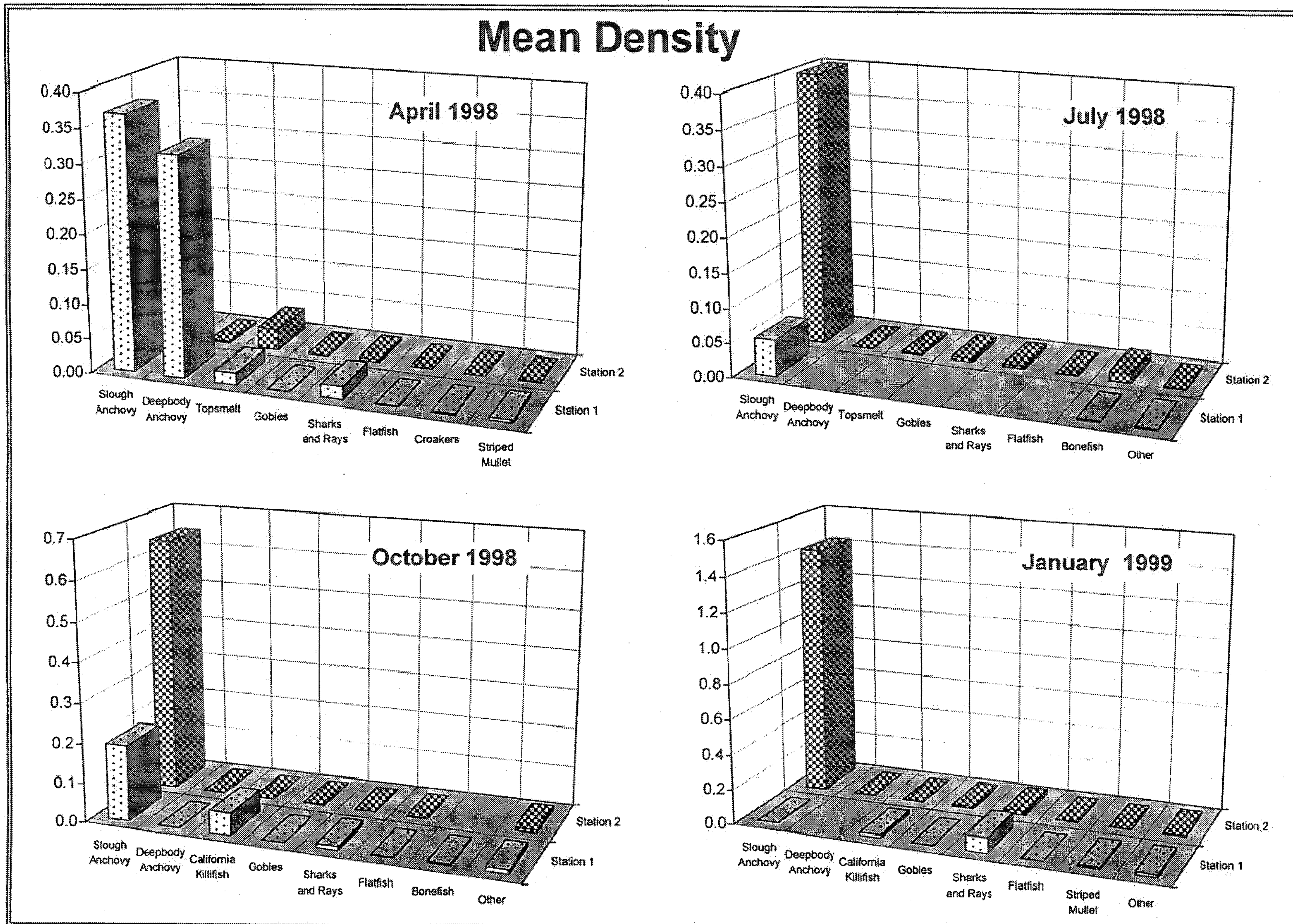




Mean Density (individuals/m^2) of Select Fish Species Caught at Stations 1 and 2
(Note different y-axis scales)
YEAR 1 - April 1997 through January 1998

Figure 3-3a

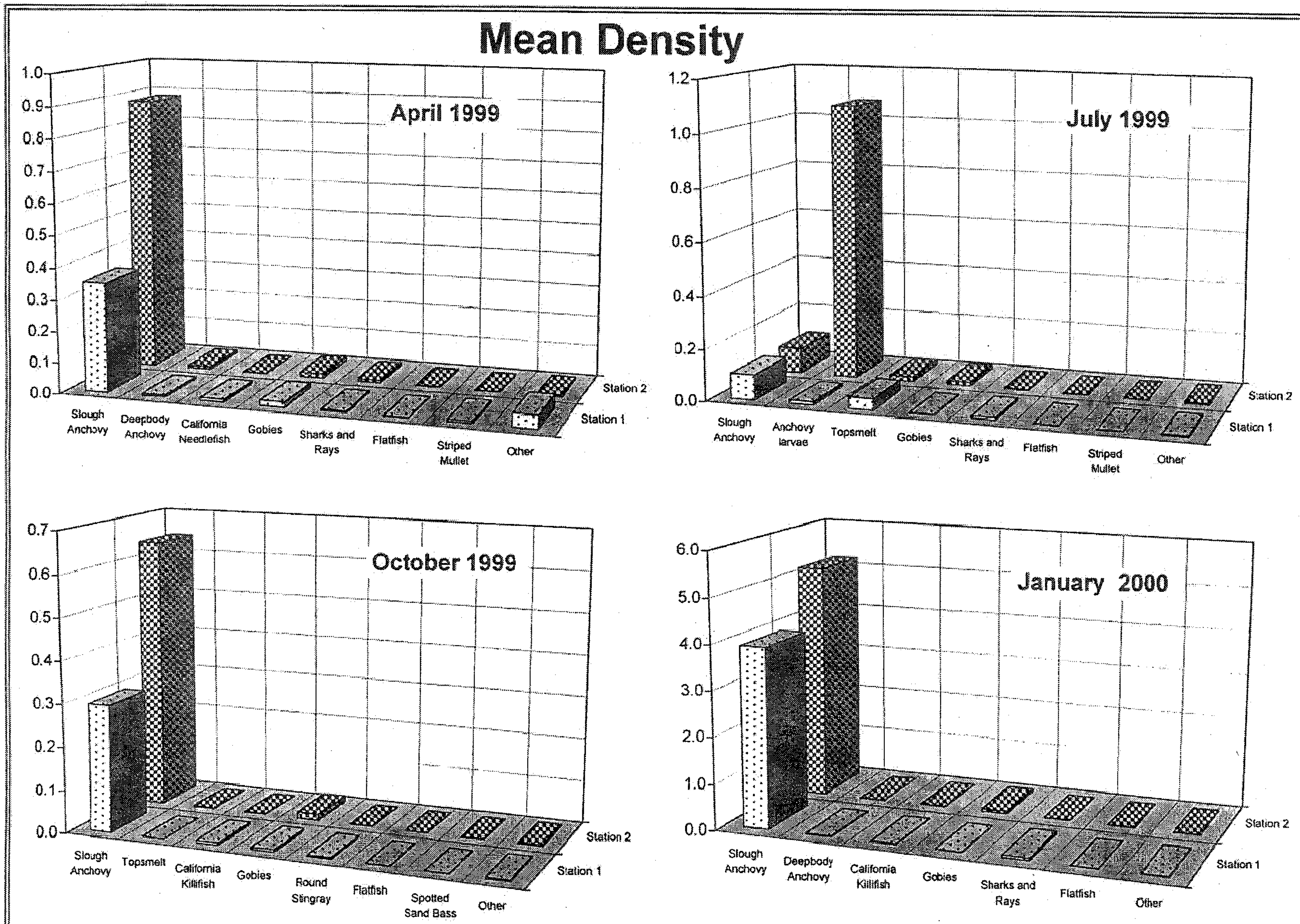
Merkel & Associates, Inc.



Mean Density (individuals/m^2) of Select Fish Species Caught at Stations 1 and 2
(Note different y-axis scales)
YEAR 2 - April 1998 through January 1999

Figure 3-3b

Mean Density



Mean Density (individuals/m^2) of Select Fish Species Caught at Stations 1 and 2
(Note different y-axis scales)
YEAR 3 - April 1999 through January 2000

Figure 3-3c

Merkel & Associates, Inc.

captured primarily in the nearshore purse seine samples of the Navy study, yielding a density of 0.11, 0.61, 0.70, and 0.84 individuals/m^2 at North, Central, South-Central, and Southern Ecoregion stations, respectively (Allen, 1999). Density of slough anchovy captured with the purse seine during the present study at both stations in the discharge channel ranged from 0.29 indiv./m^2 to 23.70 indiv./m^2, with a mean of 5.54 indiv./m^2 for the length of the study. Anchovies are an important prey item for not only larger fish, but for many species of birds. Several species of piscivorous birds, including the endangered California least tern and California brown pelican, as well as cormorants, grebes, loons, and egrets, forage regularly in the discharge channel of the power plant. Several least tern foraging study have noted that anchovies can be a primary food source for this species (reviewed in Merkel & Associates 1995). Similarly, studies have noted anchovies to comprise significant proportions of the diet of California brown pelicans. Based on the purse seine data, the discharge channel appears to support an average of 9.8 times the density of slough anchovies as areas outside of the discharge channel. This suggests that this species likely comprises the principal forage base for the observed high levels of activity within the channel by fish-eating birds.

Stronger seasonality was observed at Station 1 than at Station 2. During the warm July 1997 and 1998 survey period, the total number of fish captured at Station 1 dropped to only 53 and 313, respectively, while catches at Station 2 remained relatively high at 13,180 and 2,237 for July 1997 and 1998 respectively (Table 3-2). Large schools of anchovies were collected at various times, yielding highly variable data from both Station 1 and Station 2, however, the differences in densities between both sampling quarters and stations were found to be highly significant (quarters: $p < 0.0001$, df=11; stations: $p < 0.001$, df=1) as was the interaction between quarters and stations ($p < 0.0001$, df=11) (Appendix C).

3.1.2 Weight and Biomass

The total weight of all individuals captured at both stations during the three year survey was 715.0 kilograms (478.1 kilograms at Station 1 and 236.9 kilograms at Station 2) (Tables 3-3 and 3-4). The total weight of fish captured at each station varied between quarters (Figure 3-1) and was highest at Station 1 in January 2000 (137.5 kg) and at Station 2 in January 1999 (99.2 kg). The lowest total weight of fish was captured in July 1997 at Station 1 (0.3 kg) and in October 1999 at Station 2 (1.7 kg).

While anchovy dominated the numbers of fish captured, sharks and rays generally contributed more to the weight and biomass figures during each quarter. During the three year study, sharks and rays accounted for over 76% of the total weight of fish captured. The majority of this weight was attributable to round stingray, although a single large diamond stingray captured in January 2000 made up 7% of the total weight captured during the three year study. Shovelnose guitarfish, bat ray, California butterfly ray, and gray smoothhound made up 14%, 6%, 1% and 1%, of the total weight, respectively. Slough anchovy, the most abundant species, accounted for only 10% of the total weight during the three year survey. The only additional species that contributed more than 1% of the total weight were deepbody anchovy (6%), California needlefish (2%), and California halibut (1%).

Biomass had a more apparent seasonality than did density. Biomass was highest during months when sampled waters were cool (January) and lowest during months when sampled waters were warmest (generally July and October). This suggests that the channel environment is used as a warm water refuge during winter months and during summer months the elasmobranchs are either forced out of much of the channel by high temperatures, or improved suitability of the remaining bay areas allows these fish to be more widely distributed throughout the larger bay area and thus less restricted to the channel environs.

The highest biomass at Station 1 was found in January 2000 (24.40 g/m^2) and in January 1999 at Station 2 (17.47 g/m^2) (Figure 3-1). The lowest biomass was found in July 1997 with 0.05 g/m^2 at Station 1 and in October 1999 with 0.29 g/m^2 at Station 2. Differences in biomass between quarters were found to be highly significant ($p < 0.001$, df=11). In this study, biomass was typically driven by relatively heavy rays and sharks, which were often abundant during the cooler months of the year. For example, the 51.0 kg diamond stingray captured in January 2000 heavily weighted the biomass at Station 1 during that survey. Five large shovelnose guitarfish weighing 41.2 kg were captured in July 1999 (when water temperature was noticeably cooler than in previous July surveys), making up 83% of the total biomass at Station 1 during that period. Figures 3-4 a,b,c present a comparison of biomass of the most abundant fish species captured during each quarter of the sampling year, and clearly show the strong effect sharks and rays have on total biomass.

Although neither station consistently had higher biomass values than the other during any given sampling period, the overall biomass for the three year study was about twice as great at Station 1 than at Station 2. This is again due to the capture of more than double the weight of rays at Station 1 than 2. Biomass was significantly greater at Station 1 than Station 2 ($p=0.016$, df=1) (Appendix C).

The mean biomass of both stations calculated for the present study is 5.48 g/m^2 (7.36 g/m^2 and 3.62 g/m^2 at Stations 1 and 2, respectively). This biomass figure was calculated as total weight of fish captured per area sampled. The mean biomass calculated for San Diego Bay in the Navy study (Allen 1999) was 2.03 g/m^2. As with fish densities, it can be argued that any measured biomass is an underestimation of the true biomass of a system due to gear evasion and selectivity. Because of this Allen calculated a weighted biomass and reported these weighted values for all station and period specific analyses. This has rendered direct comparisons between the study results not possible. However, because the bias between the weighted Navy data and the raw data from the present study always favors the Navy biomass values being higher, it is possible to make loose comparisons of data sets. The Navy study calculated a weighted mean biomass of 7.48, 7.07, 4.74, and 7.42 g/m^2 at North, Central, South-Central, and Southern Ecoregions, respectively. This suggests that biomass at Station 1 roughly equates to that observed in the far northern portion of the Bay where oceanic tidal influence dominates and to that of the south bay, where more atmospheric mediated conditions prevail. Station 2 is more reflective of the biomass conditions of the south-central portion of the bay. In all cases, at all stations, round stingrays were the principal species responsible for biomass values.

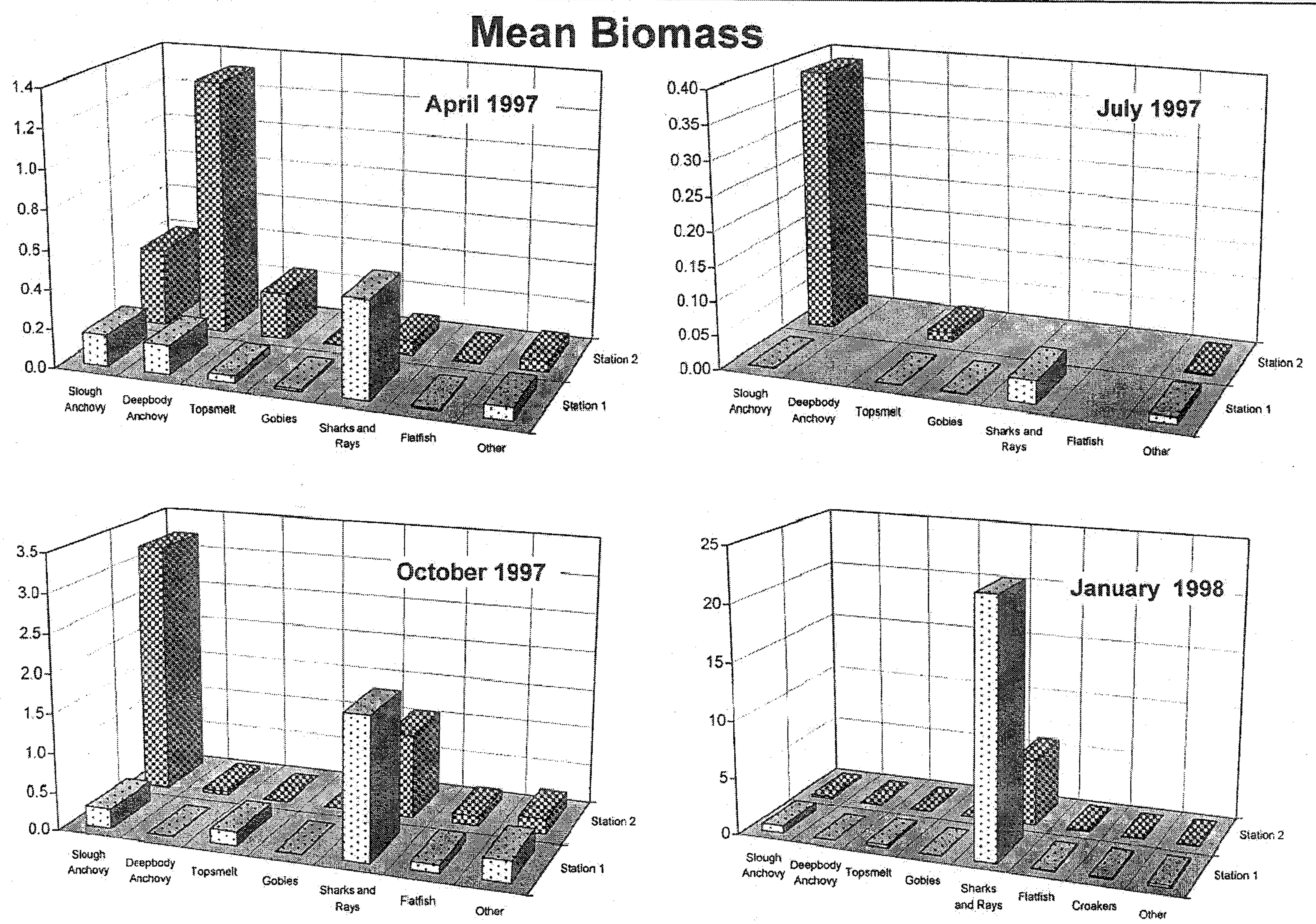
While not calculated in either the Navy study or the present study, Allen argues that the high standing biomass values suggest high fish productivity within the system. He noted that biomass values for Upper Newport Bay (Allen 1992) that are comparable to those found within San Diego Bay were accompanied by one of the highest fish productivity rates recorded in the literature. Because the SBPP discharge channel supports approximately 270% higher biomass than found in the open bay, it would also be reasonable to infer extremely high productivity within this area as well. Such a condition would not at all be surprising since frequently aquaculture operators seek to locate facilities within the cooling water discharges of power plants to capitalize on the warm-water growing conditions and plankton-rich waters of the discharge. Such conditions may also favor accelerated growth in larval and juvenile fish, which comprised the greatest proportion of the catch during the study.

Table 3-3. Total weight (g) and biomass (g/m^2) of fish caught at Station 1 (April 1997 through January 2000).

	STATION 1												
SPECIES	Apr-97	Jul-97	Oct-97	Jan-98	Apr-98	Jul-98	Oct-98	Jan-99	Apr-99	Jul-99	Oct-99	Jan-00	TOTAL
Shovelnose guitarfish					1,140.0					41,200.0			42,340.0
Gray smoothhound				308.0	2,321.0								2,629.0
Bat ray			4,087.0		6,283.0			1,620.0	1,960.0			6,753.0	20,703.0
Round stingray	2,776.0	188.0	5,507.0	118,048.0	9,781.0		5,779.0	46,339.0	5,248.7	6,079.0	1,469.0	66,169.0	267,383.7
California butterfly ray								3,100.0					3,100.0
Diamond stingray												51,000.0	51,000.0
Bonefish			504.0	95.0	100.3	123.0	1,843.0	1,286.0	144.0	166.0	265.0		4,526.3
Threadfin shad													0.0
Pacific sardine				0.9									0.9
Slough anchovy	886.5	6.3	1,377.0	3,417.4	2,031.4	307.6	296.7	5.4	1,366.8	815.6	581.2	10,390.7	21,482.6
Deepbody anchovy	812.0		23.2	6.9	29,815.0		5.7		126.0	203.0		1,569.4	32,561.2
Anchovy, unidentified larvae										5.6			5.6
Specklefin midshipman													0.0
California halfbeak	59.0	0.5	0.3			0.7	45.4	0.8	4.8	10.1	6.5	19.2	147.3
California needlefish			54.0		895.0		114.0	3,750.0	4,883.0		49.0	454.0	10,199.0
California killifish		53.5	55.2	11.9	72.0	5.5	342.1	211.3	5.2		26.3	43.8	826.8
Topsmelt	203.5	6.0	897.0	1,148.5	22.3			1,126.3	32.3	67.1	2.9	101.3	3,607.2
Barred pipefish			0.3				0.4			0.3	1.9	0.2	3.1
Bay pipefish	0.2												0.2
Staghorn sculpin												4.8	4.8
Spotted sand bass	291.0		545.0	891.0	309.0		100.0	198.0			545.0	285.0	3,164.0
Barred sand bass									315.0				315.0
Bigscale goatfish													0.0
Lookdown													0.0
Shortfin corvina				861.0	1,101.0		99.5		326.0	424.0	69.3	163.0	3,043.8
White seabass			232.0		1.9								233.9
Yellowfin croaker					181.0					114.0			295.0
Spotfin croaker													0.0
Shiner surfperch								161.0					161.0
Striped mullet			36.2	6.1	27.8	22.0	94.0	794.8	2,981.0	61.0		140.0	4,162.9
Blue bobo				91.0									91.0
Longtail goby													0.0
Longjaw mudsucker													0.0
Yellowfin goby	39.0	9.0	1.8				14.3			8.0			72.1
Cheekspot goby			1.8	1.4	5.1			0.6	8.3	4.0	5.9	8.6	35.7
Arrow/Shadow goby	27.9		1.3	0.9			5.0	2.2	10.2	0.8	2.6	2.7	53.6
Goby, unidentified larvae													0.0
California halibut			273.3	296.0			248.0	2,656.0	21.1	81.0	222.0	424.0	4,221.4
Diamond turbot	35.5		259.0	118.0	84.0		677.0		7.2	106.9	419.9	8.7	1,716.2
TOTAL WEIGHT (g)	5,130.6	263.3	13,855.4	125,302.0	54,170.8	458.8	9,664.1	61,251.4	17,439.6	49,346.4	3,666.5	137,537.4	478,086.2
Area Sampled (m^2)	5,559	5,513	5,282	5,483	5,220	5,421	5,266	5,230	5,173	5,607	5,584	5,636	64,974
Biomass (g/m^2)	0.92	0.05	2.62	22.85	10.38	0.08	1.84	11.71	3.37	8.80	0.66	24.40	7.36

Table 3-4. Total weight (g) and biomass (g/m^2) of fish caught at Station 2 (April 1997 through January 2000).

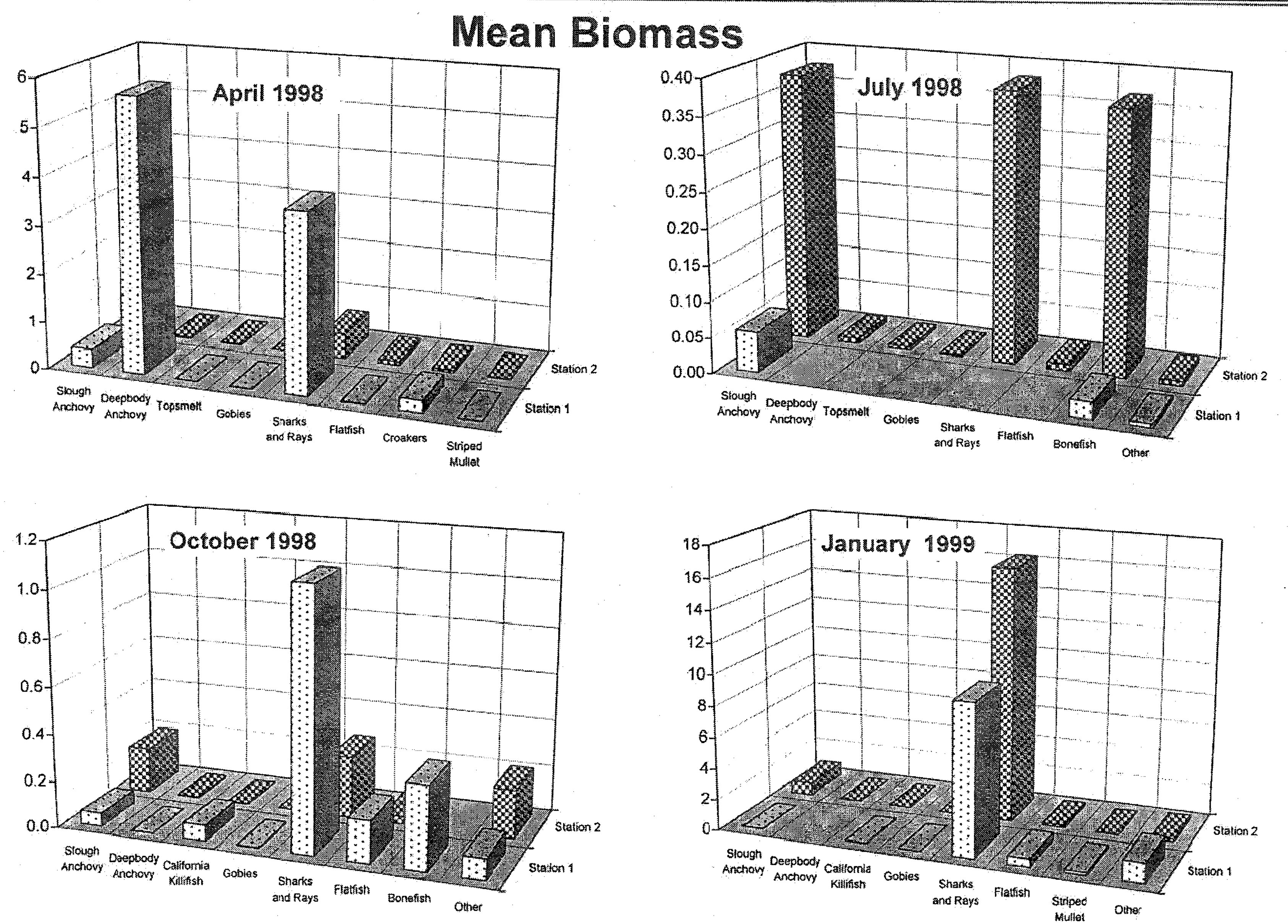
	STATION 2												
SPECIES	Apr-97	Jul-97	Oct-97	Jan-98	Apr-98	Jul-98	Oct-98	Jan-99	Apr-99	Jul-99	Oct-99	Jan-00	TOTAL
Shovelnose guitarfish													0.0
Gray smoothhound	226.0		139.0	218.0	290.0				1,800.0			121.0	2,794.0
Bat ray			3,570.0	1,480.0				73,900.0	1,929.0				80,879.0
Round stingray	130.0		1,923.0	28,826.0	2,548.0	1,976.0	745.0	18,136.0	5,078.0	1,805.0	259.9	8,906.0	70,332.9
California butterfly ray							640.0	363.0	1,408.0	607.0		1,539.0	4,557.0
Diamond stingray												750.0	750.0
Bonefish					8.2	1,914.0		50.0		390.0			2,362.2
Threadfin shad				41.0									41.0
Pacific sardine			6.0										6.0
Slough anchovy	2,094.5	2,050.7	16,842.1	1,003.3	989.8	1,960.4	1,019.5	4,621.7	2,992.9	698.5	980.1	15,290.3	50,543.8
Deepbody anchovy	6,888.0		245.7	184.5	167.0	40.0	21.5	29.3	188.6	103.9	2.9	55.0	7,926.4
Anchovy, unidentified larvae										505.7			505.7
Specklefin midshipman									0.6	0.1			0.7
California halfbeak	18.0	9.1	40.4	4.0	3.8	16.1	2.1	2.6	15.6		8.6	21.3	141.6
California needlefish	263.0		49.5				987.0	845.0	1,331.0	104.0		51.0	3,630.5
California killifish	12.0	1.7	41.9	65.5	12.3	10.0	6.5	25.4	5.0	10.7	9.6	102.7	303.3
Topsmelt	1,266.5	72.7	10.0	110.9	83.8	26.4	8.2	121.2	12.0	68.4	23.1	104.0	1,907.2
Barred pipefish			1.9	1.0		0.8	1.0		0.4	0.3	0.7	0.7	6.8
Bay pipefish	0.2	2.4								2.0			4.6
Staghorn sculpin					0.6				10.2			16.7	27.5
Spotted sand bass			840.0		1,073.0						244.0		2,157.0
Barred sand bass									445.0				445.0
Bigscale goatfish									163.0				163.0
Lookdown				31.0									31.0
Shortfin corvina		1.5			102.0		94.2	86.0		0.4	27.9	375.0	687.0
White seabass													0.0
Yellowfin croaker				162.0	151.0								313.0
Spotfin croaker			50.0										50.0
Shiner surfperch								30.0					30.0
Striped mullet				150.4	61.0	7.0		81.0	558.0	551.0			1,408.4
Blue bobo													0.0
Longtail goby											69.6		69.6
Longjaw mudsucker											0.7		0.7
Yellowfin goby	7.0							23.5		12.4	19.1		62.0
Cheekspot goby			3.3	13.1	0.7			6.6	13.2	12.6	16.5	67.2	133.2
Arrow/Shadow goby	14.5		6.7	16.2	0.6	12.0	8.2	2.9	10.2	17.1	13.9	29.2	131.5
Goby, unidentified larvae	0.4												0.4
California halibut	1.0		626.0	755.2	430.0		166.0	863.9	210.4	351.0		781.0	4,184.5
Diamond turbot	16.0			0.8		50.0			14.2	172.3	66.0	1.5	320.8
TOTAL WEIGHT (g)	10,937.1	2,138.1	24,395.5	33,062.9	5,921.8	6,012.7	3,699.2	99,188.1	16,185.3	5,412.4	1,742.6	28,211.6	236,907.3
Area Sampled (m^2)	5,249	5,309	5,205	5,173	5,258	5,219	5,241	5,678	5,686	5,522	5,996	5,967	65,503
Biomass (g/m^2)	2.08	0.40	4.69	6.39	1.13	1.15	0.71	17.47	2.85	0.98	0.29	4.73	3.62



Mean Biomass (g/m^2) of Select Fish Species Caught at Stations 1 and 2
(Note different y-axis scales)
YEAR 1 - April 1997 through January 1998

Figure 3-4a

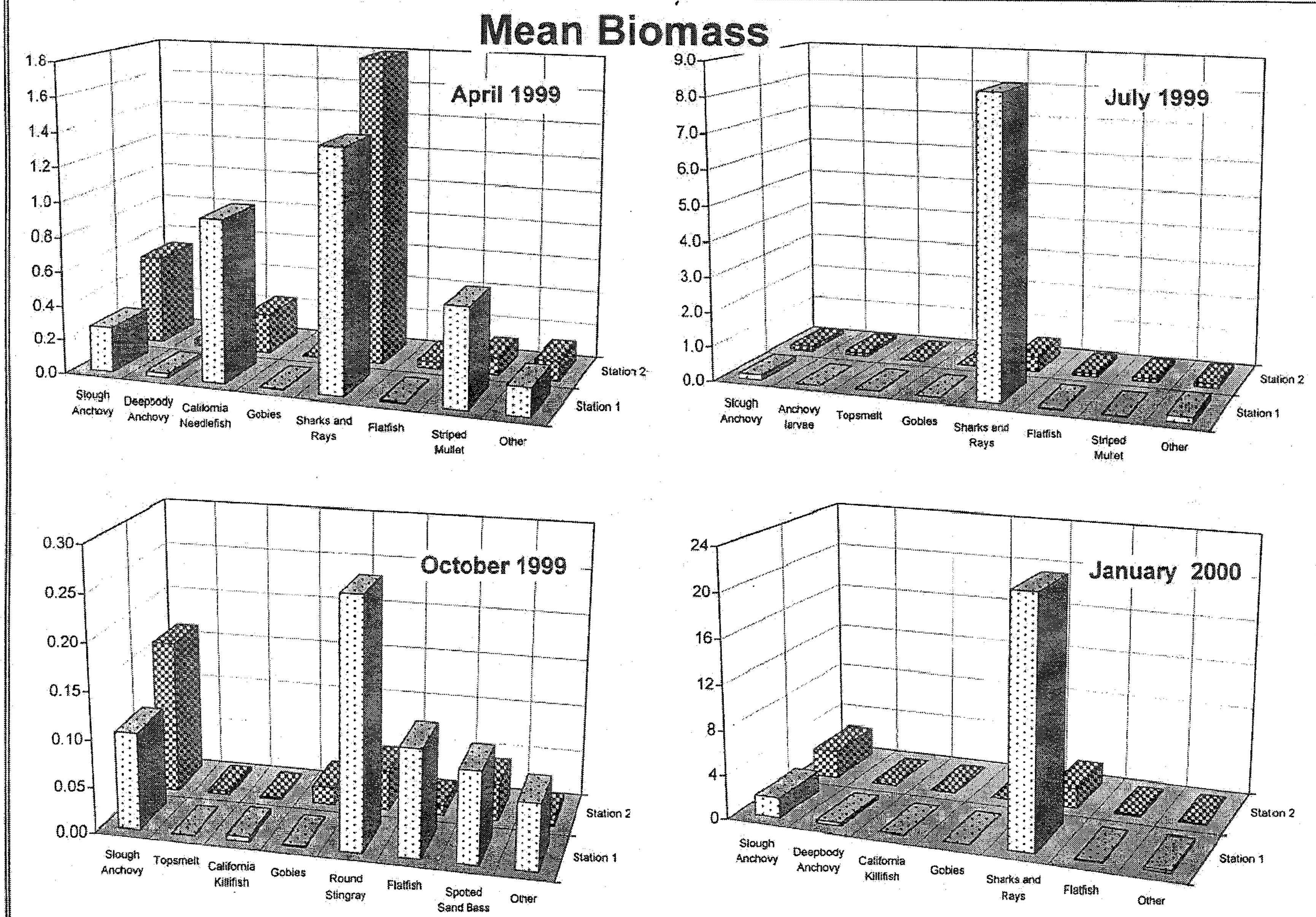
Merkel & Associates, Inc.



Mean Biomass (g/m^2) of Select Fish Species Caught at Stations 1 and 2
(Note different y-axis scales)
YEAR 2 - April 1998 through January 1999

Figure 3-4b

Merkel & Associates, Inc.



Mean Biomass (g/m^2) of Select Fish Species Caught at Stations 1 and 2
(Note different y-axis scales)
YEAR 3 - April 1999 through January 2000

Figure 3-4c

Merkel & Associates, Inc.

3.1.3 Number of Species

During the three year study, 38 species of fish were captured (Appendix B). A total of 31 and 35 species were caught at Stations 1 and 2, respectively. Species found at Station 1 but not Station 2 were shovelnose guitarfish, white seabass, and blue bobo. Species found only at Station 2 were threadfin shad, specklefin midshipman, bigscale goatfish, lookdown, spotfin croaker, longtail goby, and longjaw mudsucker. Species counts were relatively consistent throughout the survey, with the exception of lower counts during notably warm sampling periods of July 1997 and 1998, when total abundance and biomass were also low (Figure 3-1). The highest species counts occurred in January 2000 at Station 1 (19 species) and in April 1999 at Station 2 (21 species). The lowest species counts were in July 1998 at Station 1 (5 species) and in July 1997 at Station 2 (6 species). An examination of the data with a paired t-test finds no significant difference between the number of species captured at Station 1 and 2 ($p=0.083$, $df=11$).

Many uncommon species of fish were captured during this study, which interestingly coincided with the strong El Niño Southern Oscillation (ENSO) event of 1997 and 1998. The anomalous northward flow of warm equatorial waters brought species typically found at more southern latitudes. The onset of El Niño offshore is generally agreed to have occurred in late spring of 1997, reaching a peak in ocean temperature and sea level in January 1998, tapering off in spring of 1998 and returning to near normal conditions in summer of 1998 (Asanuma *et al.* 1999). While fall and winter of 1998 marked the transition to the La Niña condition offshore, featuring cooler ocean temperatures, this event was not clearly evident in the study area of the SBPP discharge channel, nor was it observed as a thermal effect in the south bay proper due to mediating atmospheric influences. However, the influence of the 1997-98 ENSO as a colonizing event was well documented in the present study. Several tropical and semi-tropical species of fish brought northward by the warm water body of El Niño continued to persist into the following years, surviving in the relatively warmer waters of the discharge channel. These species are expected to persist as juveniles and adults, but may not ever become established as residents due to an inability to successfully reproduce given pelagic larval forms that drift out of the warm waters of the channel. One semi-tropical species, the California halfbeak, has persisted long-term and the discharge channel and south San Diego Bay is recognized as one of the few, if not the only, persistent populations of this species in California waters. While this species is a suitable forage fish for piscivorous birds and a number of predatory fish, its numbers are relatively insignificant relative to more dominant species and it is unlikely to be of significant ecological constituent of the established fish community.

Two of the most interesting species captured during the study were blue bobo and lookdown (captured in January 1998). The bobo is a Pacific coast species rarely reported north of Baja, and the lookdown is a shallow water tropical species that ranges from Baja, Mexico south to Peru. In April 1999, a bigscale goatfish was captured at Station 2. This species normally occurs from Baja, Mexico south to Chile, but one record exists of a specimen caught in 1979 in the warmwater outfall of the San Onofre Nuclear Generating Station and it is reported to have been captured several times in San Diego Bay (M. Shane, pers. comm.). One individual of this species was caught in the July 1998 survey of the Navy study at its northernmost station (Figure 1-1).

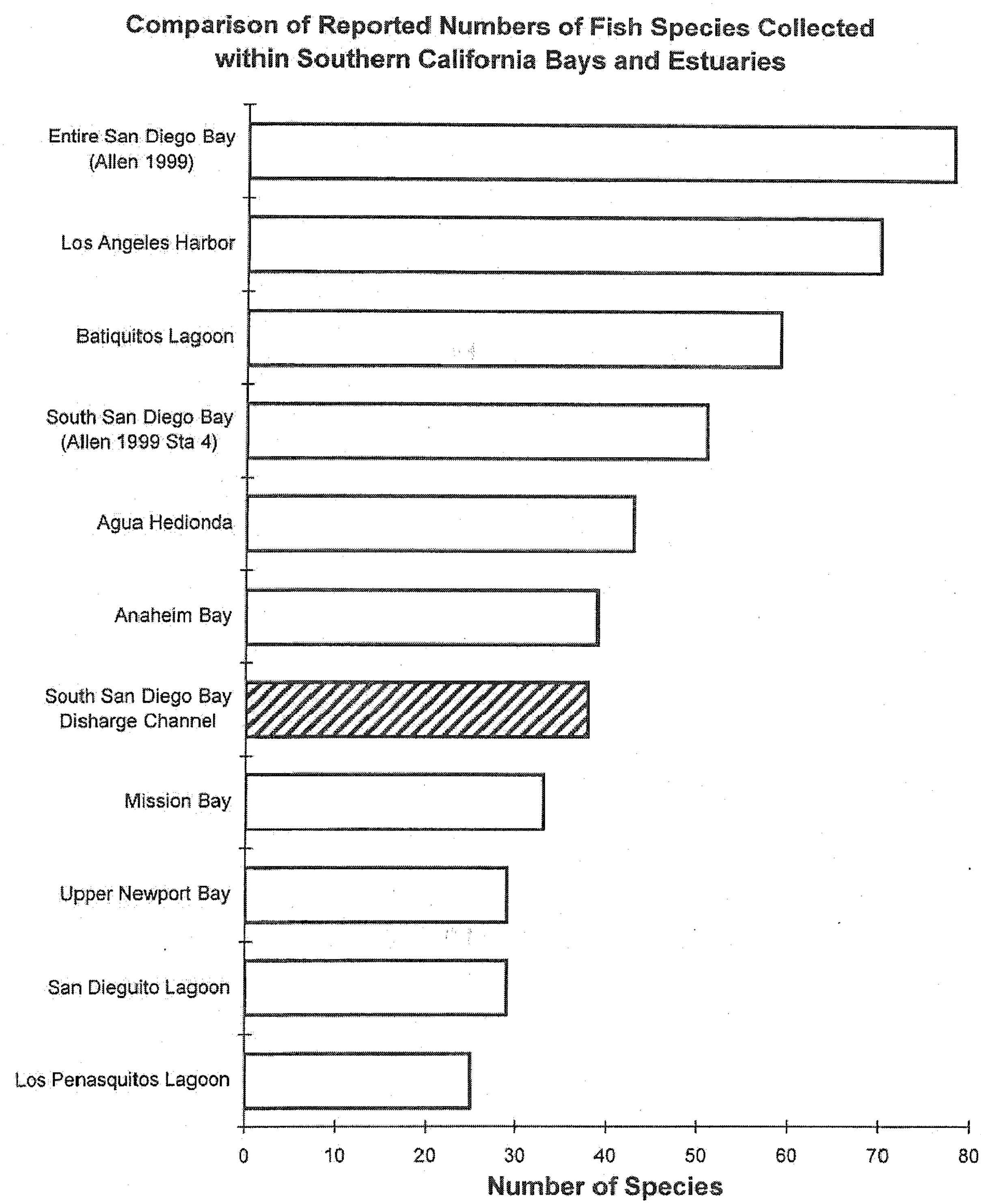
In October 1997, and again in January 1998, one bonefish was captured. In following quarters many more were captured, peaking in October 1998, then dropping to only occasional captures. No individuals of this species were captured during the last quarter, January 2000. This warm water species is also considered uncommon north of Baja California. A single individual was captured in the Navy study in July 1995, and was caught regularly after January 1998, but was uncommon by April 1999 (Allen 1999). This species was regularly reported along the southern California coast concurrent with the captures in this study. In October 1999, two longtail goby were captured at Station 2. Until recently, this species had not been found in California more than a few times. Within the last two years, however, this species has been captured at several locations along the southern California coast. Two diamond stingray were captured in January 2000, a species considered uncommon in this area, more often occurring in the Gulf of California.

Species captured during this study that were not observed in the Navy study were the lookdown, blue bobo, longtail goby, and diamond stingray, all uncommon species and not considered typical inhabitants of San Diego Bay. Of the eighteen species captured at the most southern Navy study site (see Navy Station 4 in Figure 1) that were not found during this study, only three were captured in numbers larger than eight. These were northern anchovy (*Engraulis mordax*), jacksmelt (*Atherinopsis californiensis*), and giant kelpfish (*Heterostichus rostratus*). These species are reflective of both presence of cooler and deeper waters than occur in the discharge channel (northern anchovy and jacksmelt) as well as greater habitat structure provided by such vegetated communities as eelgrass beds (giant kelpfish). A less exhaustive study which included some fish sampling in the power plant discharge channel in July and August 1968 found six species of fish, all of which were commonly found during the present study (Ford 1968).

The number of species in different southern California bays and estuaries varies substantially. The number of fish species historically captured within other coastal bays and estuaries of southern California are presented in Figure 3-5, adapted from Merkel & Associates, 2000. This figure represents a cumulative list of species, which in some cases has been compiled from multiple sources for several monitoring years. For this reason, it is evident that some bias exists related to differences in sampling gear use and intensity, frequency, and seasonality. However, the results are considered to be a reasonable representation of fish present within these various systems. The coastal water bodies of southern California vary greatly in terms of hydrology and tidal influence. San Elijo, San Dieguito, and Los Peñasquitos Lagoon are only open intermittently to the ocean. Agua Hedionda Lagoon, San Diego Bay, Mission Bay, Anaheim Bay, and Upper Newport Bay are continuously open to the ocean. Finally, Los Angeles Harbor is generally considered to represent sheltered marine waters rather than a true bay or lagoon.

The 78 species reported in this figure for San Diego Bay were recorded over a five year period and several of these species were rare or are only observed seasonally (Allen 1999). A total of 70 species have been collected within Los Angeles Harbor and 39 species within Anaheim Bay. All of these bays are open marine systems, where freshwater species are not normally observed. Fifty-nine species have been captured within Batiquitos Lagoon from 1997 to 1999. This exceeds Agua Hedionda (43 fish species), a similar tidal lagoon located approximately five miles north of Batiquitos Lagoon. Prior to the opening to tidal flushing in late 1996, the number of species within Batiquitos Lagoon more resembled the lower number of species reported from San Elijo Lagoon, an intermittently tidal lagoon located approximately six miles south of Batiquitos Lagoon.

The capture of 38 species during this study, including 31 at Station 1, closest to the cooling water discharge, indicates that the discharge channel is not a hot, wasteland, but rather supports a moderately diverse fish community. Species representing all fish guilds typical of coastal bays and estuaries were regularly captured during these surveys. Under-represented were larger, more mobile species such as leopard shark (*Triaskis semifasciata*) and scalloped hammerhead (*Sphyrna lewini*) that typically are not collected in smaller sampling gear applied in the present study. Also under-represented are species associated with deeper, more oceanic influenced waters such as northern anchovy as well as species associated with structured habitats of reefs, kelp, and eelgrass beds such as the surfperches, giant kelpfish, and Pacific seahorse (*Hippocampus ingens*).



Comparison of Number of Fish Species within Bays, Estuaries, and Coastal Lagoons of Southern California (Source: Merkel 2000)

Figure 3-5

Merkel & Associates, Inc.

3.1.4 Juvenile Fish

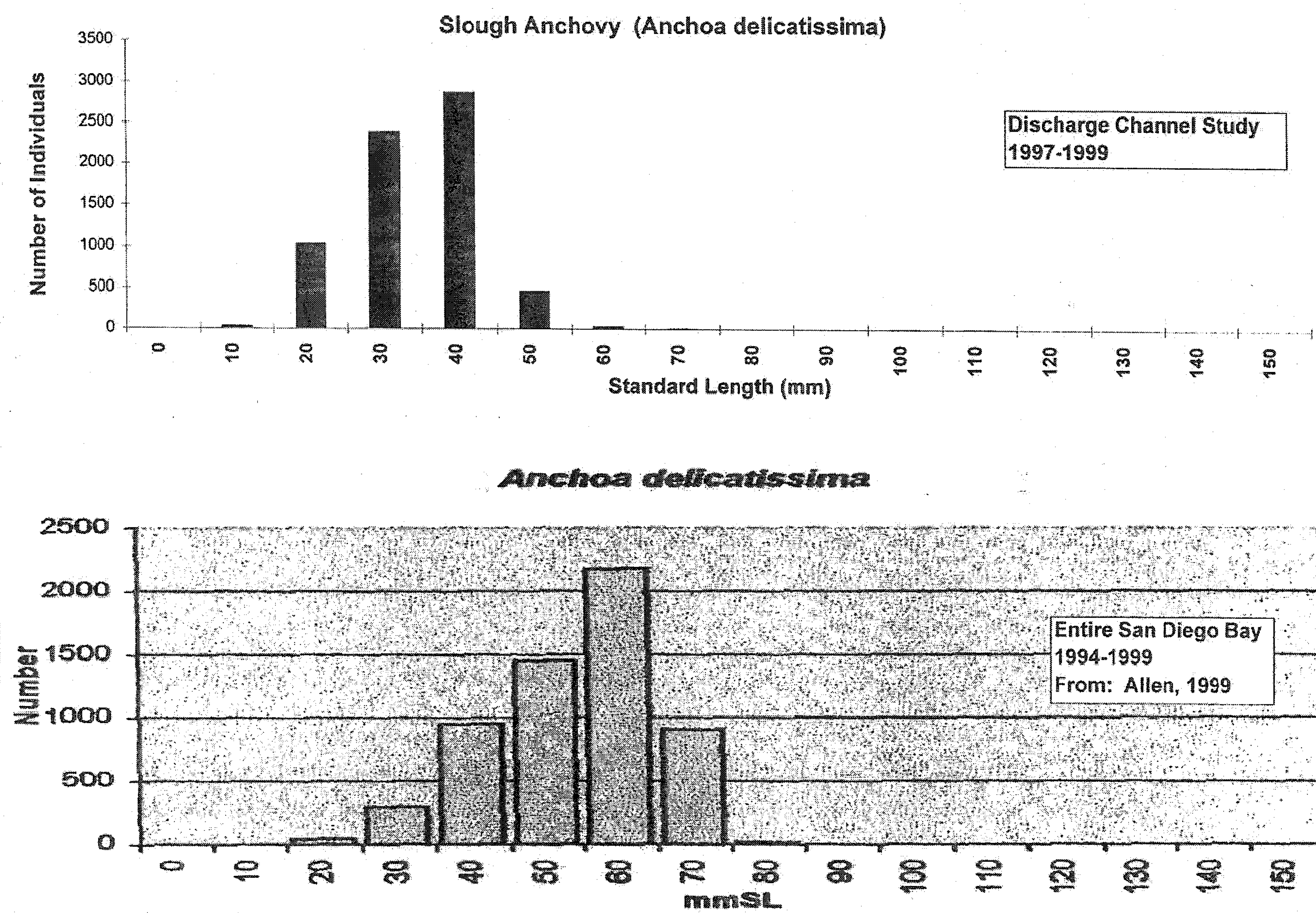
It was concluded in the Navy fish study that the San Diego Bay system acts as a nursery to many fish species (Allen 1999). The majority of fish captured in that bay-wide study were juveniles. Examination of size data for fish collected in this present study reveals that the discharge channel also serves as an important haven for larval and juvenile fish. It is unclear, however, if the area is important as a spawning site or if the study site is a just a preferred location for juvenile fish. A review of the length and weight data of captured fish suggests that the discharge channel may in fact serve as a nursery area for many species.

As discussed above, the slough anchovy was more densely occurring in the discharge channel than outside of it. The biomass of slough anchovy captured by the Navy study in greater San Diego Bay was moderately lower than that of the discharge channel study. The biomass of slough anchovy captured in the purse seine by the Navy study was 0.26 g/m^2, 1.07 g/m^2, 1.48 g/m^2, and 1.12 g/m^2 at Stations 1, 2, 3, and 4, respectively (Allen, 1999). Throughout the three year study in the discharge channel, slough anchovy biomass in the purse seine ranged from 0.47 g/m^2 to 11.60 g/m^2 with a mean of 2.52 g/m^2. The much higher density of slough anchovy in the discharge channel than the outer bay discussed above (five times higher mean density), without a proportionately higher biomass, suggests that the fish are younger and more abundant than those generally found in both the outer bay and even at the Navy station just outside of the power plant discharge channel.

An examination of the length frequency of slough anchovy captured in both studies confirms this finding. Figure 3-6 presents the number of slough anchovy captured in each size class throughout the length of each study. The majority of slough anchovy captured in the Navy study had a standard length between 60 and 70 mm, while slough anchovy captured during the current study were primarily 30 to 40 mm standard length. This suggests that fish captured in the discharge channel were primarily juveniles, either recruited there or residing in the area as they matured. An examination of the average length of both slough and deepbody anchovy by season in the study area also shows a seasonal size variability that may indicate that all stages of the life-cycle of these species are at one time present (Figure 3-7).

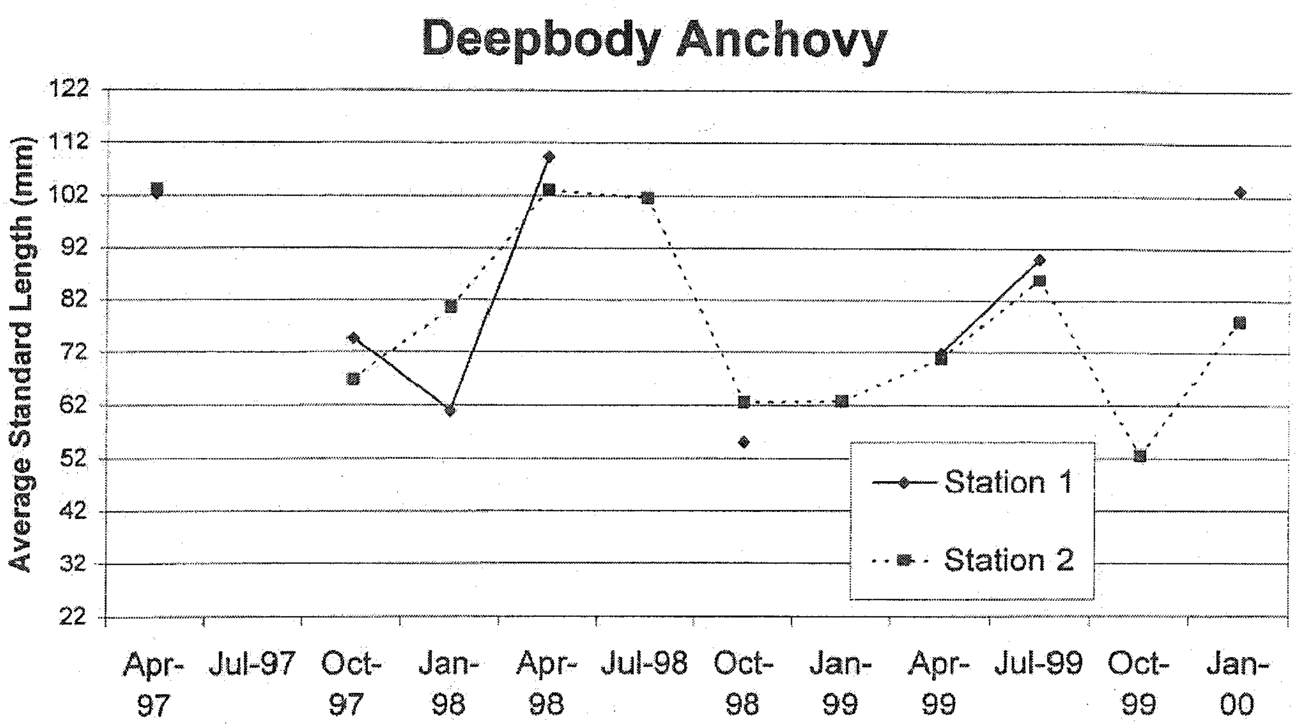
Seasonal fluctuations in the size of round stingray were also observed (Figure 3-8), indicating recruitment of the species at the site. Round stingray typically give birth to young in the fall, which is when many very small stingrays were observed during this study. Newborn stingrays were actually observed during fall field work. The majority of bat rays captured were also of a size typical of newborn individuals. Very young California halibut were also collected, although they were not present at the study site during the warm July surveys of 1997 and 1998. Of interest was the capture of 28 very young shortfin corvina (less than 100 mm standard length), including three that were 20 mm or less in length. The reproductive habits of this species are not well documented and collection of these individuals is believed to be the first confirmed record that this species is reproducing in south San Diego Bay.

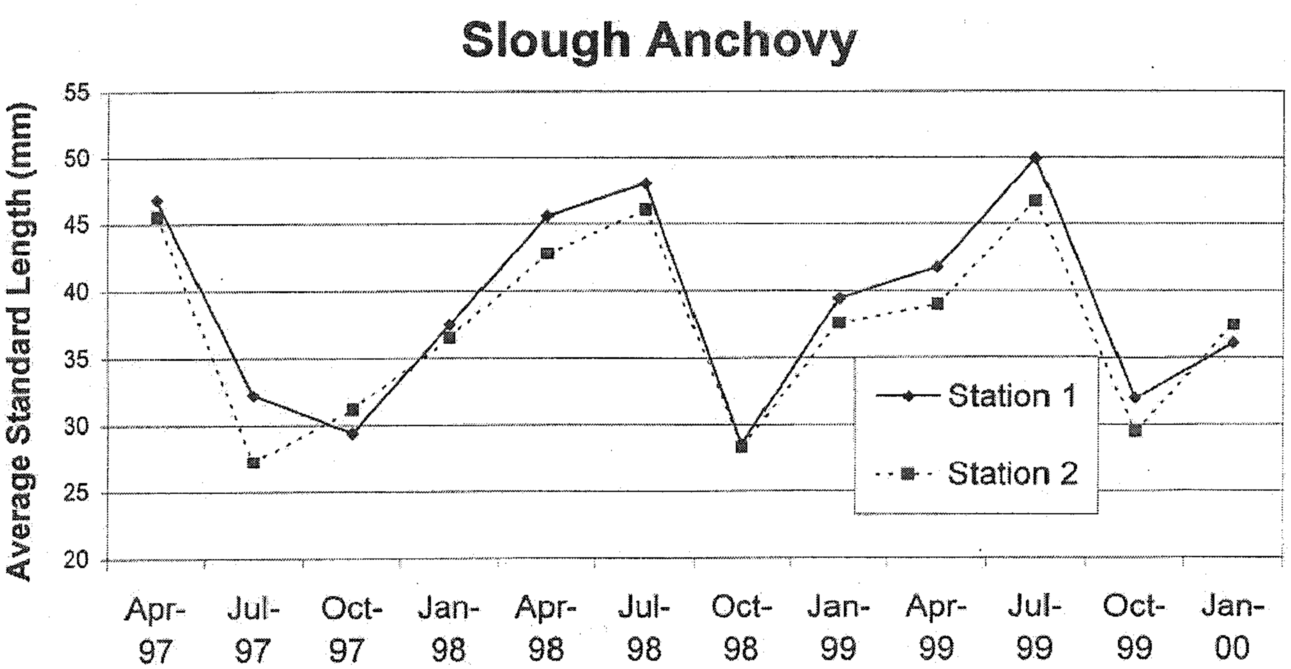
Of all thirty-eight species captured, only eight were not represented by juvenile individuals at some point during the study. Species that were primarily captured at an immature size included bonefish, round stingray, and bat rays. The capture of eight white sea bass that were all young-of-the-year was welcome in light of the severe population decline this species has suffered over the past decades due to overfishing. Other species captured at both juvenile and adult sizes included diamond turbot, California halibut, gray smoothhound, California killifish, gobies, and many others. The capture of a wide variety of fish at immature and mature stages of their life history suggests that the discharge channel supports a structured community of fish and provides habitat values beyond those favoring one particular species or age class.



Length Frequency of Slough Anchovy Found in
Power Plant Discharge Channel Study
Compared with U.S. Navy Bay-wide Study (Reprinted from Allen, 1999)

Figure
3-6

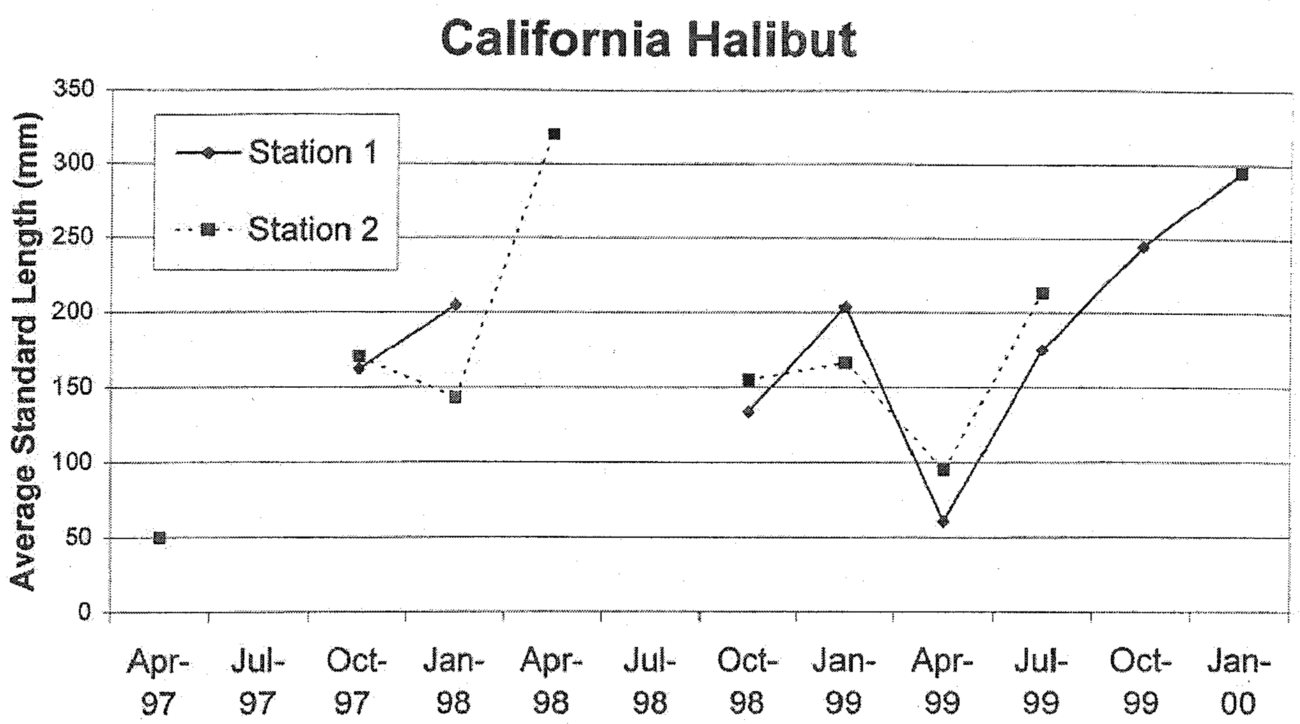


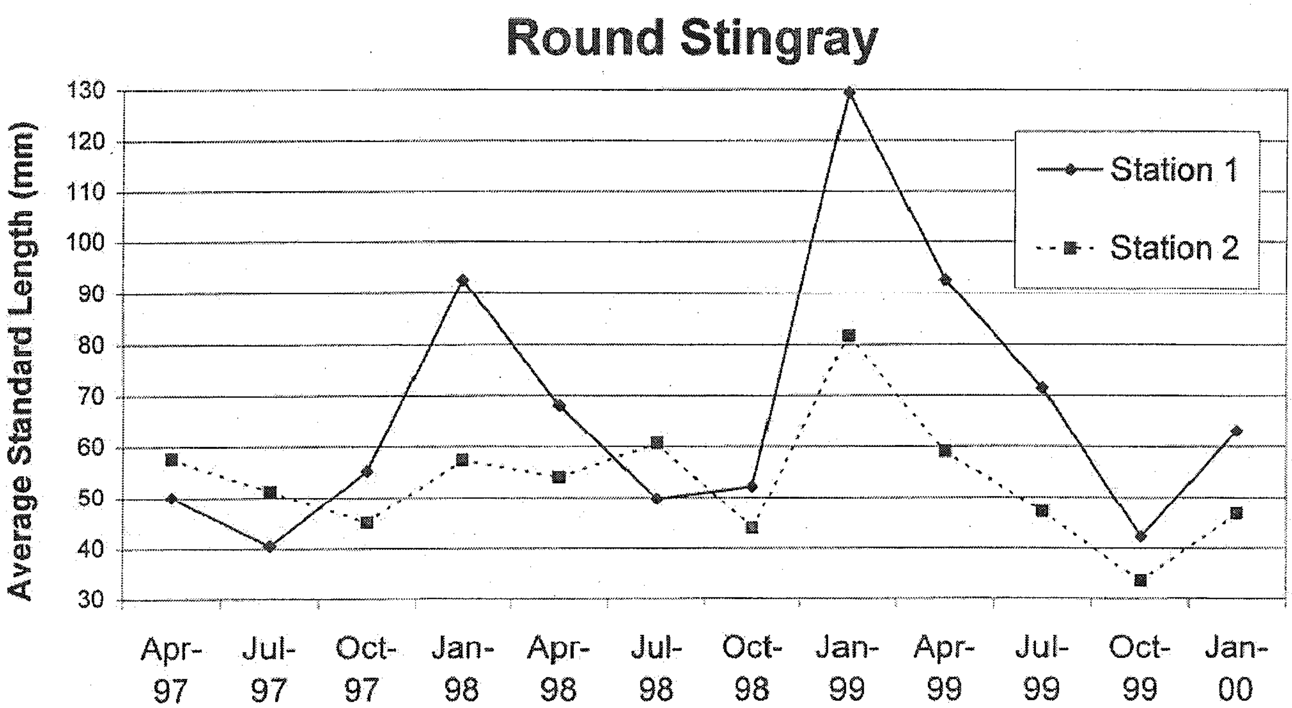


Temporal Trends in Average Standard Length (mm) of Deepbody and Slough Anchovy by Station for Year 1, 2, and 3

Figure 3-7

Merkel & Associates, Inc.





Temporal Trends in Average Standard Length (mm) of California Halibut and RoundStingray by Station for Year 1, 2, and 3

Figure 3-8

Merkel & Associates, Inc.

3.1.5 Temporal Trends in Fish Density, Biomass, and Richness

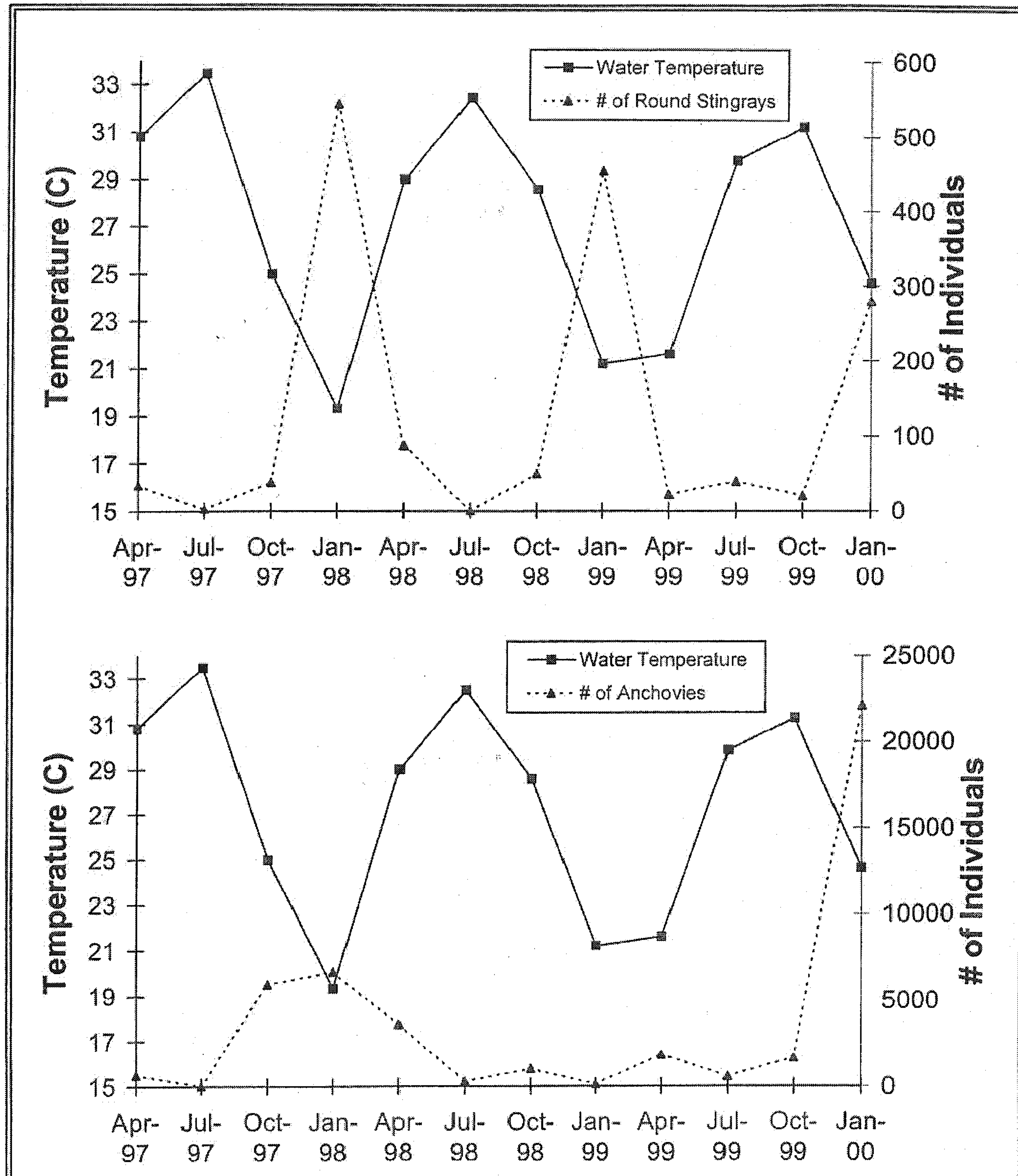
Seasonal trends in fish abundance and biomass in southern California bays and harbors are well documented (Horn and Allen 1981, Hoffman 1986 and unpubl. data, SAIC and MEC 1996). Seasonal trends have also held within other reference systems such as Batiquitos Lagoon (Merkel and Associates 1999). Allen (1999) also found seasonal patterns in fish abundance in the Navy study conducted throughout San Diego Bay, with generally higher catches in spring and summer than in winter. The power plant discharge channel also revealed seasonal trends in community composition indices of abundance, biomass, and species richness. However, it is interesting to note in this study a reversal in trends from those observed elsewhere occurs. The regularly observed trend is one of lowest abundance, biomass, and species richness during the winter months and substantially higher values for these parameters during the summer. However, within the discharge channel (Stations 1 and 2 combined) the lowest abundance, biomass, density, and richness was found during the warmer summer periods, while the highest abundance, density, and biomass was found when water temperatures were cooler. However, the high peaks in density and biomass of fish within the channel were often orders of magnitude higher than those observed outside of the channel. This pattern suggests that the discharge channel serves as a haven in the winter months as fish move into its warmer waters from the outer bay. During the summer months, some fish may either be forced out of the channel by high temperatures, or warming ambient bay waters may allow fish greater access to areas that are generally too cold during the winter season. This fall and winter concentration of fish may also provide a partial explanation for the high numbers of avian fish foragers seasonally found within the discharge channel. Specifically, the discharge channel supports an extremely dense population of brown pelicans during winter months.

Station 1, closest to the power plant, is generally warmer than Station 2, and therefore exhibits a more pronounced response of fish populations to changes in water temperature. Figure 3-9 shows the negative correlation at Station 1 between water temperature and the abundance of two species: round stingray, which drive biomass values in the study area, and anchovy, which drive density values.

Quarterly trends in the biomass and density of slough anchovy, deepbody anchovy, sharks and rays, and flatfish are presented in Figures 3-10 through 3-13. The winter influx of sharks, rays, and flatfish can be seen in Figures 3-11 and 3-10. Anchovy catches are highly variable, with generally more captured during the cooler months.

As mentioned, variation in species richness was closely related to the water temperature of the study site. In surveys when the water was warmest, particularly July of 1997 and 1998, species counts were lowest (9 and 11, respectively). Quarters that featured some of the highest species counts for the study (22 and 23 species), measured among the coolest surface water temperatures at both stations (January 1998 and April 1999) Interestingly, species counts were also high in July 1999, likely due to the waters being several degrees cooler than it had been recorded in the previous July surveys.

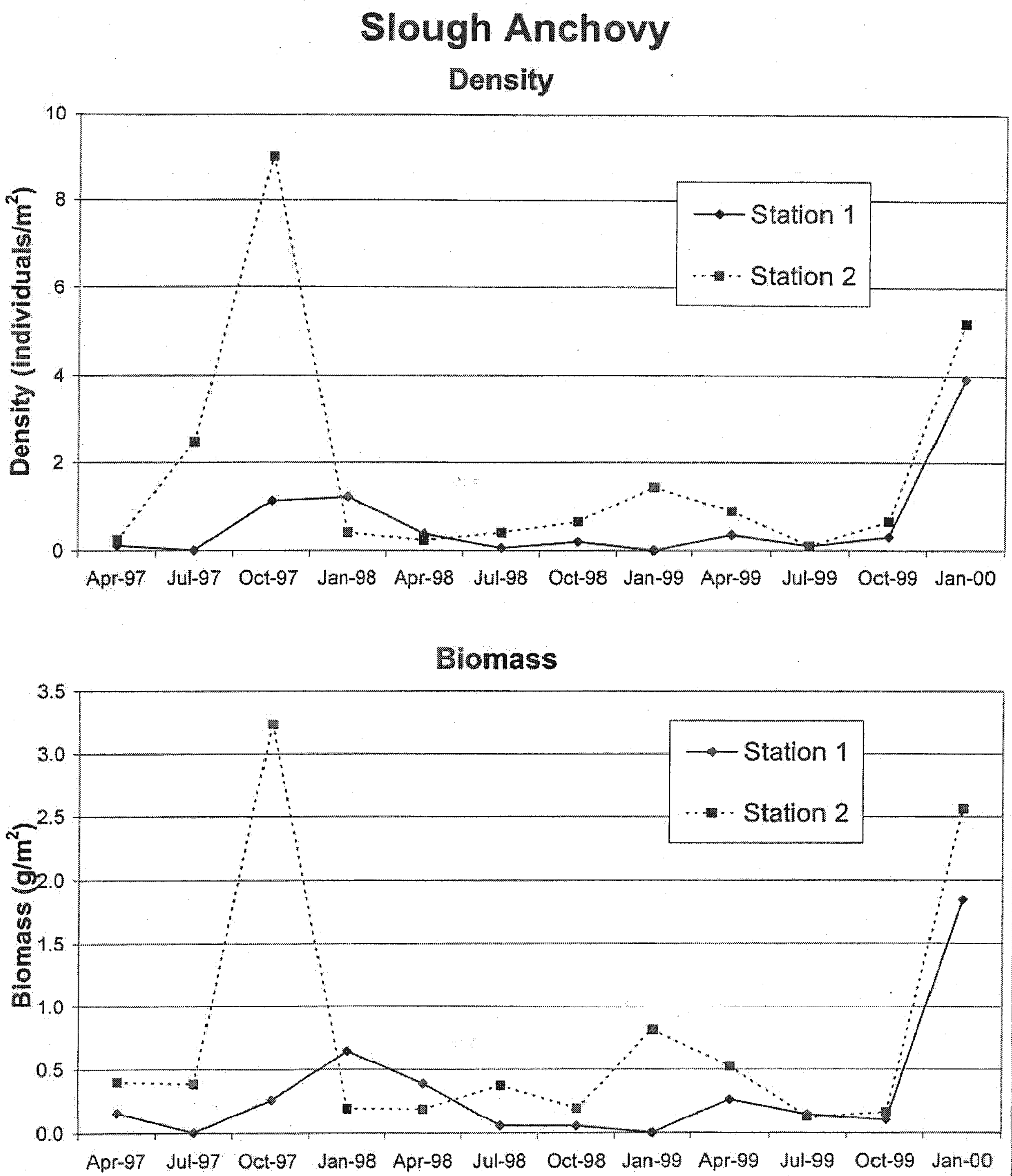
Although the data suggests that there is a smaller and less diverse community inhabiting the discharge channel during warmer months, this does not mean that the site is not productive, or an important part of the entire fish community of south San Diego Bay. Even during the warm months of the year, large numbers of fish, particularly forage species, still occur in the study area. For example, even during July 1997, the warmest of all quarters, over 13,000 slough anchovy were captured. This catch exceeded the density of most of the open bay stations of the Navy's study during the same time period. As discussed above, the channel also supports many juvenile fish, further evidenced by the over 6,000 larval anchovy captured in July 1999.



Comparison of Surface Water Temperature with Abundance of Round Stingrays and Anchovies (*Anchoa* spp.) at Station 1 April 1997 through January 2000

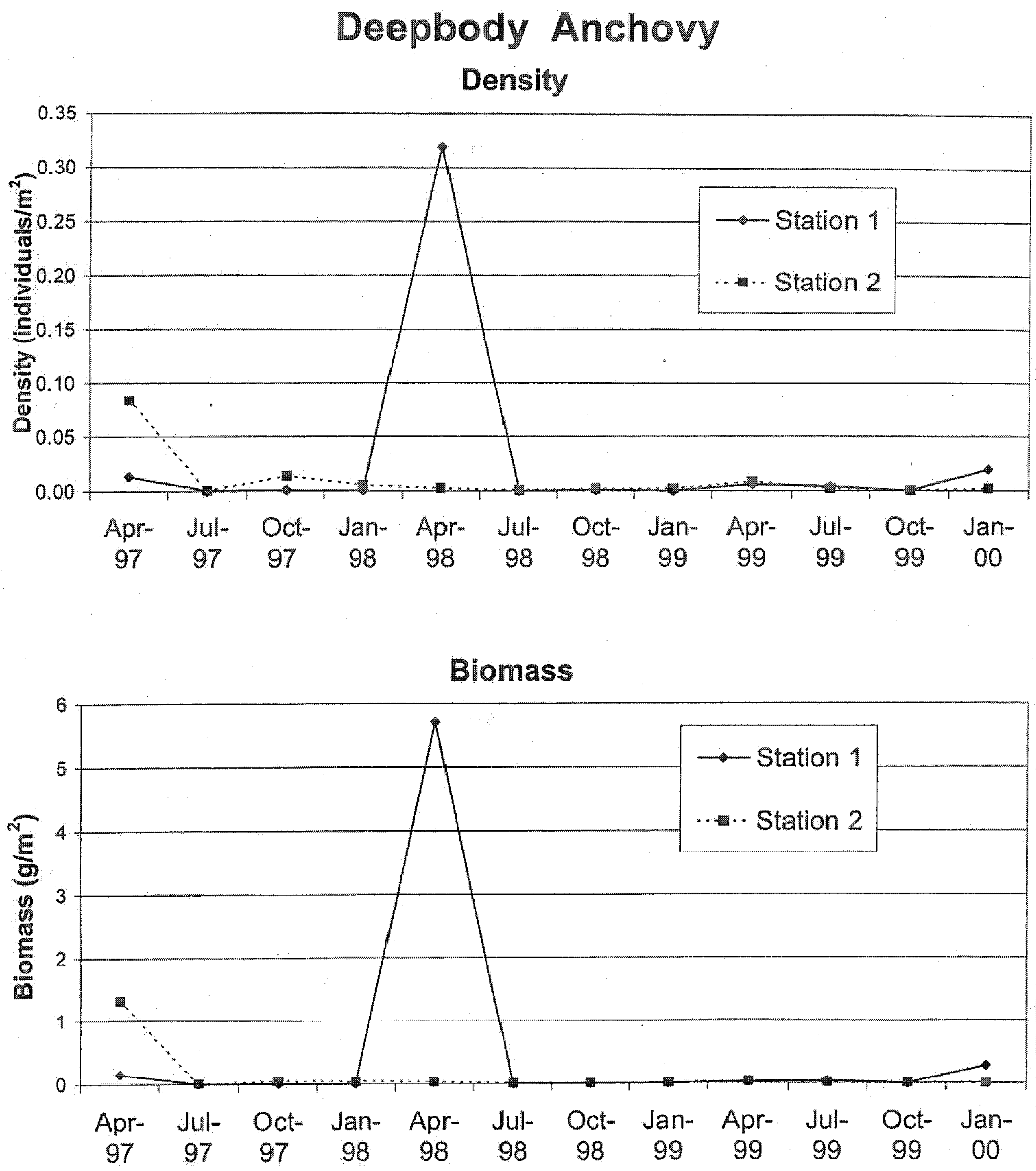
Figure 3-9

Merkel & Associates, Inc.



Temporal Trends in Density and Biomass of Slough Anchovy by Station for Years 1,2, and 3

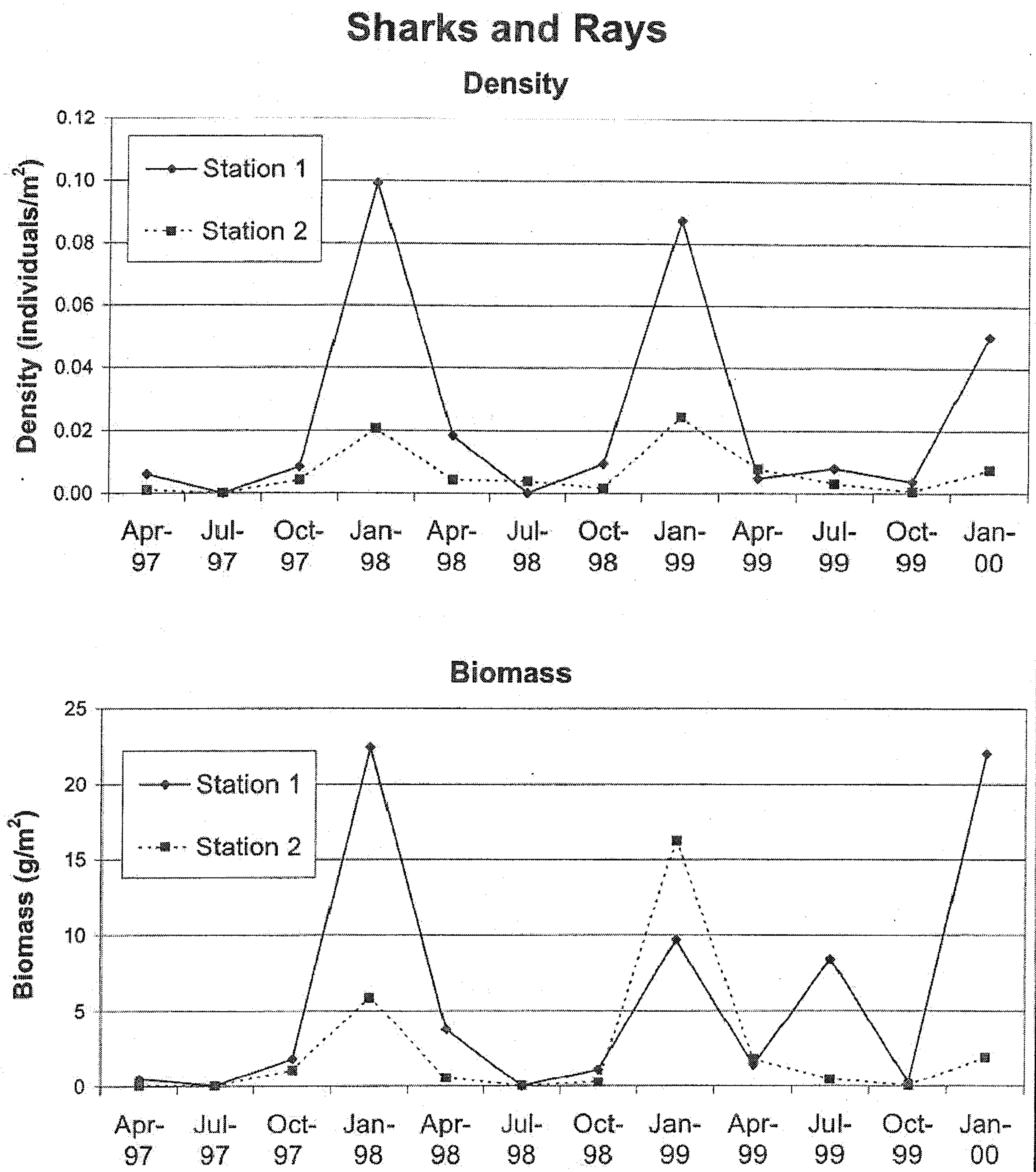
Figure 3-10



Temporal Trends in Density and Biomass of Deepbody Anchovy by Station for Years 1,2, and 3

Figure 3-11

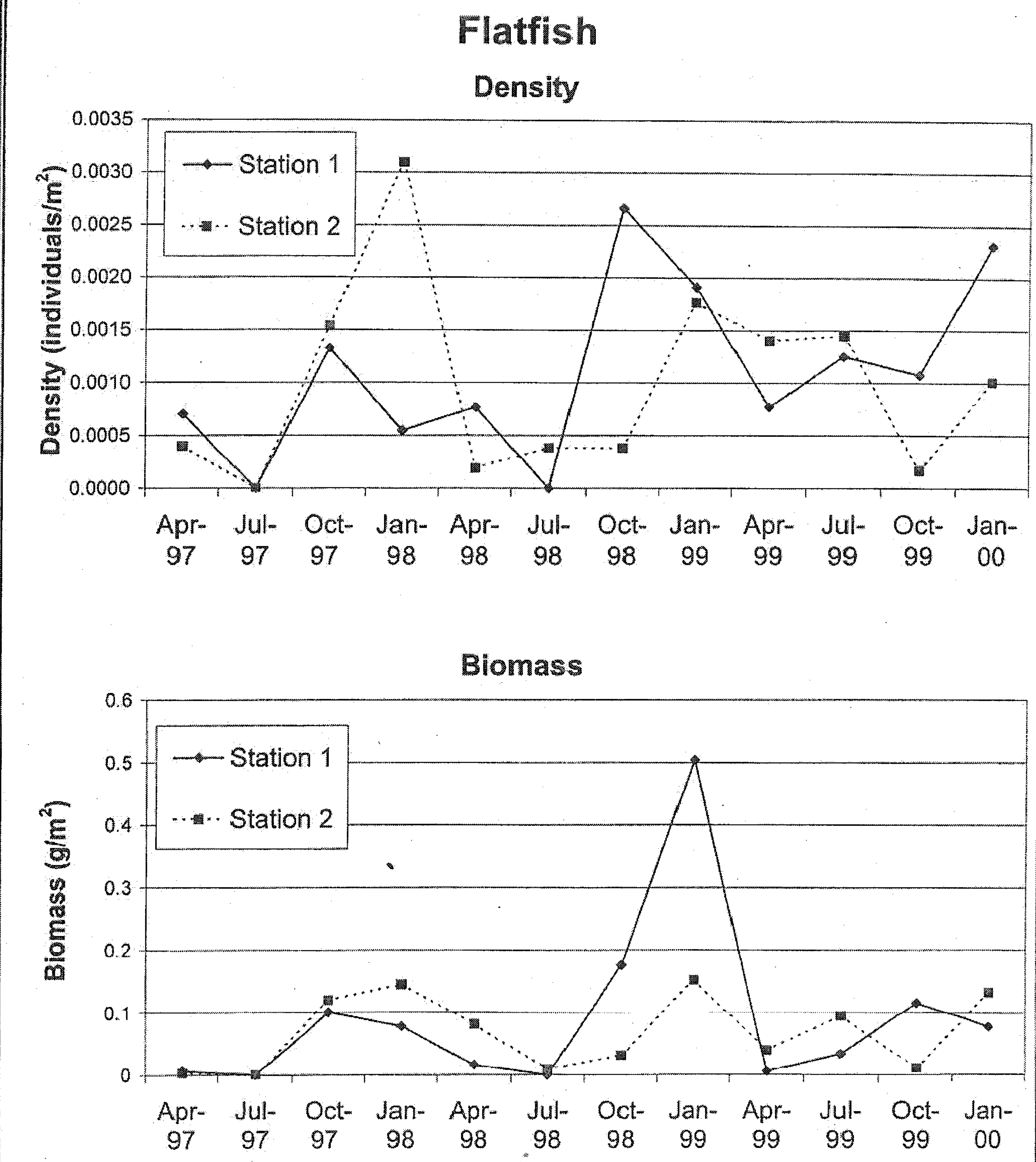
Merkel & Associates, Inc.



Temporal Trends in Density and Biomass of Sharks and Rays by Station for Years 1,2, and 3

Figure 3-12

Merkel & Associates, Inc.



Temporal Trends in Density and Biomass of Flatfish by Station for Years 1,2, and 3

Figure 3-13

One additional clear result arises from a temporal evaluation that contemplates the seasonal water temperature conditions of the discharge channel. This is the rejection of the applicability of the quantitative regression model proposed by Allen (1999) to quantitatively describe the effects of ENSO on total standing stock in the bay, based on temperature. The model put forth would predict significantly reduced populations within the discharge channel than those actually determined to be present. This suggests that such a model may be most applicable to evaluation scales where site specific microhabitat features, such as directional current flows, access to marshlands, or submerged vegetated areas are washed out by averaging across diverse and large areas.

3.1.6 Gear Analysis

This study was designed to use fishing gear that would target all guilds of fish occurring at the site. However, it was recognized that the non-destructive sampling effort would be ineffective at capturing some of the larger and more mobile species. The targeted guilds included fish representing juvenile and adults of demersal and pelagic species. However, due to the extremely shallow water of the channel area, none of the gear employed was restricted to sampling in only demersal or pelagic areas and fish from open water and near bottom areas frequently shared the same portions of the water column. A brief examination of the efficacy of each of six gear types used reveals that the purse seine captured the highest density and biomass of fish (Figure 3-14). All gears were effective at capturing the species they were designed to capture.

The results obtained in this study relative to gear efficiencies are not dissimilar from those reported for Batiquitos Lagoon sampling (Merkel & Associates 2000) or within San Diego Bay (Allen 1999).

3.2 WATER QUALITY MONITORING

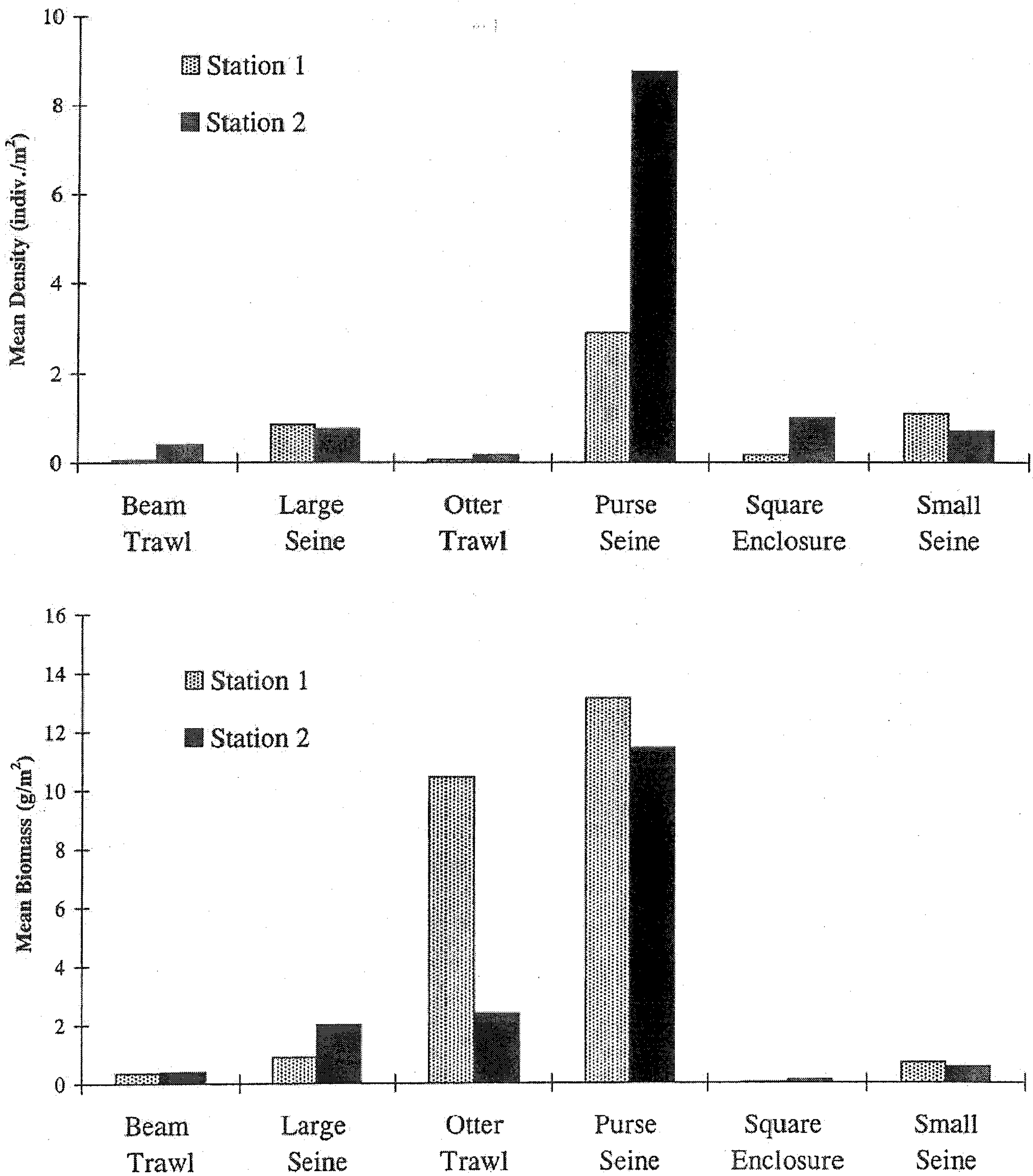
Water quality monitoring data for Year 3 at Stations 1 and 2 are presented in Tables 3-5 through 3-7 a and b and in Figures 3-15 through 3-18.

3.2.1 Temperature

Water temperature varied considerably between both stations and quarters. The lowest measured surface temperatures were recorded in January 1998 with 19.33°C at Station 1 and 19.55°C at Station 2 (Table 3-5, Figure 3-15). The highest surface temperatures were recorded in July 1997 at Station 1 (33.49°C), and in July 1998 at Station 2 (32.46°C). Water temperatures were more mild in Year 3, with surface lows of 21.61°C and 22.23°C at Stations 1 and 2, respectively, and highs of 31.26°C and 30.32°C at Stations 1 and 2, respectively. Water temperatures are notably higher within the power plant discharge channel than those reported in the ocean and in the northern portions of San Diego Bay.

Thermal stratification was seen at both stations and in all quarters (Figure 3-16 and 3-17). At Station 1 stratification was greatest in January 2000, when the surface was 4.78°C warmer than the bottom ten feet below. At Station 2 stratification was greatest in October 1999, with the surface measuring 4.73°C warmer than the bottom at a depth of seven feet. Very little difference was observed in the surface and bottom water temperatures in all of Year 2.

Temperatures were nearly always warmer at Station 1 than Station 2, with the largest difference seen in July 1997, when mean temperatures were 4.47°C higher at Station 1. A paired t-test found significant differences in temperature between the stations ($p=0.03$, $df=11$).



Mean Density (indiv./m^2) and Mean Biomass (g/m^2) of Fish Totals by Gear at Stations 1 and 2 From April 1997 through January 1999

Figure 3-14

Table 3-5a. Summary of Station 1 water quality monitoring data (April 1997 through March 1998).

Station 1 Water Quality Monitoring Data - Year 1						
Date	**Depth (feet)**	**Temperature (°C)**	**Dissolved Oxygen (mg/L)**	**Salinity (ppt)**	**pH (units)**	**Turbidity (NTU)**
24-Apr-97	6	29.86	6.70	35.20	7.7	14.9
	5	29.92	5.96	35.20	7.7	11.3
	4	30.50	5.34	35.10	7.8	10.8
	3	30.66	5.37	35.10	7.8	8.4
	2	30.79	5.40	35.10	7.8	11.7
	1	30.79	5.34	35.10	7.8	10.6
3-Jul-97	3	32.32	4.55	35.40	NM	7.6
	2	33.23	4.56	35.30	NM	10.4
	1	33.49	4.63	35.30	NM	38.4
29-Oct-97	6	24.21	7.03	35.40	8.1	7.4
	5	24.18	7.02	35.40	8.1	8.2
	4	24.16	7.02	35.36	8.1	7.2
	3	24.19	7.00	35.34	8.1	4.1
	2	24.44	6.99	35.25	8.1	2.0
	1	24.98	6.91	35.28	8.1	4.5
22-Jan-98	5	18.70	8.02	31.74	7.4	4.3
	4	19.07	7.94	31.80	7.4	3.6
	3	19.09	7.95	31.94	7.4	4.1
	2	19.37	7.89	32.00	7.4	2.5
	1	19.33	7.84	32.01	7.4	2.6

NM- not measured due to equipment failure

Table 3-5b. Summary of Station 2 water quality monitoring data (April 1997 through March 1998).

Station 2 Water Quality Monitoring Data - Year 1						
Date	Depth (feet)	Temperature (°C)	Dissolved Oxygen (mg/L)	Salinity (ppt)	pH (units)	Turbidity (NTU)
24-Apr-97	4	26.81	6.57	36.00	7.5	22.4
	3	26.68	7.15	35.50	7.6	11.2
	2	28.53	5.59	35.40	7.7	9.9
	1	28.57	5.53	35.40	7.7	16.1
3-Jul-97	7	28.53	4.49	36.00	NM	8.6
	6	28.55	4.44	36.00	NM	8.7
	5	28.55	4.44	36.00	NM	8.6
	4	28.55	4.44	35.90	NM	8.4
	3	28.55	4.52	35.90	NM	10.1
	2	28.55	4.46	35.90	NM	10.6
	1	28.54	4.49	35.90	NM	13.1
29-Oct-97	7	24.47	6.97	35.60	8.2	8.9
	6	24.45	6.99	35.58	8.2	2.9
	5	24.46	7.03	35.58	8.2	6.1
	4	24.47	7.00	35.41	8.1	7.0
	3	24.52	6.98	35.41	8.1	2.7
	2	24.53	6.95	35.37	8.1	5.7
	1	24.53	6.92	35.41	8.1	9.6
22-Jan-98	6	18.92	7.27	32.09	7.4	41.5
	5	19.04	7.45	32.08	7.4	43.0
	4	19.07	7.46	32.04	7.4	21.4
	3	19.11	7.47	32.02	7.4	19.5
	2	19.20	7.45	31.98	7.4	18.5
	1	19.55	7.64	31.97	7.4	12.4

NM- not measured due to equipment failure

Table 3-6a. Summary of Station 1 water quality monitoring data (April 1998 through January 1999).

Station 1 Water Quality Monitoring Data - Year 2						
Date	Depth (feet)	Temperature (°C)	Dissolved Oxygen (mg/L)	Salinity (ppt)	pH (units)	Turbidity (NTU)
10-Apr-98	6	28.97	6.72	28.02	7.9	15.5
	5	28.96	6.77	27.99	7.9	14.6
	4	28.98	6.75	27.99	7.9	14.0
	3	28.99	6.87	27.95	7.9	13.6
	2	29.03	6.93	27.92	7.9	15.4
	1	29.00	6.95	27.89	8.0	12.5
10-Jul-98	4	32.49	5.95	37.34	7.8	55.1
	3	32.50	5.96	37.33	7.8	11.5
	2	32.51	6.03	37.33	7.8	0.0
	1	32.46	5.99	37.31	7.8	0.0
2-Oct-98	5	28.52	5.83	36.50	8.1	39.2
	4	28.54	5.82	36.62	8.1	38.6
	3	28.56	5.81	36.51	8.1	16.0
	2	28.53	5.87	36.10	8.1	2.7
	1	28.57	5.88	36.22	8.1	0.0
11-Jan-99	5	21.07	7.23	34.76	8.1	0.0
	4	21.06	7.13	34.76	8.1	0.0
	3	21.10	7.16	34.83	8.1	0.0
	2	21.15	6.91	34.50	8.1	0.0
	1	21.21	6.72	34.49	8.1	0.0

Table 3-6b. Summary of Station 2 water quality monitoring data (April 1998 through January 1999).

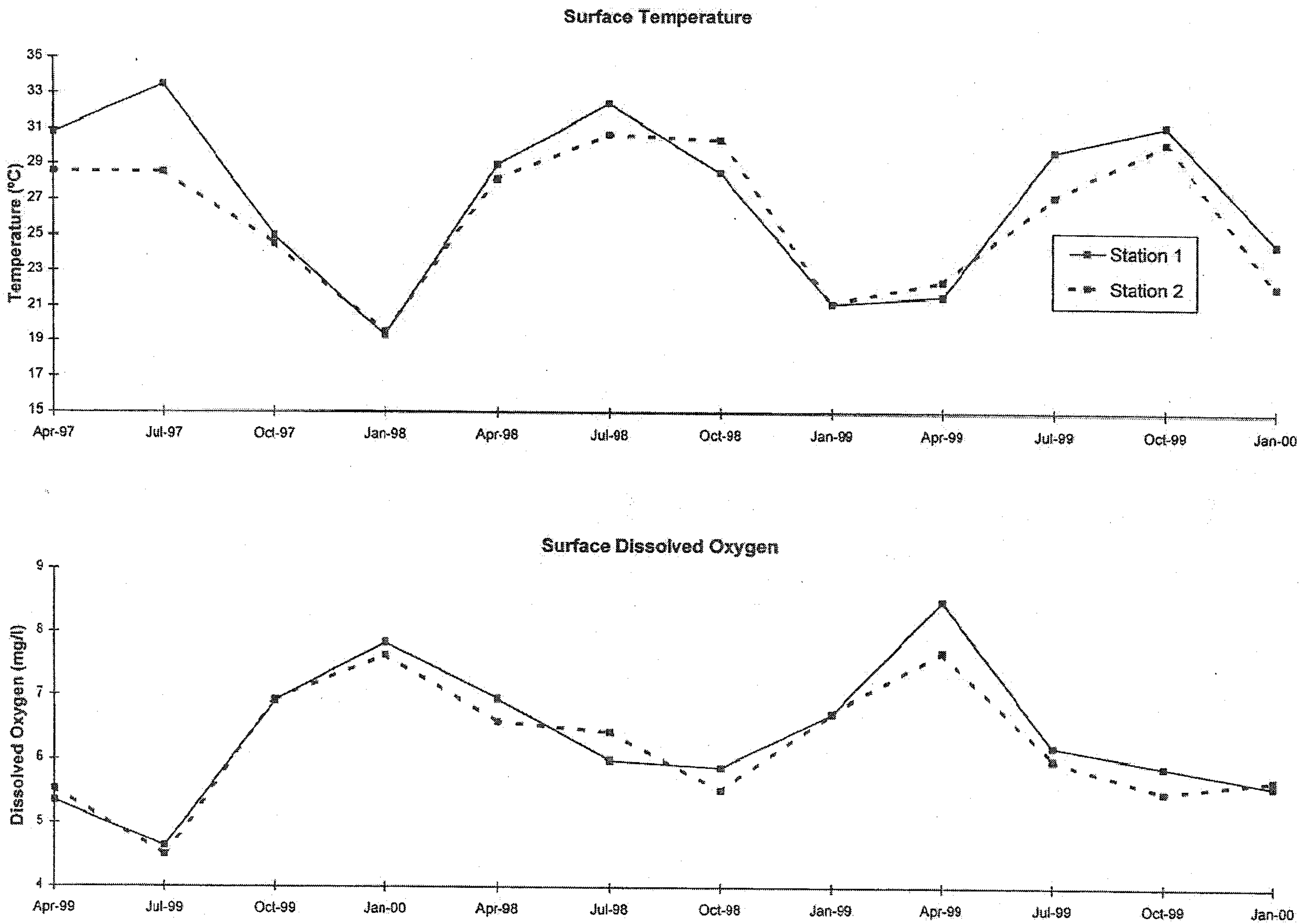
Station 2 Water Quality Monitoring Data - Year 2						
Date	**Depth (feet)**	**Temperature (°C)**	**Dissolved Oxygen (mg/L)**	**Salinity (ppt)**	**pH (units)**	**Turbidity (NTU)**
10-Apr-98	8	27.73	7.01	28.13	7.9	125.0
	7	27.76	6.89	28.08	7.9	108.0
	6	27.80	6.84	28.04	7.9	76.3
	5	27.79	6.76	28.03	7.9	71.3
	4	27.77	6.65	28.03	7.9	88.8
	3	27.86	6.63	28.03	7.9	64.1
	2	28.08	6.62	28.03	7.9	45.1
	1	28.19	6.59	28.02	7.9	28.5
10-Jul-98	3	30.45	6.60	37.42	7.8	2.8
	2	30.69	6.39	37.38	7.9	11.7
	1	30.74	6.43	37.36	7.9	0.0
2-Oct-98	6	30.50	5.41	36.33	8.0	153.0
	5	30.52	5.47	36.44	8.0	175.0
	4	30.52	5.43	36.67	8.0	31.0
	3	30.54	5.43	36.46	8.0	29.6
	2	30.50	5.42	36.09	8.0	27.1
	1	30.43	5.52	36.30	8.0	6.4
11-Jan-99	6	21.21	6.82	34.74	8.1	0.0
	5	21.21	6.83	34.86	8.1	0.0
	4	21.22	6.99	34.76	8.1	0.0
	3	21.22	6.97	34.91	8.1	0.0
	2	21.23	6.91	34.48	8.1	0.0
	1	21.22	6.73	34.52	8.1	0.0

Table 3-7a. Summary of Station 1 water quality monitoring data (April 1999 through January 2000).

Station 1 Water Quality Monitoring Data - Year 3						
Date	Depth (feet)	Temperature (°C)	Dissolved Oxygen (mg/L)	Salinity (ppt)	pH (units)	Turbidity (NTU)
2-Apr-99	4	21.38	8.35	34.24	NM	10.1
	3	21.44	8.43	34.24	NM	6.9
	2	21.55	8.46	34.25	NM	0.0
	1	21.61	8.49	34.22	NM	0.0
6-Jul-99	5	28.22	6.52	37.77	7.9	43.2
	4	29.01	6.41	37.63	7.9	16.2
	3	29.61	6.17	37.57	7.9	2.9
	2	29.66	6.15	37.15	7.9	2.4
	1	29.83	6.18	37.19	7.9	0.0
6-Oct-99	8	30.78	5.77	34.65	7.8	0.0
	7	30.90	5.79	34.87	7.8	0.0
	6	30.96	5.81	35.10	7.8	0.0
	5	31.08	5.80	35.23	7.8	0.0
	4	30.91	5.71	35.27	7.9	0.0
	3	31.12	5.77	35.21	7.9	0.0
	2	31.36	5.81	35.30	7.9	0.0
	1	31.26	5.85	35.53	7.9	0.0
25-Jan-00	10	19.85	5.54	33.35	7.9	5.8
	9	20.52	5.46	33.26	7.9	4.8
	8	20.43	5.40	33.50	7.9	4.9
	7	21.48	5.31	33.34	7.9	4.6
	6	22.07	5.34	33.62	7.9	3.8
	5	23.22	5.54	33.82	7.9	3.5
	4	23.45	5.56	33.65	7.9	4.1
	3	23.92	5.69	33.33	7.9	2.0
	2	24.50	5.65	33.44	7.8	2.0
	1	24.63	5.64	33.63	7.8	0.0

Table 3-7b. Summary of Station 2 water quality monitoring data (April 1999 through January 2000).

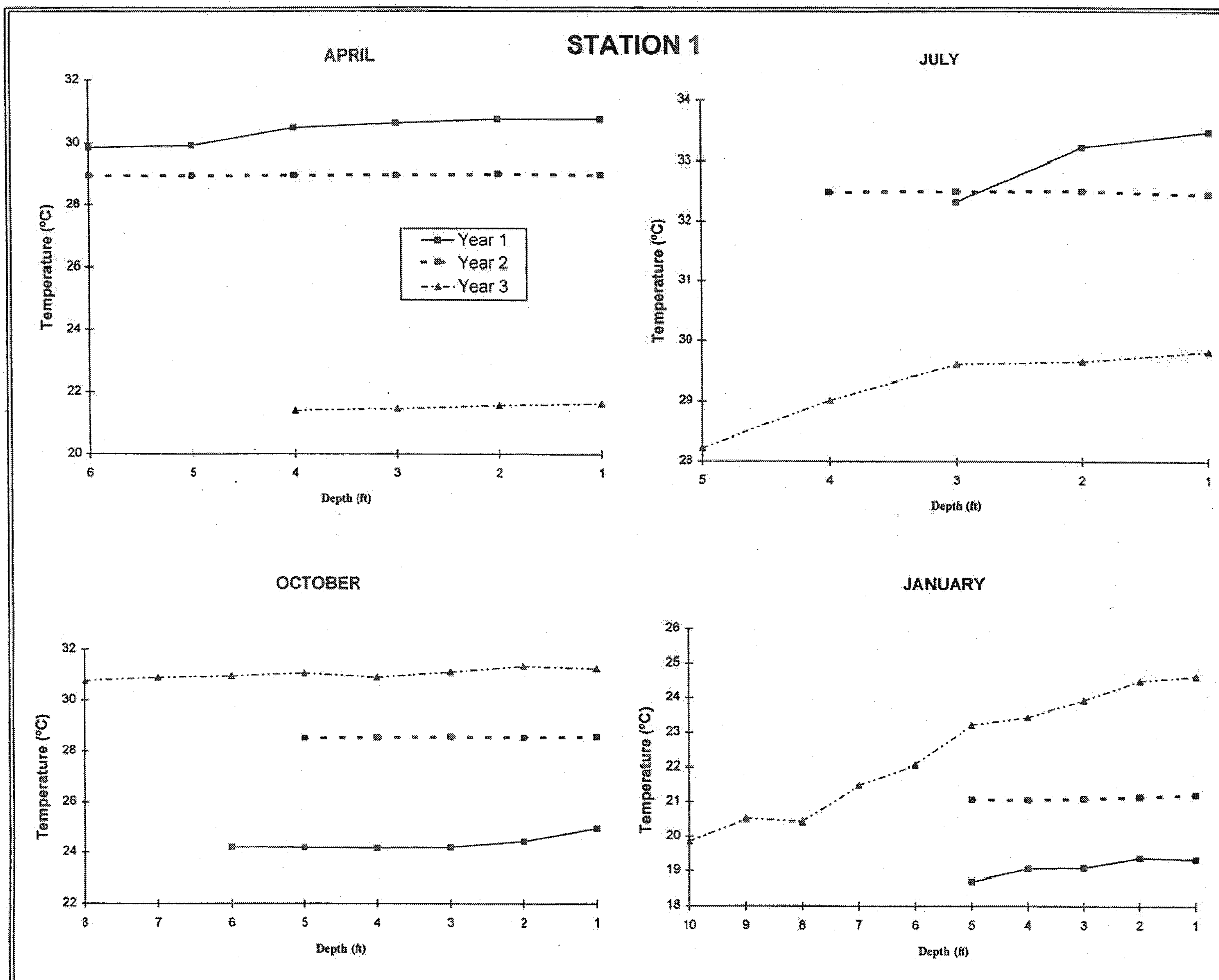
Station 2 Water Quality Monitoring Data - Year 3						
Date	**Depth (feet)**	**Temperature (°C)**	**Dissolved Oxygen (mg/L)**	**Salinity (ppt)**	**pH (units)**	**Turbidity (NTU)**
2-Apr-99	4	22.47	7.44	34.98	NM	16.1
	3	22.46	7.42	34.95	NM	13.7
	2	22.47	7.58	34.94	NM	11.8
	1	22.48	7.66	34.87	NM	9.9
6-Jul-99	7	26.72	6.12	37.43	7.9	2.0
	6	26.73	6.15	37.51	7.9	2.0
	5	26.70	6.19	37.55	7.9	2.7
	4	26.76	5.92	37.51	7.9	2.0
	3	26.92	5.96	37.02	7.9	1.6
	2	27.27	5.95	37.01	7.9	0.0
	1	27.30	5.98	37.31	7.9	0.0
6-Oct-99	7	25.59	5.30	34.77	8.0	5.7
	6	26.02	5.52	35.05	8.0	4.3
	5	26.80	5.77	35.18	8.0	2.8
	4	27.82	5.53	35.18	7.9	1.3
	3	29.99	5.56	35.39	7.9	1.5
	2	30.11	5.54	35.39	7.9	0.9
	1	30.32	5.52	35.42	7.9	0.4
25-Jan-00	8	19.48	5.53	33.58	7.9	19.0
	7	19.50	5.45	33.60	7.9	6.8
	6	19.56	5.47	33.63	7.9	5.4
	5	19.85	5.55	33.68	7.9	4.5
	4	19.95	5.53	33.75	7.9	3.4
	3	19.93	5.53	33.49	7.9	3.6
	2	20.72	5.61	33.37	7.9	2.3
	1	22.23	5.71	33.78	7.9	2.4



Surface Water Quality Monitoring Data
April 1997 through January 2000

Figure 3-15

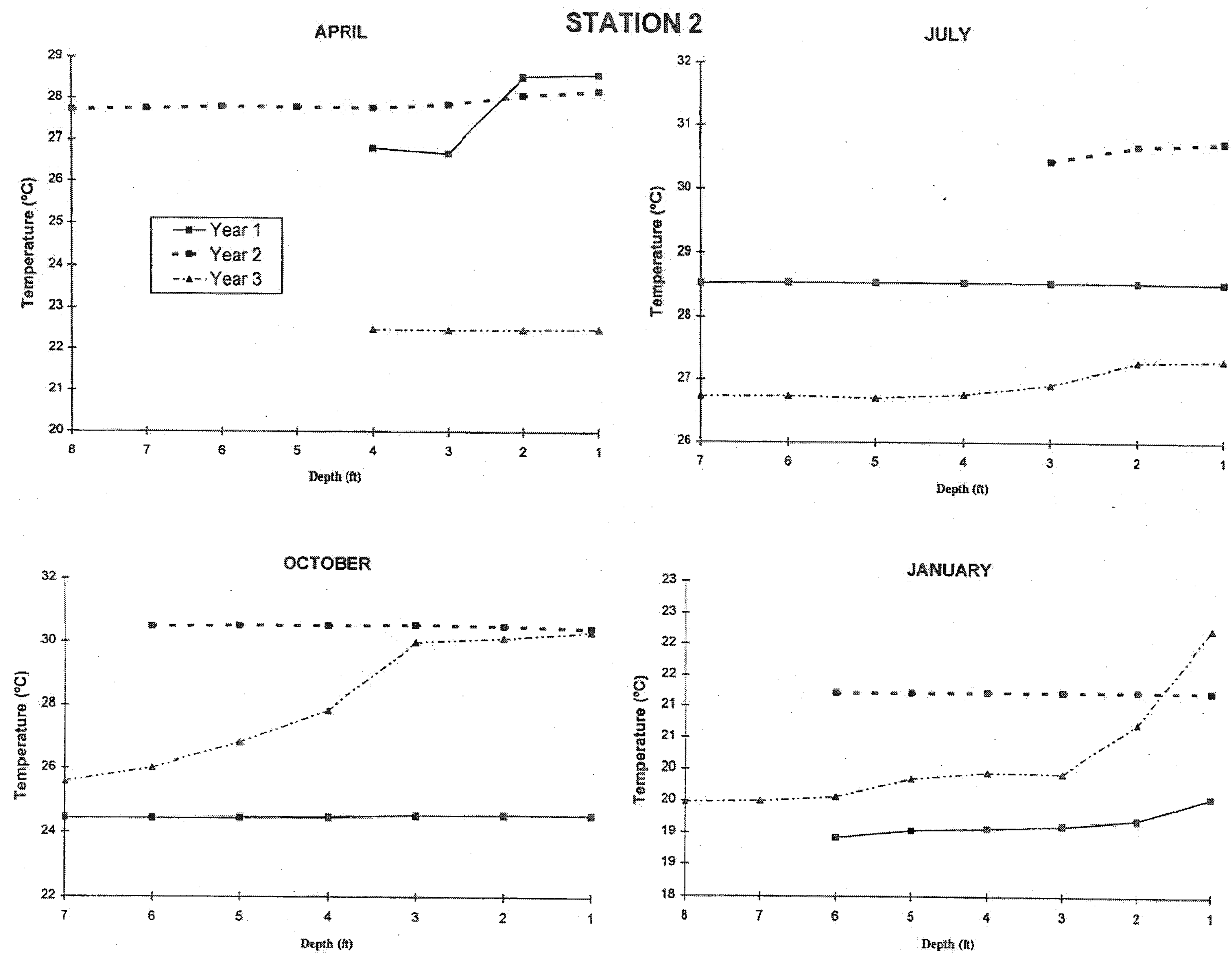
Merkel & Associates, Inc.



Temperature Depth Gradient at Station 1 by Quarter
Year 1 (April 1997- January 1998), Year 2 (April 1998- January 1999), and Year 3 (April 1999 - January 2000)

Figure 3-16

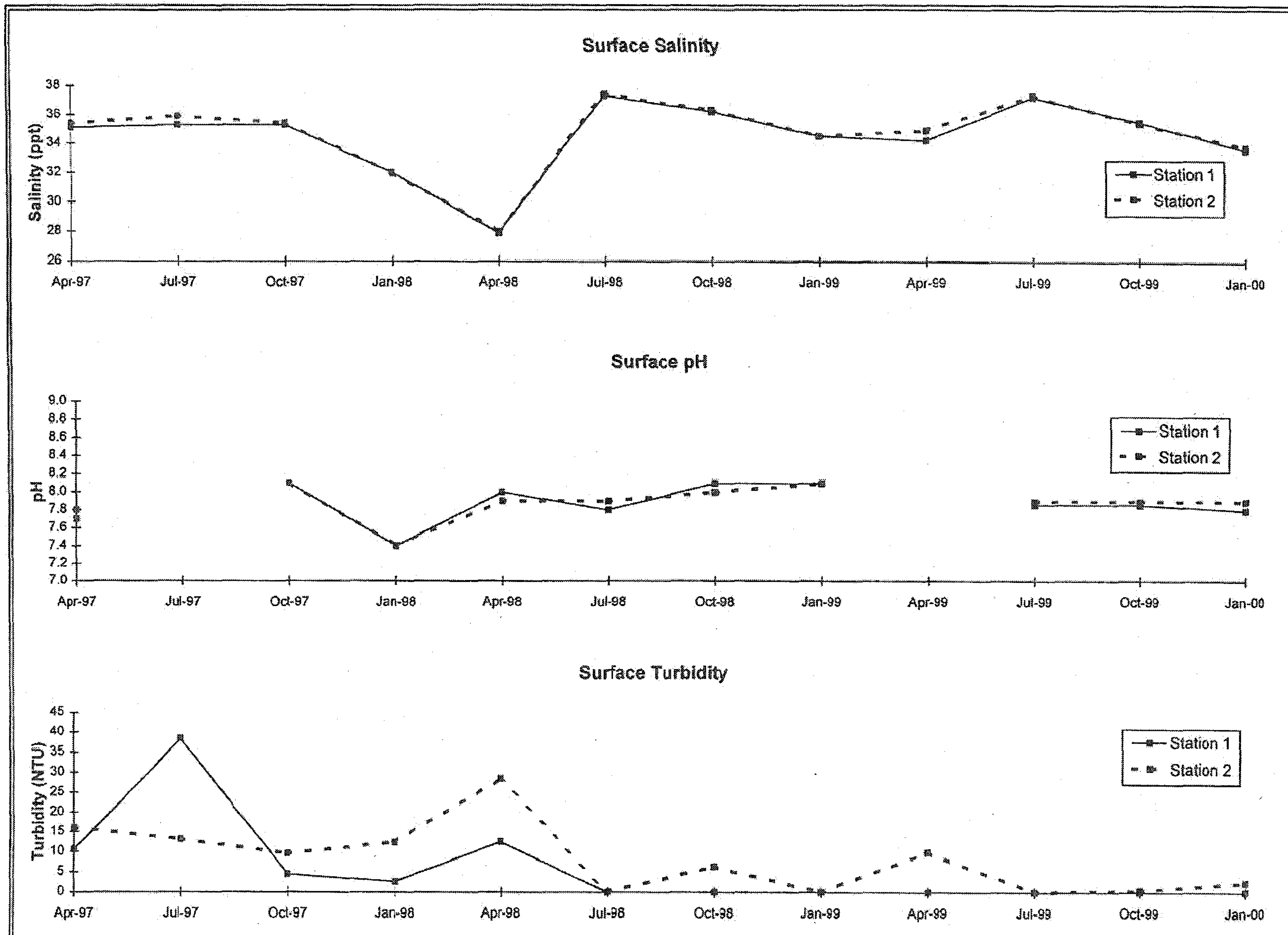
Merkel & Associates, Inc.



Temperature Depth Gradient at Station 2 by Quarter
Year 1 (April 1997- January 1998), Year 2 (April 1998- January 1999), and Year 3 (April 1999 - January 2000)

Figure 3-17

Merkel & Associates, Inc.



Surface Water Quality Monitoring Data
April 1997 through January 2000

Figure
3-18

Merkel & Associates, Inc.

3.2.2 Dissolved Oxygen

Throughout the study, surface dissolved oxygen (DO) ranged from 4.63 mg/l (July 1997) to 8.49 mg/l (April 1999) at Station 1 and from 4.49 (July 1997) to 7.64 mg/l (January 1998) at Station 2 (Figure 3-15). As would be expected, DO was generally highest when the water was cool and lowest when the water was warmest. The measured DO levels are not considered to fall outside of the range of normal for warmwater shallow marine environments. These levels are similar to those measured in comparable habitats of Batiquitos Lagoon during the same period (Merkel & Associates, 2000)

3.2.3 Salinity

Recorded salinity was typical of back-bay environments. Surface salinity ranged from 28.02 ppt (April 1998) to 37.31 ppt (July 1998) at Station 1 and from 28.0 ppt (April 1998) to 37.4 ppt (July 1998) at Station 2 (Figure 3-18). Very little variation in salinity was observed between Station 1 and 2. Surface salinity was lower than bottom salinity during quarters when the bay had received significant freshwater input from winter rains.

3.2.4 pH

The pH probe was malfunctioning and did not collect data in July 1997 and April 1999. Measured pH during the three year study consistently ranged between 7.4 and 8.1 at both stations (Figure 3-18). Surface and bottom water pH did not vary by more than 0.2 units at either station during any monitoring quarter, and more commonly was the same at all depths. Mean pH throughout the study was 7.9 at both Station 1 and 2. All values are within the normal range for sea water.

3.2.5 Turbidity

Turbidity followed a general pattern of being higher at the bottom and lower closer to the surface (Figure 3-18). Turbidity at the bottom may be generated by disturbance of loose bottom sediments by channel currents. Sampling during Year 3 generally revealed lower turbidity than in Year 1 and 2, likely due in part to the very mild winter season that brought very little of the rains that commonly increase turbidity in South San Diego Bay. Turbidity at Station 1 ranged from 0.0 to 55.1 NTU, averaging 8.1 NTU for the year and at Station 2 ranged from 0.0 to 175.0 NTU, averaging 20.5 NTU for the year.

3.3 Fish Abnormalities or Epidural Lesions

None of the fish collected during the course of the three year study exhibited abnormalities. Some of the round stingrays were lacking their tail spine, due to mechanical removal by pliers or wire cutters. This has been noted elsewhere in the bay and is believed to be due to fishermen. While unfortunate, such damage is not fatal and wounds rarely become infected.

In the January 1999 survey, one California killifish was captured that hosted a parasitic leech of the Order Rhyncobdellae. Leeches are not uncommon fish parasites in this region. A killifish and slough anchovy were also caught that hosted an epidermal parasite of the Order Isopoda. Two gobies and three anchovies were captured in the April, July, and October 1999 surveys that hosted a parasite of the Order Isopoda. These isopods commonly occur on fish is this region. The frequency of capture of fish hosting parasites was no greater than that observed at Batiquitos Lagoon, where long-term fish monitoring was concurrently being conducted (Merkel 2000). All other fish appeared healthy and did not exhibit abnormalities.

4.0 PRIMARY CONCLUSIONS

Several conclusions can be drawn from this three year study of the fish community of the South Bay Power Plant discharge channel. Most importantly, the channel is not a barren, hot, wasteland as has been speculated by some. Rather, this thorough investigation of the discharge channel has shown it to support a diverse fish community that has a similar density as other areas of San Diego Bay and maintains, on average, a biomass that is approximately 270% higher than San Diego Bay as a whole. The resources detected in the present study confirm that the fish habitat present within the discharge channel is equal to or greater than that detected in 1968 (Ford 1968).

The discharge channel provides a year-round forage base of fish of suitable type and size for piscivorous birds, including California least tern and California brown pelican. There are also abundant prey species for larger foraging fish. The area also appears to provide a nursery area for a number of species (such as anchovy) and may also provide a spawning area, however this is not confirmed.

The 38 species collected during the three year study in the discharge channel can not be directly compared to the 78 species collected during the five year study of the entire bay that was completed by the Navy (Allen 1999). This is due to a number of factors including the fact that the Navy survey sampled in many more habitats than are represented within the discharge channel, extended for two years longer than the discharge channel study, and sampled over twelve times as much area than that sampled within the discharge channel. Although species richness is not directly comparable for the two studies, it is believed that the discharge channel is less rich, due to lack of habitat diversity and environmental limitations (increased water temperature during summer months) on some species. The unique temperature environment of the channel may provide a warm water refuge area for several bay species during the winter, but may similarly preclude some species from full use of the area during the hottest portions of the summer months when bay temperatures provide thermally relaxed restrictions on species movements. The site provides a warm haven for fish and for green sea turtles in winter, as well as for interesting Panamic province fish such as the diamond stingray, California halfbeak, California needlefish, bonefish, shortfin corvina, California butterfly ray, and bigscale goatfish.

The levels of fish epi-parasitism and abnormality were determined to be comparable to that of other systems sampled for the suite of fish examined in the present study, suggesting that the power plant does not cause an unnaturally high occurrence of fish malformation or parasitism.

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APPENDIX A

Data Corrections

Appendix A: Data corrections

Corrections in count and weight

Quarter	Station	Gear	Replicate	Species	Reported Count	Revised Count	Reported Weight (g)	Revised Weight (g)
Oct-97	1	OT	2	Round stingray	12	11	1836.0	1256.0
Oct-97	1	OT	1	Round stingray	4	3	445.0	221.0
Jan-98	2	PS	3	Round stingray	8	2		No Change
Jan-98	2	PS	1	California halibut	0	1		No Change
Jan-98	2	BT	3	Diamond turbot	1	0		No Change
Jan-98	2	OT	1	Diamond turbot	3	0		No Change
Jan-98	2	OT	3	Diamond turbot	1	0		No Change
Jan-98	2	SS	3	Diamond turbot	2	1		No Change
Jan-98	2	PS	1	California halfbeak	1	0		No Change
Oct-99	2	LS	1	Longjaw mudsucker		No Change	0.7	7.3

Finalizations in taxonomy

Quarter	Station	Gear	Replicate	Species (first reported)	Species (final reported)	Number of Individuals
Jul-97	2	BT	1	Orangemouth corvina	Shorfin corvina	1
Jan-98	1	PS	2	Orangemouth corvina	Shorfin corvina	1
Jan-98	1	PS	3	Orangemouth corvina	Shorfin corvina	8
Oct-98	1	BT	2	Orangemouth corvina	Shorfin corvina	4
Oct-98	1	OT	3	Orangemouth corvina	Shorfin corvina	1
Oct-98	1	PS	2	Orangemouth corvina	Shorfin corvina	1
Oct-98	1	PS	3	Orangemouth corvina	Shorfin corvina	3
Oct-98	2	LS	2	Orangemouth corvina	Shorfin corvina	3
Oct-98	2	LS	3	Orangemouth corvina	Shorfin corvina	6
Oct-98	2	PS	1	Orangemouth corvina	Shorfin corvina	1
Oct-98	2	SS	2	Orangemouth corvina	Shorfin corvina	3
Jan-99	2	PS	1	Orangemouth corvina	Shorfin corvina	1
Apr-99	1	PS	3	Orangemouth corvina	Shorfin corvina	3
Apr-99	2	OT	3	Mexican goatfish	Bigscale goatfish	1
Oct-99	1	LS	2	Orangemouth corvina	Shorfin corvina	4
Oct-99	1	LS	3	Orangemouth corvina	Shorfin corvina	1
Oct-99	1	SS	1	Orangemouth corvina	Shorfin corvina	1
Oct-99	2	LS	3	Orangemouth corvina	Shorfin corvina	1
Oct-99	2	SS	2	Arrow/Shadow goby	Longjaw mudsucker	1

APPENDIX B

List of Fish Species Observed

Appendix B. List of Fish Species Observed (Years 1, 2, and 3).

Common Name	Scientific Name	Apr '97	Jul '97	Oct '97	Jan '98	Apr '98	Jul '98	Oct '98	Jan '99	Apr '99	July '99	Oct '99	Jan '00
Gray smoothhound	*Mustelus californicus*	X		X	X	X				X			X
Shovelnose guitarfish	*Rhinobatos productus*					X					X		
Bat ray	*Myliobatis californica*			X	X	X			X	X			X
Round stingray	*Urolophus halleri*	X	X	X	X	X	X	X	X	X	X	X	X
California butterfly ray	*Gymnura marmorata*							X	X	X	X		X
Diamond stingray	*Dasyatis dipterura*												X
Bonefish	*Albula vulpes*			X	X	X	X	X	X	X	X	X	
Threadfin shad	*Dorosoma petenense*				X								
Pacific sardine	*Clupea harengus*			X	X								
Slough anchovy	*Anchoa delicatissima*	X	X	X	X	X	X	X	X	X	X	X	X
Deepbody anchovy	*Anchoa compressa*	X		X	X	X	X	X	X	X	X	X	X
Specklefin midshipman	*Porichthys myriaster*									X	X		
California needlefish	*Strongylura exilis*	X		X		X		X	X	X	X	X	X
California halfbeak	*Hyporhamphus rosae*	X	X	X	X	X	X	X	X	X	X	X	X
California killifish	*Fundulus parvipinnis*	X	X	X	X	X	X	X	X	X	X	X	X
Topsmelt	*Atherinops affinis*	X	X	X	X	X	X	X	X	X	X	X	X
Bay pipefish	*Syngnathus leptorhynchus*	X	X								X		
Barred pipefish	*Syngnathus auliscus*			X	X		X	X		X	X	X	X
Staghorn sculpin	*Leptocottus armatus*					X				X			X
Spotted sand bass	*Paralabrax maculatofasciatus*	X		X	X	X		X	X			X	X
Barred sand bass	*Paralabrax nebulifer*									X			
Bigscale goatfish	*Pseudupeneus grandisquamis*									X			
Lookdown	*Selene vomer*				X								
White seabass	*Atractoscion nobilis*			X		X							
Spotfin croaker	*Roncador stearnsii*			X									
Yellowfin croaker	*Umbrina roncador*				X	X					X		
Shortfin corvina	*Cynoscion parvipinnis*		X		X	X		X	X	X	X	X	X
Shiner surfperch	*Cymatogaster aggregata*								X				
Striped mullet	*Mugil cephalus*	* X	* X	X	X	X	X	X	X	X	X	* X	X
Blue bobo	*Polydactylus approximans*				X								
Longtail goby	*Gobionellus sagittula*											X	
Longjaw mudsucker	*Gillichthys mirabilis*											X	
Yellowfin goby	*Acanthogobius flavimanus*	X	X	X				X	X		X	X	
Cheekspot goby	*Ilypnus gilberti*			X	X	X			X	X	X	X	X
Arrow/Shadow goby	Gobiidae	X		X	X	X	X	X	X	X	X	X	X
Gobiidae larvae	Gobiidae	X											
California halibut	*Paralichthys californicus*	X		X	X	X		X	X	X	X	X	X
Diamond turbot	*Hypsopsetta guttulata*	X		X	X	X	X	X		X	X	X	X
SPECIES COUNT PER SAMPLING INTERVAL		15	9	21	22	21	11	17	18	23**	22**	20**	21**
ACCUMULATED SPECIES COUNT		15	16	23	27	29	29	30	31	34	35	37	38

* - observed escaping from net, not included in abundance counts or weights

**- shadow goby included in this count

APPENDIX C
Statistical Tests of Significance

Appendix C. Statistical analyses of spatial and temporal patterns in fish catch data (Years 1-3).

Two Factor ANOVA- Density (Quarter x Station)

Source of Variation	*df*	*F*	*P-value*	*F crit*	*Significance*
Stations	1	17.31424	0.00013	4.04265	***
Quarters	11	10.79004	1.24E-09	1.99458	***
Quarters x Station	11	5.09622	3.14E-05	1.99458	***
Within	48				
Total	71				

Two Factor ANOVA- Biomass (Quarter x Station)

Source of Variation	*df*	*F*	*P-value*	*F crit*	*Significance*
Stations	1	6.23700	0.01599	4.04265	*
Quarters	11	4.84842	0.00005	1.99458	***
Quarters x Station	11	2.26462	0.02562	1.99458	*
Within	48				
Total	71				

Paired t-test- Number of Species- Station 1 and Station 2

Source of Variation	*Station 1*	*Station 2*	*Significance*
Mean	14.58	15.75	
Variance	22.27	16.02	
Observations	12	12	
Hypothesized Mean Difference	0		
df	11		
t Stat	-1.48324		
P(T<=t) one-tail	0.083043		NS
t Critical one-tail	1.795884		

Paired t-test- Water Temperature Station 1 and Station 2

Source of Variation	*Station 1*	*Station 2*	*Significance*
Mean	27.26	26.18	
Variance	22.65	15.74	
Observations	12	12	
Hypothesized Mean Difference	0		
df	11		
t Stat	2.07412		
P(T<=t) one-tail	0.031164		*
t Critical one-tail	1.795884		

NS = not significant at a p =0.05 level; * = 0.05>p>0.01; ** =0.01>p>0.001; ***=p<0.001