Demersal Fishes and Megabenthic Invertebrates

Southern California Bight 1998 Regional Monitoring Program Vol V.

Southern California Bight 1998 Regional Monitoring Program: V. Demersal Fishes and Megabenthic Invertebrates

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SOUTHERN CALIFORNIA BIGHT 1998 REGIONAL MONITORING PROGRAM

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FOREWORD

The Southern California Bight (SCB) is an important and unique ecological resource. The diverse habitats present in the SCB allow for the coexistence of a broad spectrum of species, including more than 500 species of fish and 1,500 species of invertebrates. The SCB is also one of the most densely populated coastal regions of the country, which creates stress upon the marine environment through activities such as contaminant discharge from effluents and nonpoint sources, fishing, and habitat modification. Over $10 million is spent annually to monitor coastal environmental quality in the SCB. These monitoring programs provide important site-specific information about the impacts of individual waste discharges, but do not describe the condition of the SCB as a whole. Regional information is needed by resource managers to assess cumulative impacts of contaminant inputs and to evaluate relative risk among different types of stresses.

The Southern California Bight 1998 Regional Monitoring Project (Bight'98) is part of an effort to provide an integrated assessment of the SCB through cooperative regional-scale monitoring. Bight'98 is an expansion of the Southern California Bight 1994 Pilot Project (SCBPP) (SCBPP 1998) and represents the joint efforts of 62 organizations. Bight'98 is organized into three technical components: (1) Coastal Ecology; (2) Shoreline Microbiology; and (3) Water Quality. This report represents the results of the demersal fishes and megabenthic invertebrates portion of Bight'98, which is part of the Coastal Ecology component. Copies of this and other Bight'98 reports are available for download at www.sccwrp.org.

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EXECUTIVE SUMMARY

Demersal fishes and megabenthic invertebrates inhabit the soft-bottom habitat and hence are widely distributed on the mainland shelf of the Southern California Bight (SCB). Populations of these sedentary fishes and invertebrates have been monitored extensively during the past three decades to assess impacts of treated wastewater discharge to the shelf. During this period, inputs of many anthropogenic contaminants (e.g., chlorinated hydrocarbons) to the SCB decreased significantly, and levels of these contaminants are presently low. Nevertheless, historical deposits of contaminants in the sediments may still affect populations of demersal organisms or organisms that feed on them. While demersal populations have been well studied in discharge areas, less is known about their condition throughout southern California. Earlier reference or regional studies were limited in scope or based on compilations of data from studies conducted independently in local areas.

The first synoptic regional survey of the demersal fauna of the mainland shelf of southern California was conducted in 1994. This study provided baseline information on the relative abundance of fish and invertebrate populations, distribution of their assemblages, and the extent of contamination in fish tissue. Although the study provided useful baseline information for the fauna of the mainland shelf, bays and islands were not sampled. In addition, while DDT and PCBs were widely distributed in flatfishes, the extent of area of fish with contaminant levels of concern was not determined due to lack of an appropriate threshold of concern and to the use of species with limited ranges in the SCB. In part to remedy these problems, a regional survey was conducted again in 1998. The objective of this study was to assess the status of fish and invertebrate populations and assemblages of the mainland shelf, islands, and bays, and to determine the extent of fish with contaminant levels of concern in the SCB.

Trawl samples were collected from 314 stations at depths of 2-202 m on the mainland shelf, islands, and bays from Point Conception, California to the United States-Mexico international border, from July to September 1998. The stations were selected from a stratified random sampling design. Fish and invertebrate populations were sampled by small (7.6-m headrope) semiballoon otter trawls towed for 10 min along isobaths. Fish and invertebrates were identified to species, counted, weighed by species to the nearest 0.1 kg, and examined for anomalies. Fish and sea cucumber lengths were measured to centimeter size classes. Sample collection and processing, and taxonomic identification of organisms, followed protocol delineated in a field manual designed for the study. Quality control checks were conducted before, during, and after the survey.

Data were analyzed for the SCB as a whole and for specific subpopulations. Regional subpopulations included three mainland regions (northern region — Point Conception to Point Dume; central region — Point Dume to Dana Point; southern region — Dana Point to the United States-Mexico international border) and three island regions (Northwest Channel Islands – San Miguel and Santa Rosa Islands; Southeast Channel Islands – Santa Cruz, Anacapa, and Santa Barbara Islands; and Santa Catalina Island). Shelf (depth) zone subpopulations included bays and harbors (2-30 m), inner shelf (5-30 m), middle shelf (31-120 m), and outer shelf (121-202 m). Anthropogenic influence areas in shelf zone areas included the following: 1) bays/harbors — ports, marinas, and other bays; 2) inner shelf — river mouths, small POTW areas, "other mainland" inner shelf, and island inner shelf; 3) middle shelf — large publicly owned treatment work (LPOTW) monitoring areas, small POTW areas, mainland non-POTW areas, and island middle shelf; and 4) outer shelf — mainland outer shelf, island outer shelf. Fish and invertebrate population data were summarized by subpopulation and for the SCB as a whole.

Fish and invertebrate assemblages were analyzed separately and as combined fish and invertebrates. Species assemblages were described by recurrent group analysis, cluster analysis, and cladistics analysis (fish and combined only). Site assemblages were described by cladistics analysis (combined only) and cluster analysis with square-root transformation of abundance data, Bray-Curtis dissimilarity index, and an agglomerative, hierarchical, flexible sorting method. The results of the cluster analysis were displayed in dendrograms and two-way tables; the results of cladistics analyses were presented as cladograms.

The fish contamination study focused on a guild (a group of ecologically similar species) rather than on individual species to attain broader areal coverage, and on predator-risk guidelines to define thresholds of concern. The guild used was the sanddab guild, a group of medium-mouthed flatfishes with generalized feeding habits, and which occurred in 96% of the samples in 1994. Whole-fish composites of Pacific sanddab (*Citharichthys sordidus*), longfin sanddab (*Citharichthys xanthostigma*), speckled sanddab (*Citharichthys stigmaeus*), slender sole (*Lyopsetta exilis*), and small (<20 cm) California halibut (*Paralichthys californicus*) were collected for chemical analysis. Chemical concentrations in fish tissue were compared against predator-risk guidelines for DDT, PCBs, and chlordane. Whole-fish composites of sanddab guild species were analyzed at 225 stations. Samples were composited by species in the field and frozen. Prior to chemical analysis, these samples were thawed and homogenized. Whole-fish homogenates were analyzed for 6 DDT and 2 chlordane isomers, and for PCB congeners (with focus on 12 potentially toxic congeners) using gas chromatography with either electron capture detection (GC-ECD) or mass selective detection (GC-MS). Data were summarized by subpopulation by each contaminant for the sanddab guild as a whole and for individual species. Percent of area and percent of guild above the predator risk thresholds for each contaminant were determined for the sanddab guild as a whole for the SCB and for subpopulations. Contaminant concentrations and sites above thresholds were mapped.

A fish biomarker study focused on fluorescent aromatic compounds (FACs) in the bile, (a measure of polynuclear aromatic hydrocarbon [PAH] exposure), and on DNA damage in fish blood (a measure of stress). Flatfishes were collected in bays/harbors and at the Channel Islands. The bile FACs study targeted California halibut in bays/harbors and Pacific sanddab at the islands. The DNA damage study targeted a variety of flatfish species at both locations. Concentrations of bile FACs were determined using reverse-phase, high-performance liquid chromatography and fluorescence detection. DNA damage, expressed as relative degree of strand breakage, was examined in DNA from fish blood cell nuclei.
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Of 442 attempted trawl stations, 314 (71%) were successfully sampled. Most of the 128 unsampled stations were abandoned due to the unsuitability of the seafloor for trawling. All fish and 99% of the invertebrates collected were counted. All fish and invertebrates were identified to the lowest possible taxon, with 99% of the fish and 79% of the invertebrates being identified to species. Approximately 99% of the fish counted were measured. Biomass was determined for all of the fish and 99% of the invertebrates. Measurement error was higher for biomass than for counts of individuals because biomass measurements were made on a moving boat. Anomalies audited in the field were correctly identified.

A total of 143 species of fish, representing 57 families and 4 classes, were collected in this survey. Sebastidae (rockfishes) were the most diverse family, with 24 species. Seventeen fish species occurred in 20% or more of the survey area. Two species (Pacific sanddab; California lizardfish, *Synodus lucioceps*) occurred in more than 50% of the survey area. Thirty-two species cumulatively comprised 95% of the fish abundance with four species (white croaker, *Genyonemus lineatus*; Pacific sanddab; California lizardfish; and queenfish, *Seriphus politus*) in combination accounting for 50% of the total abundance. Forty-four species cumulatively comprised 95% of the biomass, with five species (white croaker, Pacific sanddab, California halibut, longfin sanddab, and queenfish) in combination comprising 50% of the total biomass. Pacific sanddab was widespread (65% of the area), abundant, and high in biomass; in contrast, white croaker, queenfish, and California halibut were abundant and high in biomass but occurred in 17, 10, and 21% of the area, respectively (mostly in Los Angeles/Long Beach Harbor). Fish captured in this survey ranged in size from 3.5 cm to approximately 106.5 cm in length. Most of the fish were small, with most ranging from 4.5 to 18.5 cm in length. The modal size class (7.5 cm) of the fish comprised 12% of the catch.

Fish population attributes (abundance, biomass, species richness, and diversity) varied by region and depth. By subpopulation, median fish abundance was highest on the island outer shelf, biomass in "other bay," and species richness and diversity at the southeast Channel Islands. Lowest medians were found on the island inner shelf for all attributes. By shelf zone, the lowest values of fish abundance, biomass, and species richness were found on the inner shelf, while fish diversity was lowest in bays/harbors. However, the highest values of biomass were found in bays and harbors, and the highest values of attributes other than biomass were found on the middle and outer shelf zones. The percent of area of POTW areas with fish biomass higher than the non-POTW median was significantly higher in 1994 than in 1998.

The prevalence of fish anomalies and parasites was lower in 1998 (0.5%) than in 1994 (1.0%), and this prevalence was similar to background anomalies in the mid-Atlantic and Gulf coasts. In contrast, anomaly prevalence in 1969-1976 in the SCB was 5%. Fin erosion, an indicator of contaminated sediments, was not observed. Epidermal tumors occurred in 0.7% of Dover sole (*Microstomus pacificus*), the only fish with tumors. The prevalence of parasites in fish was 0.5%, with 77% of those parasitized being Pacific sanddab. Eye copepod (*Phrixocephalus cincinnatus*) was the primary parasite in this species.

A total of 313 species of megabenthic invertebrates representing 132 families, 21 classes, and 9 phyla were collected in the survey. Mollusks were the most diverse phylum, malacostracan crustaceans the most diverse class, and spider crabs (Majidae) the most diverse family. Fourteen species occurred at more than 20% of the stations on the mainland, with three (white sea urchin, *Lytechinus pictus*; California sand star, *Astropecten verrilli*; ridgeback rock shrimp, *Sicyonia ingentis*) occurring in 50% or more of the area. Twenty-four species cumulatively accounted for 95% of the total abundance, with white sea urchin accounting for 53% of the abundance. Thirty-six species cumulatively accounted for 95% of the total biomass, with four species (California sea cucumber, *Parastichopus californicus*; fragile sea urchin, *Allocentrotus fragilis*; California lamp shell, *Laqueus californianus*; ridgeback rock shrimp) combined accounting for more than 50% of the biomass.

Invertebrate population attributes (abundance, biomass, species richness, and diversity) varied by region and depth. By subpopulation, median invertebrate abundance, species richness, and diversity were highest at the southeast Channel Islands and biomass at Santa Catalina Island. Median invertebrate abundance and mean biomass were lowest at inner shelf small POTW areas; median species richness was lowest on the inner shelf in small POTW and other mainland areas; and diversity was lowest on the mainland outer shelf. By depth, the inner shelf zone had the lowest invertebrate abundance, biomass, and diversity, with values increasing with depth and in bays/harbors. The percent area of high invertebrate abundance and biomass was significantly higher at POTW areas in 1998 than in 1994, whereas 1994 was higher for diversity.

Assemblages were defined for fishes, invertebrates, and combined fish/invertebrates. Although a variety of methods were used, assemblages described by each were generally associated with specific depth zones. Most assemblages were found in one or more of the predetermined shelf depth zones. Distinct assemblages were identified for bays and harbors for fishes, invertebrates, and combined fish/invertebrates. San Diego Bay (a natural bay) had assemblages that were distinct from those of Los Angeles/ Long Beach Harbor (an artificially enclosed part of the inner shelf zone). Distinct invertebrate site assemblages were defined for the middle shelf/outer shelf zone of the island and mainland regions. Specific fish and invertebrate assemblages were generally not associated solely with POTW areas, although one invertebrate recurrent group occurred more frequently at POTW areas than elsewhere.

Fish, invertebrate, and combined fish/invertebrate biointegrity indices identified 85-97% of the southern California shelf area as having reference (healthy) assemblages. The few nonreference sites were clustered near river mouths (especially at the Santa Clara River), suggesting runoff effects.

Some effects of the 1997-1998 El Niño were apparent in fish and invertebrate populations and assemblages. Invertebrate populations showed an overall decrease in mean abundance, biomass, species richness, and diversity in 1998 relative to 1994 (a warm year) and 1957-1975 (a generally cooler period). The number of fish species found in 50% or more of the area decreased from six in 1994 to two in 1998. The areal occurrence of many fish foraging guilds decreased between 1994 and 1998; and many important community members expanded or shifted their distributions to deeper parts of the shelf. Two species of fish and three species of invertebrates collected in the 1998 survey had never been recorded off California prior to 1998; all normally occur from southern Baja California south.

Despite assemblage health, sanddab-guild fish with tDDT concentrations higher than the predator-risk guideline comprised 71% of the southern California shelf. Fish with PCB toxicity equivalent quotient (TEQ) concentrations higher than the mammal and bird predator-risk guidelines comprised 8 and 5% of the area, respectively. Although highest tDDT levels were found in fish from the Palos Verdes Shelf, 100% of the fish from the southeast Channel Islands were also above the predator-risk guideline, even though concentrations there were low relative to those near Los Angeles. The source of DDT is assumed to be historically deposited sediments. Although the degree of existing predator risk for DDT is not known, it is probably less than the risk of two or three decades earlier. Previous studies have shown that DDT concentrations in liver and muscle tissues of southern California fishes have decreased more than an order of magnitude during the past three decades. Port, large POTW, and “other bay” areas had the highest percent of area above the PCB TEQ guideline for mammals; whereas for birds, the percent of area above the guideline was highest for the POTW and southeast Channel Islands areas. These differences were due to variances in the relative toxicity of different PCB congeners to birds and mammals and the relative concentrations of these congeners. This first assessment of the extent of fish with contamination above predator-risk guidelines in southern California indicates that there is a large area of potential concern for tDDT and that additional study is needed to better understand the nature and degree of actual risk in local bird and mammal populations.

Biomarker analysis revealed sublethal effects in flatfishes in southern California bays and harbors. Bile FAC concentrations (an indicator of exposure to PAHs) were elevated in fish from all bays and harbors compared to Camp Pendleton, with statistically significant elevated levels found at Marina del Rey, Long Beach Harbor, and Alamitos Bay. Levels in Pacific sanddab at the Channel Islands corresponded to reference values found at Camp Pendleton in California halibut along the coast. DNA damage in California halibut blood was highest in Long Beach Harbor and lowest in King Harbor. Of seven species of flatfishes examined, speckled sanddab had the highest levels of DNA damage, and hornyhead turbot (*Pleuronichthys verticalis*) the lowest. Although overall, no significant relationship was found between bile FAC concentrations and DNA damage, the incidence of DNA damage increased with bile FAC concentrations in Ventura Harbor and Marina del Rey.

Anthropogenic debris (mostly plastic, metal, and cans) was found in 25% of the southern California shelf; it was most common in ports, marinas, and at Santa Catalina Island. The percent of area of natural debris was higher than anthropogenic debris in all subpopulations, but at Santa Catalina Island, both were nearly equal.

Overall, demersal fishes and invertebrate populations and assemblages in 1998 appeared to be relatively healthy, with anomalies at background levels. Biointegrity indices indicated that almost all of the area was reference, with nonreference areas being associated with river mouth areas. A few minor population attribute differences occurred at large POTW areas between 1994 and 1998. Fish and invertebrate assemblages were generally associated with shelf depth zones. Bay and harbor assemblages were distinct from coastal inner shelf assemblages, but assemblages in San Diego Bay differed from those in Los Angeles/Long Beach Harbor. Assemblages at islands were less distinct from mainland assemblages. Effects of the 1997-1998 El Niño included reduced average population attribute values in 1998 relative to earlier years, shifts in dominant species, changes in depth ranges among species, and the addition of new species to the area.

Although populations and assemblages appear to be relatively healthy, this first study of DDT levels in sanddab guild species relative to a predator-risk guideline found that 71% of the area was above the guideline. The source of DDT exposure is assumed to be historically deposited sediments. The degree of risk to predators is not known, but is thought to be much less than two to three decades earlier. Low levels of predator risk were found for PCBs. Biomarker analysis in flatfishes showed sublethal responses and DNA damage in some bay and inner shelf species. These studies indicate that contaminant effects in demersal fishes can still be identified, even though contaminant inputs have generally decreased dramatically during the past three decades.

TABLE OF CONTENTS

SECTION **PAGE**

SECTION	PAGE

SECTION	PAGE

SECTION	PAGE

SECTION	PAGE

SECTION	PAGE

SECTION	PAGE

SECTION	PAGE

LIST OF FIGURES

NUMBER **PAGE**

NUMBER		PAGE

NUMBER		PAGE

NUMBER		PAGE

NUMBER		PAGE

LIST OF TABLES

NUMBER **PAGE**

NUMBER		PAGE

NUMBER		PAGE

NUMBER **PAGE**

INTRODUCTION

Demersal fishes (species living on or near the seafloor) and megabenthic invertebrates (large species living on the seafloor) are widely distributed on the soft-bottom habitat of the southern California shelf. This fauna is diverse, consisting of more than 100 species of fish (Allen 1982, Allen *et al.* 1998) and several hundred species of invertebrates (Moore and Mearns 1978, Allen *et al.* 1998). Most of these species are relatively sedentary, and hence are potentially important indicators of human impacts on the soft-bottom habitat. Thus, populations of these organisms have been extensively monitored during the past 30 years to assess impacts resulting from wastewater discharge on the shelf.

Existing monitoring programs of populations of these organisms and of their contaminant burdens in the Southern California Bight (SCB) are focused near outfalls of large municipal wastewater dischargers, also known as publicly owned treatment works (POTWs). These programs have conducted surveys for many years, with results being reported annually by various agencies (e.g., CSDLAC 1990; CLAEMD 1994a,b; CSDMWWD 1995; CSDOC 1996). These monitoring programs are useful for assessing point-source impacts and historical trends near specific outfalls (Stull 1995, CSDOC 1996, Stull and Tang 1996). Although these programs have provided much information about the condition of demersal fishes and megabenthic invertebrates in local areas (e.g., Carlisle 1969a,b; SCCWRP 1973; Mearns *et al*. 1976; Allen 1977; Diehl 1992; Stull 1995; Stull and Tang 1996), less has been known about their spatial and temporal variability and condition throughout the SCB. Some past regional assessments were made based on a compilation of trawl data collected at different times and places and for varied purposes (Allen and Voglin 1976, Allen 1982, Thompson *et al*. 1993a). Others were based on regional surveys of limited scope (generally focused in reference areas) (Allen and Mearns 1977, Word *et al*. 1977, Thompson *et al*. 1987, Thompson *et al*. 1993b). As a result, it has been difficult to assess the Bight-wide extent of contamination in these organisms and the extent of anthropogenic alterations in their populations and assemblages. A baseline survey of the mainland shelf fauna of the SCB was needed to resolve this problem.

In 1994, 12 agencies concerned with addressing region-wide concerns about pollution effects in the SCB formed the Southern California Bight Pilot Project (SCBPP). This project conducted the first synoptic survey (Southern California Bight 1994 Regional Survey) of the demersal fish and megabenthic invertebrates, benthic infauna, toxicity, sediment contamination, and water column of the mainland shelf of southern California at depths of 10-200 m (SCBPP 1998). The demersal fish and megabenthic invertebrate study (Allen *et al.* 1998) described baseline variability in fish and invertebrate populations and assemblages along the mainland shelf, and assessed the extent of anthropogenic impact on these populations and assemblages. To assess the extent of anthropogenic impact, the study assessed the spatial extent and distribution of tissue contamination in flatfishes, the health of fish and invertebrate populations, variation in population attributes in POTW and non-POTW areas, alterations in assemblages, and indicators of impacted fish and invertebrate populations. It also described the extent of anthropogenic debris on the shelf. This study found that demersal fish and invertebrate populations and assemblages appeared to be relatively healthy, with notable improvements since the 1970s. These improvements included more than an order of magnitude decrease in DDT and PCB levels in flatfishes (Schiff and Allen 2000), a decrease in anomalies such as fin erosion (Allen *et al.* 2001b), and minor changes in the assemblages, probably due to warmer ocean conditions (Allen and Moore 1997a). Detectable levels of DDT and PCB were widespread in flatfish livers (Schiff and Allen 2000) and fish and invertebrate population attributes were higher near POTW areas (Allen and Moore 1996). Anthropogenic debris was not widespread but was found largely on the outer shelf and at POTW areas. It consisted primarily of fishing gear and beverage containers, suggesting marine vessel activity as a source (Moore and Allen 2000). Depth was the primary determinant of fish and invertebrate assemblages (Allen and Moore 1997a,b; Allen *et al.* 1999a,b).

Although the 1994 regional survey provided baseline information on population and assemblage variability and the health of the fish and invertebrate populations, it covered only the mainland shelf of southern California at depths of 10-200 m. The study was not conducted in bays and harbors (which clearly are sources of human activity) or around the islands off southern California. Thus, baseline information on fish and invertebrate populations and assemblages comparable to that of the mainland shelf was lacking for these habitats. The study determined neither the extent of fish with contamination levels of concern nor the extent of altered fish assemblages, due to a lack of appropriate analytical tools for these assessments. Given this, there was a need for additional studies to address these issues.

Because of the overall success of the Southern California Bight 1994 Pilot Project study areas (fish, benthos, toxicity, and sediment chemistry) in providing baseline information on the extent of human activities and on natural variability on the mainland shelf, a second study of similar design was conducted in 1998. This Southern California Bight 1998 Regional Survey (Bight'98) consisted of 62 organizations. It expanded the study area to include bays and harbors and several islands off southern California and included a shoreline microbiology survey, along with surveys of fish, benthos, toxicity, sediment chemistry, and water quality. The results of these surveys are presented in separate reports. Although five organizations participated in the fish survey in 1994, nine organizations participated in 1998.

The general objective of the 1998 study was the assessment of spatial variability and extent of human impact on demersal fish and megabenthic invertebrate populations on the mainland shelf, bays, and islands of the SCB. Specific objectives were the following:

1) To describe patterns in fish and invertebrate population attributes for the SCB, geographic regions (including islands), bathymetric zones (including bays and harbors), and point sources of contaminants (large and small POTW monitoring areas and river mouths);

2) To describe assemblages of demersal fishes and megabenthic invertebrates based on the expanded study area;

3) To assess the condition and extent of anthropogenic impact on fish and invertebrate populations and assemblages in the SCB based on the spatial extent and distribution of the following:

    a) Tissue contamination in flatfishes;

    b) Health of fish and invertebrate populations (anomalies and sublethal effects);

    c) Status of population attributes in potentially impacted and reference areas;

    d) Assemblage biointegrity and organization;

    e) Debris.

This report is organized into 13 major sections: 1) Introduction, 2) Materials and Methods, 3) Quality Assurance, 4) Demersal Fish Populations; 5) Megabenthic Invertebrate Populations; 6) Assemblages and Biointegrity, 7) Bioaccumulation, 8) Biomarkers and Sublethal Effects, 9) Debris, 10) Discussion, 11) Conclusions, 12) Recommendations, and 13) Literature Cited. The Introduction provides the background of the study, problem addressed, and study objectives. Materials and Methods describes field, laboratory, and analytical methods. Quality Assurance describes the logistical success of the survey and results of quality assurance protocol and quality control audits. The next six sections (Demersal Fish Populations through Debris) provide the results of the study. Each of these sections will internally include a short introduction, a description of 1998 survey results, and a discussion of these results (including a comparison to the 1994 survey, if appropriate). The first three of these sections provide baseline descriptions of populations and assemblages, and assessments of differences between potentially impacted (e.g., river mouths, POTW areas, ports) and reference areas. Demersal Fish Populations and Megabenthic Invertebrate Populations provide results for population attributes, species composition, population structure, and anomalies for fish and invertebrates. Assemblages and Biointegrity describes assemblages (recurrent groups, site and species clades, site and species clusters) for fishes, invertebrates, and combined fishes and invertebrates; describes the functional organization of fish communities; and assesses the assemblage biointegrity. The Bioaccumulation section assesses the extent and significance of fish contamination in the region while the Biomarkers and Sublethal Effects section assesses biochemical responses of fish to contamination in bays and island areas. The Debris section describes the extent of anthropogenic debris in the study area. The Discussion chapter, Conclusions, Recommendations, and Literature Cited follow these sections.

A glossary defining the terms used in this document and providing alphabetical lists of fish and invertebrate species collected in this study by common name and scientific name is found at the end of this document, following the Appendices.

MATERIALS AND METHODS

SAMPLING DESIGN

The trawl survey study area included bays and the shelf of the mainland and selected islands of the SCB (Figure 1). Sampling sites were selected using a stratified random design. Details of site selection are provided by Stevens (1997). Subpopulations were defined for region, shelf (depth)/habitat, and human influence categories. The following subpopulation categories were defined within this area:

- Regions — Northern mainland (Point Conception to Point Dume); central mainland (Point Dume to Dana Point); southern mainland (Dana Point to United States-Mexico international border); north west Channel Islands shelf (San Miguel Island, Santa Rosa Island, and western Santa Cruz Island); southeast Channel Islands shelf (eastern Santa Cruz Island, Anacapa Island, and Santa Barbara Is land); and Santa Catalina Island shelf.

- Shelf Zones/Habitats – Bays and harbors (5-30 m), inner shelf (5-30 m), middle shelf (31-120 m), and outer shelf (121-200 m).

- Human Influence – Large POTW, small POTW, non-POTW, and river mouth areas were identified along the coast and in ports, marinas, and other bay areas.

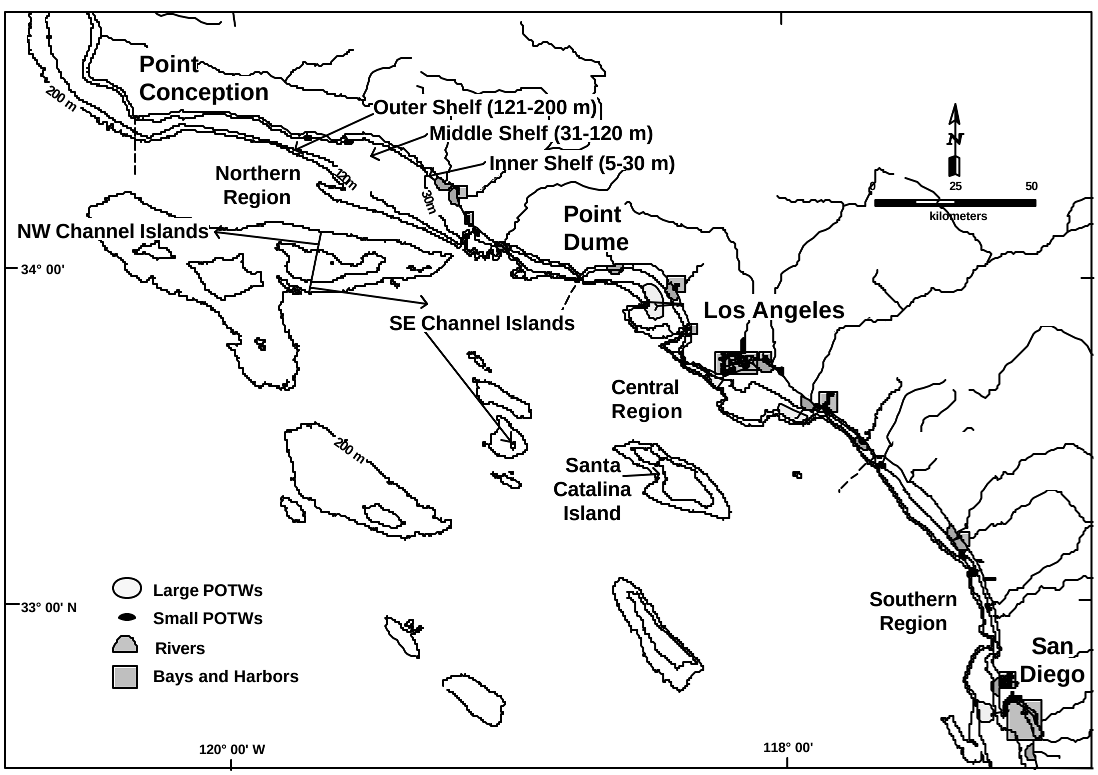


Figure 1. Distribution of subpopulations (regions, shelf depth zones, and human influence areas) used in the Southern California Bight 1998 Regional Survey, July-September 1998.

The northern, central, and southern mainland populations are the same in this study as in the 1994 SCBPP study (Allen *et al*. 1998), but three additional island regions have been added. The Channel Islands have been divided into two regions for faunal assessment of cold-water (Northwest Channel Islands) and warm-water islands (Southeast Channel Islands). Santa Catalina Island is also regarded in this study as a warm-water island.

Bays and harbors were added to the shelf zone/habitat subpopulations; this subpopulation overlaps in depth with the inner shelf zone of the coast. Inner, middle, and outer shelf zones are biogeographic life zone divisions of the continental shelf along the west coast of the United States and Canada (Allen and Smith 1998). The depth ranges of these shelf life zone divisions have been slightly modified from Allen (1982), Allen and Smith (1988), and Allen *et al*. (1998). Depth ranges of the inner, middle, and outer shelf zones, respectively, were 10-25 m, 26-100 m, and 101-200 m in 1994 but were 5-30 m, 31-120 m, and 121-200 m in 1998.

The large POTW areas delineate the monitoring areas around ocean outfalls of the four large POTWs (i.e., City of Los Angeles, Hyperion Treatment Plant; Sanitation Districts of Los Angeles County, Joint Water Pollution Control Plant; Orange County Sanitation District; and City of San Diego, Point Loma Wastewater Treatment Facility). The largest POTWs discharge at depths of 60 m near Los Angeles (Santa Monica Bay, Palos Verdes Shelf, San Pedro Bay) or 100 m off San Diego. The large POTW areas are smaller and more focused around the outfalls in 1998 than they were in 1994.

Small POTW and river mouth areas were defined as subpopulations in the 1998 trawl survey study but not in the 1994 study. Nine small POTW outfall areas were sampled: Goleta, Santa Barbara, Oxnard, Terminal Island, Aliso, South East Regional Reclamation Authority (SERRA), Oceanside, Encina, and San Elijo wastewater treatment facilities. The discharge depth of these outfalls was generally about 30 m. Nearshore areas at the mouths of 12 important rivers were also sampled. These rivers included Ventura River, Santa Clara River, Malibu Creek, Ballona Creek, Los Angeles River, San Gabriel River, Santa Ana River, Aliso Creek, Santa Margarita River, San Luis Rey River, San Diego River, and Tijuana River.

Bay and harbor areas were partitioned into ports, marinas, and other bay areas. Ports were areas with ship terminals and commercial, industrial, and/or military shipping activity. Marinas were areas with recreational boating activity and slips. Other bay areas were areas not used for shipping or recreational boating. Port areas occurred in Los Angeles-Long Beach Harbor and San Diego Bay, whereas marinas and other areas occurred in Channel Islands Harbor, Marina del Rey, Los Angeles/Long Beach Harbor, Newport Bay, Mission Bay, and San Diego Bay.

FIELD SAMPLING

Fish and Invertebrate Sample Collection and Processing

Collection of Data for Trawl Assemblage and Debris Studies

Fish and invertebrate samples for assemblage analysis were collected from 314 trawl stations from Point Conception, California, to the United States-Mexico international border, and around the Channel Islands, Santa Barbara Island, and Santa Catalina Island at depths of 2 to 202 m between July 13 and September 16, 1998 (Figure 2). Station coordinates, depths, and other characteristics are given in Appendix A1. The subpopulation classification of each station is provided in Appendix A2.

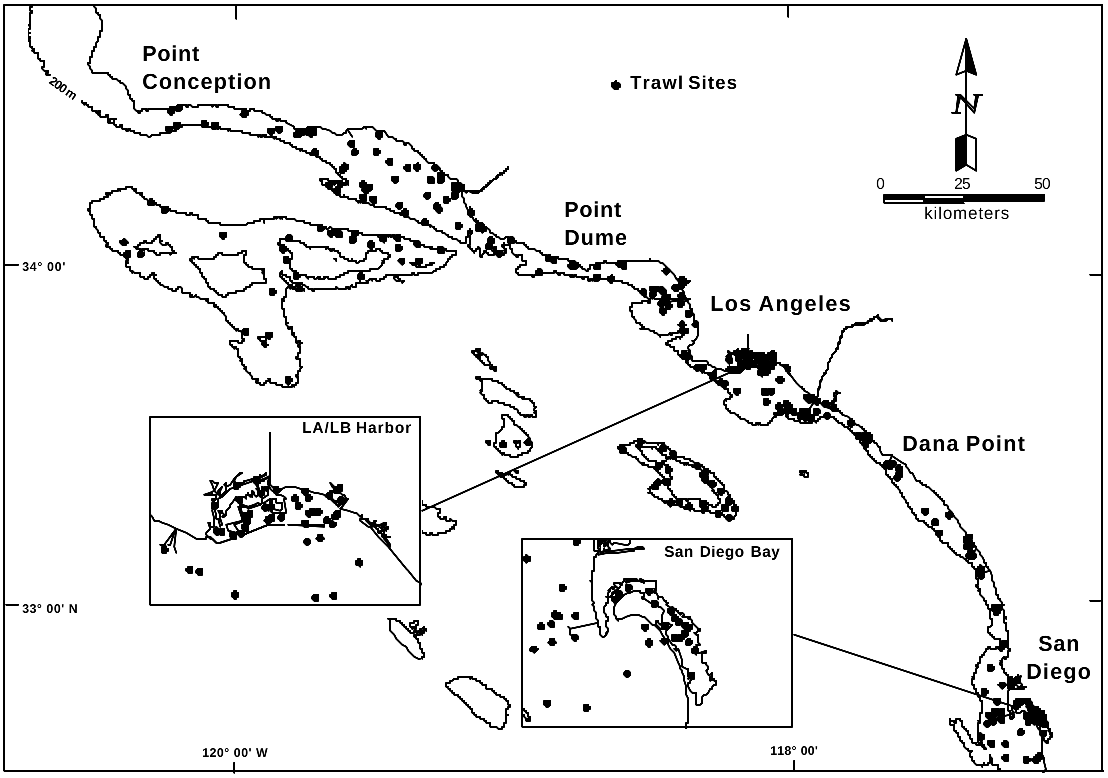


Figure 2. Population and assemblage study stations sampled by trawl on the southern California shelf at depths of 2-202 m in the Southern California Bight 1998 Regional Survey, July-September 1998. LA/LB = Los Angeles/ Long Beach.

Trawl samples were collected according to standard methods described in a field manual developed specifically for the survey (B'98, FSLC 1998). Stations were located using a differential global positioning system (DGPS). If a site could not be trawled or was too deep, stations could be moved up to 100 m from the nominal station site (but not to exceed 10% of the depth at that site). Samples were collected with 7.6-m head-rope semi balloon otter trawls with 1.25-cm cod-end mesh. Trawls were towed along isobaths for 10 min (5-10 min in bays and harbors) at 0.8-1.0 m/sec (1.5-2 kn), as determined by the DGPS. Based on a 1 m/sec trawling speed, these tows covered distances of 300 and 600 m for 5-min and 10-min trawls, respectively.

All fish and megabenthic invertebrates were processed. Megabenthic invertebrates were defined as epibenthic species with a minimum dimension of 1 cm; hence, this classification did not include pelagic, infaunal, or small species that are better sampled by other methods. Infaunal, pelagic, and colonial species, as well as unattached fish parasites (e.g., leeches and cymothoid isopods), were noted but not processed.

Fish and invertebrates were identified to species, individuals were counted, and species were weighed to the nearest 0.1 kg (using spring scales). Lengths of individual fish were measured to centimeter size class on measuring boards; total length (TL) was measured for cartilaginous fishes and board (or maximum) standard length (SL) was measured for bony fishes. Each organism was also examined for external anomalies. Targeted fish anomalies included fin erosion, tumors, external parasites, ambicoloration, albinism, diffuse pigmentation, skeletal deformities, and lesions. Targeted invertebrate anomalies included burnspot disease and external parasites.

In a special study included within the survey, sea cucumbers (*Parastichopus* spp.) from selected locations were also counted and measured to centimeter size class on measuring boards. Because the length of a sea cucumber varies with its morphological state (long and variable if flaccid, short and less variable if turgid), sea cucumbers were classified as turgid or flaccid before being measured to centimeter size class on measuring boards. When flaccid sea cucumbers became turgid after squeezing for 10-15 sec, they were recorded as turgid. Turgid and flaccid sea cucumbers were weighed separately to the nearest 0.1 kg using spring scales.

Debris collected in a trawl sample was classified into 12 type categories: rocks, terrestrial vegetation, marine vegetation, lumber, plastic, metal debris, cans, glass bottles, fishing gear, tires, benthic debris, and “other” anthropogenic debris. The amount of debris in each category was reported in abundance and weight classes. Abundance classes were the following: Present (1 item), low (2-10 items), moderate (11-100 items), and high (> 100 items). weight classes included trace (0.0-0.1 kg), low (0.2-1.0 kg), moderate (1.1-10.0 kg), and high (>10.0 kg).

Collection of Fish for Bioaccumulation Study

Fish samples for bioaccumulation analysis were collected at 225 stations (Figure 3, Appendix A1), a subset of the stations sampled for assemblage analysis. Primary target species for this study included seven species of the sanddab guild and secondary target species of the turbot guild (Table 1). The species composition of these guilds is slightly expanded from those described in Allen (1982).

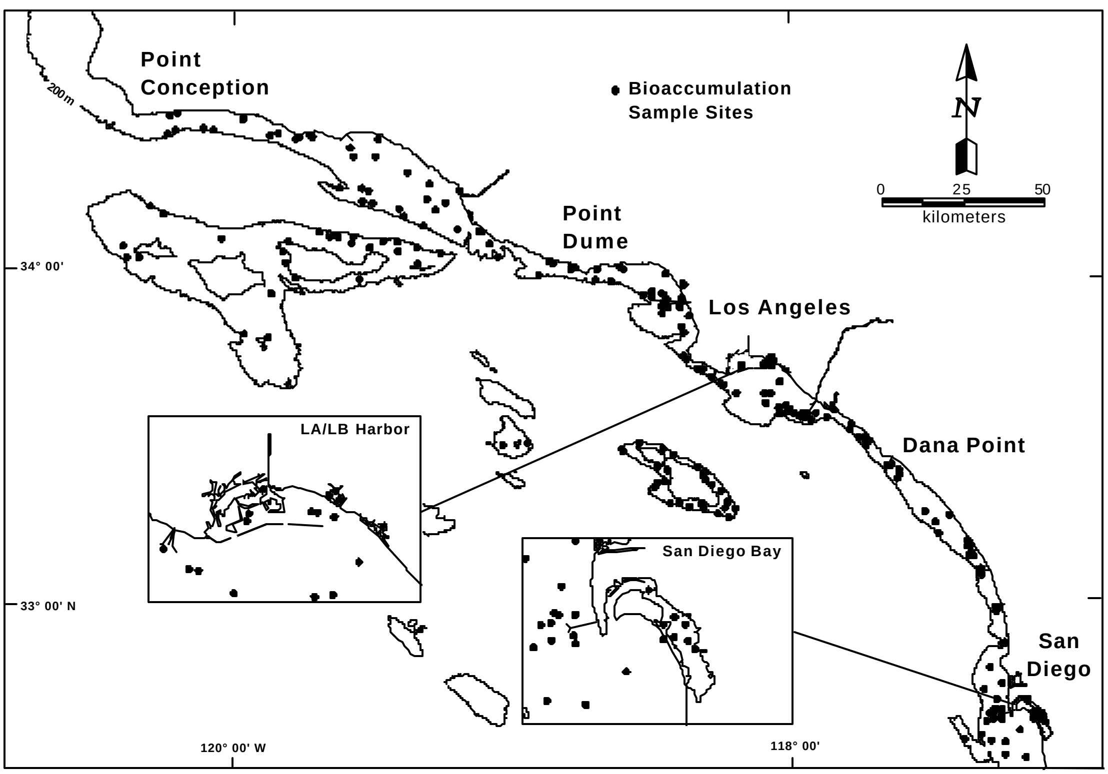


Figure 3. Bioaccumulation study stations sampled by trawl on the southern California shelf at depths of 2-202 m in the Southern California Bight 1998 Regional Survey, July-September 1998.

Table 1. Coastal shelf species targeted for bioaccumulation and biomarker studies in the Southern California Bight 1998 Regional Survey, July-September 1998.

		Standard Length Ranges (cm)			
		Age Class			
Common Name	Scientific Name	0	1	2	Other
Sanddab Guild Species[1]					
speckled sanddab	*Citharichthys stigmaeus*	5-7	8-10	11-16	--
longfin sanddab	*Citharichthys xanthostigma*	5-8	9-13	14-16	--
Pacific sanddab	*Citharichthys sordidus*	5-8	9-13	14-16	--
gulf sanddab	*Citharichthys fragilis*	5-7	8-10	11-14	--
slender sole	*Lyopsetta exilis*[3]	5-8	9-10	11-12	--
petrale sole	*Eopsetta jordani*	5-7	8-14	15-20	--
California halibut	*Paralichthys californicus*	5-9	10-20	NT	--
Turbot Guild Species[2]					
diamond turbot	*Pleuronichthys guttulatus*[3]	--	--	--	5-20
spotted turbot	*Pleuronichthys ritteri*	--	--	--	5-20
C-O sole	*Pleuronichthys coenosus*	--	--	--	5-20
hornyhead turbot	*Pleuronichthys verticalis*	--	--	--	5-20
curlfin sole	*Pleuronichthys decurrens*	--	--	--	5-20
Dover sole	*Microstomus pacificus*	--	--	--	5-20
English sole	*Parophrys vetulus*[3]	--	--	--	5-20
rock sole	*Lepidopsetta bilineata*[3]	--	--	--	5-20

[1] Sanddab guild species, slightly expanded from Allen (1982) and Allen *et al*. (2002). Age classes of primary sanddab guild species from Allen *et al*. (2002).
[2] Turbot guild species, slightly expanded from Allen (1982).
[3] Name updated from database and study plan. Name is based on Cooper and Chapleau (1998): *Lyopsetta exilis* = *Eopsetta exilis*; *Parophrys vetulus* = *Pleuronectes vetulus*; *Pleuronichthys guttulatus* = *Hypsopsetta guttulata*; *Lepidopsetta bilineata* = *Pleuronectes bilineatus*.
[4] Name modified from *vetula* to *vetulus* in Orr and Matarese (2001).

NT = Not targeted.

The five species in the sanddab guild of Allen (1982) were speckled sanddab (*Citharichthys stigmaeus*), longfin sanddab (*Citharichthys xanthostigma*), Pacific sanddab (*Citharichthys sordidus*), gulf sanddab (*Citharichthys fragilis*), and slender sole (*Lyopsetta* [= *Eopsetta*] *exilis*). In this study (Table 1), small (< 21 cm SL) California halibut (*Paralichthys californicus*) and petrale sole (*Eopsetta jordani*) have been added to this guild. The primary sanddab guild species (as well as small petrale sole) are benthic generalists and feed, at least partly, on the benthos. Small California halibut are the most likely ecological counterpart of sanddab species in bays, whereas the other flatfish species in southern California bays (i.e., diamond turbot, *Pleuronichthys guttulatus* [= *Hypsopsetta guttulata*] and spotted turbot, *Pleuronichthys ritteri*) feed on infaunal polychaetes and clam siphons. The sanddab guild species provide the best opportunity to assess Bight-wide distributions of contaminated fish. The primary members of this guild (speckled sanddab, longfin sanddab, Pacific sanddab, and slender sole) had similar uptake of DDT when any two species occurred at the same site (Allen *et al.* 2002).

The turbot guild of Allen (1982) included diamond turbot, spotted turbot, C-O sole (*Pleuronichthys coenosus*), curlfin sole (*Pleuronichthys decurrens*), hornyhead turbot (*Pleuronichthys verticalis*), and Dover sole (*Microstomus pacificus*). In this study (Table 1), rock sole (*Lepidopsetta bilineata* [= *Pleuronectes bilineatus*]) and English sole (*Parophrys* [=*Pleuronectes*] *vetulus*) have also been included in this guild. With the exception of the English sole, all of these species are benthic infaunal extractors that feed predominantly on tube-dwelling polychaetes and clam siphons. English sole, an infaunal excavator, was included because it is the only other polychaete-feeding flatfish in the study area.

The sanddab guild was chosen as a primary target because 1) component species show similar levels of contamination with similar levels of exposure to sediment contaminants (Allen *et al.* 2002), and 2) the guild occurred in 96% of the area of the southern California shelf and was generally abundant in 1994 (Allen *et al.* 1998). The turbot guild was selected as an alternate in the event insufficient sanddab guild samples were collected. The turbot guild occurred in 92% of the area of the shelf but is less abundant than the sanddab guild.

For sanddab guild species, a sample composite consisted of 6 fish of an age class (Table 1), whereas for turbot guild species, a sample composite consisted of 3-6 fish of 5-20 cm SL. At each station, composites were made for each age class of all sanddab guild species and, similarly, composites were made for all turbot guild species.

Sanddab guild species were most desirable, and a reasonable effort was made to collect these species first. If no target species were collected in the first trawl, sampling was considered to be complete, and field crews moved on to the next station. If target species were taken in the first trawl, additional trawls (two 10-min trawls or one 20-min trawl) were conducted to collect sufficient numbers of fish for composites. No more than 30 min of trawling was conducted at any station to collect composite fish.

At the end of trawling at a station, all complete composites were saved for sanddab guild and turbot guild species (i.e., any age of sanddab guild species with 6 individuals, as well as any turbot guild species with 3-6 individuals). This was done because the best combination of species and age classes for chemical analysis would not be known until the end of the survey. Composites of each target species were placed in separate Ziploc® bags and immediately frozen for transport to the processing facility on land.

Collection and Field Dissection of Fish for Biomarker Studies

Two biomarker studies were conducted during the 1998 survey, one examining levels of fluorescent aromatic compounds (FACS) in fish bile and one examining DNA damage in fish blood cells. Fish for these studies were collected from two strata: 1) bays and harbors, and 2) the Channel Islands. The bays/harbors stratum was selected because these areas have a history of sediment contamination, including polycyclic aromatic hydrocarbons (PAHs), metals, and pesticides (Fairey *et al.* 1996, Anderson *et al.* 1998, Phillips *et al.* 1998). The Channel Islands stratum was selected as a potential reference area. These islands are located away from large sources of pollution (e.g., point sources and heavy boat traffic).

The two studies overlapped greatly in stations sampled (Appendix A1). However, fish were collected from 48 unique stations for the bile FACs study and 50 unique stations (as well as additional stations outside of those planned for this study) for the DNA damage study (Figure 4, Appendix A1). Within the bays and harbors stratum, 78 stations were sampled at 10 locations: Ventura Harbor, Channel Islands Harbor, Marina del Rey, King Harbor, Los Angeles/Long Beach Harbor, Alamitos Bay, Newport Bay, Oceanside Harbor, Mission Bay, and San Diego Bay. Within the Channel Islands stratum, 76 stations were sampled in six substrata: Northwest Channel Islands inner, middle, and outer shelf zones, and the Southeast Channel Islands inner, middle, and outer shelf zones. Additional fishes and sediment were collected from a reference location off Camp Pendleton on August 23, 1999. This station is located approximately 5 km from the Santa Margarita River and 8 km from Oceanside Harbor, the nearest discrete sources of contamination.

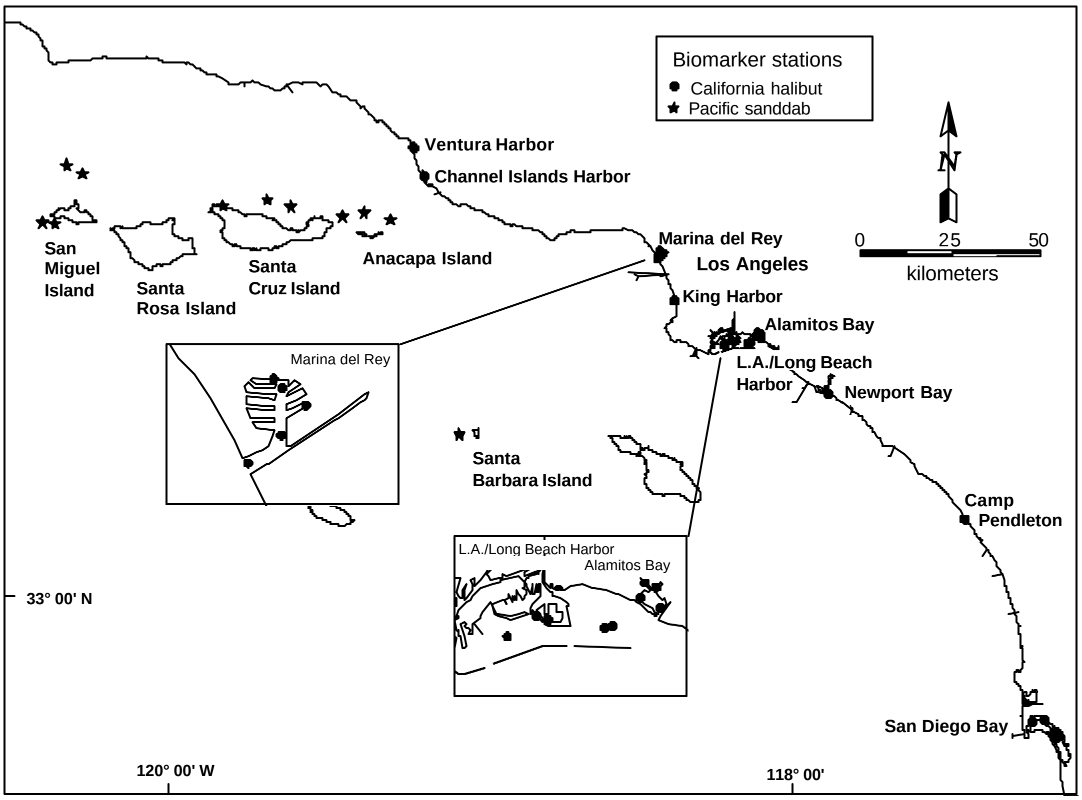


Figure 4. Fish biomarker stations sampled by trawl in bays and harbors and the Channel Island shelf in the Southern California Bight 1998 Regional Survey, July-September 1998. California halibut (*Paralichthys californicus*), Pacific sanddab (*Citharichthys sordidus*).

The fish targeted for both biomarker studies were the same species targeted in the bioaccumulation study. This included members of both the sanddab and turbot guilds (Table 1). Biomarker fish were obtained from the assemblage and bioaccumulation trawls.

Because DNA in fish blood cells degrades rapidly after a fish has died, fish dissections occurred on board by trained personnel soon after collection, and tissues were frozen immediately. Before dissection, information on fish species, length, sex, maturity, and condition was recorded. Dissections were conducted in an area of the boat that was most free of PAHs. Prior to each day's sampling, instruments were cleaned by a detergent scrub, followed by acid, methanol, and deionized water rinses (B'98, FSLC 1998).

For the bile FACs study, livers and gall bladders were dissected on boards covered with clean polyethylene sheeting, using scissors and forceps (B'98, FSLC 1998). Livers and gall bladders were removed as a unit, placed in aluminum foil, and frozen on dry ice or in liquid nitrogen. The tissues were stored in the laboratory at –80°C until they were analyzed. Dissection tools were cleaned by rinsing with deionized water between dissections. Polyethylene sheeting was replaced as needed.

For the DNA damage study, blood samples of fish (usually those dissected for bile FACs) were collected by cutting a gill arch. Blood samples were preserved by gently mixing and freezing a small volume (<100 uL) in 1 mL of ice-cold cryopreservation solution, phosphate buffered saline/10% DMSO. All samples were frozen in liquid nitrogen before being transferred and stored in a –70°C freezer. Samples were packed in dry ice and shipped to the CSC Biomarker Lab, San Diego, California where they were received frozen.

Benthic Sediment Samples

A separate sediment chemistry survey, conducted during the same time period as the trawl survey, assessed the extent of contaminated sediments. Sediment samples were collected and analyzed at 290 stations on the southern California mainland shelf at depths of 5-120 m. In addition, 50 samples were collected at this depth range on the island shelf off southern California but not analyzed. Another 71 samples were collected and analyzed off the mainland shelf off northern Baja California south to Ensenada. Of the sediment stations, 132 were the same as fish bioaccumulation stations, and hence provide information on grain size and sediment contamination at locations where trawl samples were collected (Appendix A3).

Sediment samples were collected using a 0.1 m^2 modified Van Veen grab (B'98, FSLC 1998). Sediment samples for sediment chemistry and grain-size analysis were collected from the top 2 cm of acceptable grab samples using a stainless steel, Teflon®-coated stainless steel, or plastic (polyethylene) scoop, taking care to avoid sediments in contact with the wall of the grab. From each grab sample, a single 100-g sample of sediment was collected for grain-size analysis and for total organic carbon (TOC) analysis; whereas two 200-g replicate samples were collected for trace metal analysis and trace organics analysis. Subsamples were placed in 4-oz (118-mL) borosilicate glass containers with Teflon®-lined lids. Sediment grain-size samples were not frozen, unlike the sediment chemistry samples, which could either be frozen on board or returned to the laboratory within 24 h for freezing. Toxicity and infaunal samples were collected from the remaining sediment in the grab; the results of the toxicity, benthic infauna, and sediment chemistry studies are described in other reports of the Southern California Bight 1998 Regional Survey.

LABORATORY METHODS

Bioaccumulation Analysis

Selection of Species and Tissue

The 1994 regional survey (Allen *et al*. 1998) was not able to answer the question, "What is the extent of fish on the southern California shelf with contamination levels of concern?" because 1) no species occurred across the entire depth range, and 2) there was no established health-risk threshold for levels of contaminants in the liver. In this survey, our goal was to focus on a guild of species that allows complete coverage of the study area and to choose a tissue with an established health-risk threshold for identifying contamination levels of concern.

The bioaccumulation study focused on the sanddab guild for chemical analysis, and did not analyze any of the turbot guild species that were collected. Five species of flatfish of the somewhat expanded guild of Allen (1982) were selected for chemical analysis: small California halibut, speckled sanddab, longfin sanddab, Pacific sanddab, and slender sole. Gulf sanddab and small petrale sole did not occur frequently in this survey.

More composites of sanddab guild species were collected than were analyzed for contaminants. Selection of species for analysis emphasized the most frequent age classes and the most frequent species to increase the comparability of the samples.

Whole fish samples were chosen for analysis to allow comparison of contaminant levels to predator-risk thresholds. Muscle tissue would be appropriate for human-health studies but not for predator-risk studies, as predators do not fillet their prey. We chose predator-risk guidelines developed by the National Academy of Science (NAS 1974) and Environment Canada (1997, 1998) for this study.

Target Analytes

Chlorinated hydrocarbons were measured due to their inherent bioaccumulation potential (Gossett *et al*. 1982), historical importance in the SCB, and role in human and environmental health concerns. The DDT and polychlorinated biphenyls (PCBs) were the only chlorinated hydrocarbons found in flatfishes on the mainland shelf of southern California in 1994, and both were found in virtually all fish examined (Allen *et al*. 1998, Schiff and Allen 2000). Because of this, DDT and PCBs were chosen for analysis in this study. Chlordane was also chosen because it was a pesticide of concern in bay and harbor areas.

Whole fish samples were analyzed for 2 isomers of chlordane, 2 isomers of DDT and their 4 common metabolites, and 41 PCB congeners (Table 2). Congener-specific analysis was performed because the transport, persistence, bioavailability, and toxicity varies substantially among different PCB congeners. Moreover, congener-specific data are more meaningful for use in biological impact assessments. The list of 41 PCB target analytes was developed based upon their presence in four common Aroclor mixtures (i.e., 1242, 1248, 1254, 1260); their occurrence in environmental samples; and their potential toxicity as identified by McFarland and Clarke (1989).

Processing of Whole Fish Samples

Frozen composites were thawed. Each fish was measured to centimeter size class (SL), weighed individually to the nearest gram, rinsed in deionized water to remove visible particles, and shake-dried. Individual fish weights were summed to give a composite weight. Composite samples were homogenized in a blender, with 0.5 or 1.0 L stainless steel or glass containers with silicone or BUNA rubber gaskets with Teflon® (or aluminum foil-lined) lids. The composite fish and an equal weight of deionized water (to facilitate blending) were combined and blended for 2-5 min to obtain a smooth homogenate. Two equal-sized aliquots of homogenate were used to fill two wide-mouthed glass jars with Teflon®-lined lids (and external labels) to three-fourths full or less; the remainder of the sample was discarded. Blenders were washed with nonionic soap and water, rinsed several times with deionized water, dried, and then rinsed with an appropriate solvent (e.g., methanol, ethanol, acetone) and dried. Samples were kept at -20°C (± 2°C) for up to six months.

Table 2. Chlorinated hydrocarbons analyzed in fish bioaccumulation study of the Southern California Bight 1998 Regional Survey, July-September 1998.

Pesticides	Polychlorinated Biphenyl (PCB) Congeners		
DDT and Metabolites	Predator-risk Congeners	Other PCB Congeners	
p,p’-DDT	PCB-77	PCB-18	PCB-138
p,p’-DDD	PCB-81	PCB-28	PCB-149
p,p’-DDE	PCB-105	PCB-37	PCB-151
o,p’-DDT	PCB-114	PCB-44	PCB-153
o,p’-DDD	PCB-118	PCB-49	PCB-158
o,p’-DDE	PCB-123	PCB-52	PCB-168
	PCB-126	PCB-66	PCB-170
Chlordanes	PCB-156	PCB-70	PCB-177
	PCB-157	PCB-74	PCB-180
Chlordane-a	PCB-167	PCB-87	PCB-183
Chlordane-g	PCB-169	PCB-99	PCB-187
	PCB-189	PCB-101	PCB-194
		PCB-110	PCB-201
		PCB-119	PCB-206
		PCB-128	

Chemical Analysis

Prior to analysis, sample aliquots were thawed and thoroughly mixed to ensure a uniform homogenate and then subsequently solvent extracted. Extraction methods included soxhlet extraction, accelerated solvent extraction (ASE), microwave-assisted solvent extraction (MASE), and homogenization solvent extraction. The extracts were subjected to appropriate clean-up procedures and analyzed by gas chromatography with either electron capture detection (GC-ECD) or mass selective detection (GC-MS). Following analysis, the measured concentration was doubled to correct for the equal weight of water added to the sample during homogenization.

Bile Fluorescent Aromatic Compounds Analysis

Fish bile was collected by piercing the side of the gall bladder and allowing the contents to flow into a small test tube. The bile was diluted 1:1 with 50% MeOH, then centrifuged to remove debris that would interfere with the analysis. When there was insufficient material from individual fish, bile from all fish at a given station was combined for composite analysis.

Concentrations of FACs were determined following the methods of Krahn *et al.* (1986) as modified by the Northwest Fisheries Science Center (NWFSC), using reverse-phase high performance liquid chromatography (HPLC) and fluorescence detection. A 10 x 3 mm ID guard column containing 10 µm particle C_{18} material was used in series with a 250 x 3 mm ID, 10 µm particle C_{18} column. The guard column and analytical columns were housed in a column heater that was maintained at 50°C. Five µL of the diluted bile supernatant was injected onto the HPLC. Bile proteins and other bile components that could potentially interfere with PAH quantification are water soluble, and were passed through the nonpolar reverse-phase column with a 5 ppm acetic acid solution mobile phase, while the hydrophobic PAHs and metabolites were adsorbed onto the column. The PAH metabolites were then eluted from the column using methanol, and measured using fluorescence detection.

Fluorescence of the PAH metabolites was measured at the excitation/emission wavelength pair (380/430 nm) appropriate for PAHs with similar structure as benzo [a]pyrene (BaP) and its metabolites. The higher molecular weight PAHs (products of combustion) and their metabolites tend to fluoresce at the same wavelength, and are semiquantitated collectively as BaP equivalents. Fluorescent values were converted to ng BaP equivalents using a seven-point BaP standard curve.

DNA Damage Analysis

DNA damage analysis samples were prepared by thawing cryopreserved samples on ice. Then 15 or 30 µL of blood was added to 140 µL ice cold phosphate-buffered saline solution (PBS) in a clean 1.5 mL centrifuge tube; and the remaining sample was re-frozen. Cells were pelleted at 600 x g for 2 min, the supernatant was discarded, and the pellet was resuspended in 150 or 300 µL 0.65% low-melting-temperature agarose (FisherBiotech; low–melting, DNA-grade agarose) in PBS at 30°C (PBS/LMA). Then 25 µL of the resuspended cells were transferred onto GelBond slides in duplicate and the cell/agarose suspension was allowed to solidify on an ice-chilled stainless steel tray, and covered with a top-coat of 25 µL PBS/LMA. After solidifying, the slides were placed in 4°C lysing solution (LS), 2.5 M NaCl, 10 mM Tris, 0.1 M EDTA, 1% Triton X-100, and 10% DMSO, pH 10.0 in polycarbonate trays and incubated at 4°C for at least 1 hr.

Slides were then transferred from LS to trays filled with distilled water. The water was replaced with fresh 3 times over a 10 min period. The slides were then placed in a submarine gel electrophoresis chamber filled with 300 mM NaOH and 1 mM EDTA. The DNA was denatured under alkaline conditions for 15 min. After unwinding, electrophoresis was performed at 300 mA, 25 V for 10 min. The slides were then neutralized with three 2-min rinses in 0.4 M Tris. They were then removed, excess solution blotted away, and placed in ice cold ethanol for 5 min. The ethanol-fixed slides were dried in an oven at 37°C for 20 min and transferred to slide boxes.

For the analysis, the DNA was stained with 15 µL of a 20 µg/mL solution of ethidium bromide in distilled water (EtBr) and covered with a coverslip. Stained slides were analyzed by viewing at 200 times with an epifluorescent microscope (excitation filter 510-560 nm green light, barrier filter 590 nm), attached CCD camera, and image analysis software (Komet image analysis system, Kinetic Imaging, Ltd U.K.). The diameter of the fluorescent "head" or nucleus and the length (µm) of any accompanying trailing DNA "tails" resulting from strand breakage were measured for each nucleus analyzed. Measurements were made in five sectors on each slide, counting 5-10 nuclei in each sector, randomly positioning the lens above each sector, and counting left to right from the upper left-hand corner of the field of view. Overlapping nuclei or tails were not counted. The image system calculates a large number of quantitative parameters for each nuclei, the most important being the total intensity of each comet (comet optical intensity), the percent DNA in the tail, and the tail moment (TM), which is the product of the percent DNA in the tail times the tail length divided by 100.

Two distinct types of nuclei were found in flatfish blood: small, highly damaged nuclei and large nuclei with low levels of damage. Populations of similar nuclear types that represented nucleated red blood cells (RBCs) and white blood cells (WBCs) have been observed in other organisms (e.g., herons) examined by this laboratory. The nuclear types could be distinguished by the very pronounced difference in the overall intensity of the white cells in the fish. The eye could easily distinguish fish white and red cell nuclei. The WBCs generally have a nuclear diameter greater than 7 um and an intensity greater than 100; RBCs are below these values.

Three different scoring strategies were used for scoring the comet slides; 1) random analysis of 50 cells regardless of type (overall); 2) white blood cells (WBCs, comets with an optical intensity >100), scored 50 white cells; and 3) red blood cells (RBCs, comets with an optical intensity <100), scored 50 red cells. A mean tail moment value was calculated for each fish sampled.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PROCEDURES

Trawl Assemblage Survey

Field Protocol

Special quality assurance/quality control (QA/QC) procedures were developed for the study (B'98, SC 1998), modeled after SCBPP (1994b), because eight organizations were involved in the field survey. Field equipment and sampling protocol were described in a field operations manual (B'98, FSLC 1998), which was developed by representatives of the participating agencies. Field crews were required to adhere to the specified standards and protocols for sampling methods, taxonomic identification, and QA/QC audits.

A team of 18 individuals from 13 agencies modified an existing field methods manual (SCBPP 1994a) to produce a new field methods manual (B'98, FSLC 1998) to address new scientific questions. This field operations manual was distributed to all participating organizations during a protocol meeting with chief scientists and boat captains. Chief scientists were responsible for training all participating field personnel in the prescribed sampling methods for the regional survey.

Presurvey audits were conducted on four new participating agencies to ascertain their field sampling capabilities. The goal was to assess trawl methodologies and taxonomic competence for the regional survey. Presurvey audits consisted of checking equipment and sampling procedures utilized by each agency to determine consistency and needs among the agencies, and making adjustments as needed prior to conducting the survey. Any discrepancies were corrected prior to the survey start date.

To ensure compliance with sampling procedures and data quality, preassigned field QA/QC auditors performed in-survey audits on all participating vessels in the trawl program. Auditors used checklists for equipment, trawling methods, and sample processing to assess compliance to field manual requirements. All auditors were taxonomic specialists assessing identification techniques for field personnel.

Postsurvey field QA/QC involved checking station location data relative to survey design strata. The regional survey used stratified random survey design to select sites from a geographical information system (GIS) computer. Site locations were as accurate as the underlying maps on the computer. To verify that the actual sampling sites were still within their proper design strata, postsurvey station occupation data were overlaid onto the stratification maps. Other data checks included sampling depth, distance from nominal site, trawl distance, and duration.

Taxonomic Identification

Uniform animal identification was vital for the biological assessment, which involved eight agencies. All fish and most invertebrates were to be identified to species, using taxonomic keys and field guides as needed (see B'98, FSLC 1998). Standard common or scientific names (Robins *et al.* 1991) were used for fish but scientific names alone were used for invertebrates. Because most fish and invertebrates were to be identified to species in the field, it was important that field identifications be done correctly. The importance of integrity and bringing questionable species back to the laboratory for final identification was emphasized.

Prior to the survey, lists of recommended taxonomic identification aids and trawl-caught species for southern California were distributed to participating agencies. Two presurvey information transfer meetings (one as a lecture and one in the field) were held for identifying common and easily confused species. All organizations participated in a presurvey intercalibration exercise that identified preserved species from a bucket (30 fish species and 30 invertebrate species). Organizations that had more than 5% misidentifications were required to repeat the exercise.

During the surveys, taxonomic QA/QC auditors conducted random checks with each participating organization to assess the accuracy of fish and invertebrate identification. Voucher specimens for each species, difficult-to-identify species, and each species/anomaly combination were collected by each agency. These specimens were fixed in a 10% buffered formalin-seawater solution, and returned to the laboratory for confirmation. Larger specimens were photographed and released.

Postsurvey field taxonomy checks were accomplished through submitted voucher specimens. Each agency submitted properly preserved species identified in the field, in addition to difficult-to-identify species and species/anomaly combinations. Each organization submitted a voucher specimen for each species it collected to predetermined taxonomic specialists. When voucher identification checks were completed, any errors found were corrected on the original data sheets (by crossing out the original name and adding the correct name) and database.

Data

Field data were checked and entered into a computer database by agency personnel. All computer data were checked against the original field data. After approval by the agencies and trawl QA/QC officer, the data were made available electronically to all agencies participating in the survey.

Chemistry

Whole fish samples were analyzed through the collaborative efforts of five participating laboratories. The QA/QC requirements for this study are performance based. The particular analytical methods used for the analysis were left to the discretion of the individual laboratory with the requirement that each demonstrate acceptable analyte recoveries and detection limits, and meet the general data quality objectives (DQOs) specified in the 1998 Regional Marine Monitoring Survey Quality Assurance Plan (B'98, SC 1998). All laboratories were required to evaluate and monitor their analytical performance through the use of method blanks, certified reference materials (CRMs), matrix spikes, and sample duplicate analyses.

Method blanks were used to assess any laboratory contamination introduced during all stages of the sample preparation and analysis. Certified reference materials were used to assess the accuracy of the analytical results. The recommended CRM for the fish tissue analysis was the CARP-1, available from the Research Council of Canada. The CARP-1 CRM is a ground whole common carp (*Cyprinus carpio*) sample with certified values for 14 PCB congeners. In addition, an inter-laboratory calibration study was performed to derive consensus values for DDT and it metabolites. Each laboratory was required to obtain comparable results in relation to both the certified values and the consensus values. Matrix spike samples were used to evaluate recoveries and analytical performance for low concentrations of target analytes. A sample of orange roughy (*Hoplostethus atlanticus*) was spiked with target analytes at concentrations near the reporting limit and subjected to the entire analytical procedure to determine the accuracy of the results for analytes in the lower region of the calibration range. Note that in contrast to CRMs, blanks, and duplicates, there was no specific frequency or data quality objective stated for matrix spikes. Finally, duplicate analyses were performed on approximately 5% of the samples (i.e., one per batch) in order to estimate the precision of the analytical results.

Bile Fluorescent Aromatic Compounds

Quality assurance objectives for the bile FACs study were established for field sampling, sample storage, and analysis. For field sampling, the objective was to collect at least five fish of the same species from each location. Power analysis with limited FAC data for fish from wastewater discharge areas indicated the optimal number of fish at each station was five (a = 0.05, ß = 0.80).

Laboratory quality assurance procedures conducted prior to sample analysis included measurement of a 50% MeOH blank, BaP calibration standard replicates, and a California halibut bile reference sample. The fluorescence response of the 50% MeOH blank was used to subtract the background noise of the calibration standards, the bile composite, and all samples. If the fluorescence response exceeded the usual background noise, corrective maintenance was performed.

The BaP calibration standard was analyzed three times prior to sample analysis to assess instrument stability. The performance of the HPLC was considered stable if the relative standard deviation of the standard replicates was within 10%. The calibration standard was also measured after every 7 samples.

A bile reference sample containing an elevated FAC concentration was analyzed to assess accuracy and precision of the measurements. If the FAC value for the reference sample exceeded two standard deviations of the expected value, corrective maintenance was performed.

A seven-point calibration curve was used that encompassed the expected range of sample concentrations. If the fluorescence response of the samples exceeded the calibration curve, the sample was diluted and reanalyzed.

DNA Damage Quality Assurance

Accuracy and precision of the measurements was assessed by conducting replicate measurements of known reference samples of bird blood, consisting of bird white blood cells with little damage as negative (no damage) controls, and bird red blood cells with extensive DNA strand damage as positive controls. Control slides were processed alongside fish blood samples. The acceptable mean damage levels of the control slides had to fall within the 95% confidence limits previously determined for the reference samples. Any reference values outside of the expected limits would require a review of the procedures used for that batch and repeat analysis of that batch of samples. Slides with cell densities too high to perform image analysis were diluted and rerun.

DATA ANALYSES

Description of Populations

Data Adjustments

In the 1994 regional survey (Allen *et al.* 1998), all stations were trawled for 10 min. However, the 1998 regional survey also had stations in bays and harbors, where it was difficult to trawl for 10 min. In these areas, trawls were towed for 5 min rather than 10 min. To compare the 5-min and 10-min trawl data, we considered two options: 1) adjust catch information to catch per minute and then adjust catch by minutes of trawling, or 2) standardize the catch to a 10-min trawl and double the 5-min trawl catch. We considered the following two points in making our decision: 1) the time that the net is actually on the bottom during a trawl is uncertain (Diener and Rimer 1993), and 2) the distribution of the fish and invertebrates in the trawl path varies by species, ranging from random to clumped. Thus, a per-minute adjustment of catch did not seem warranted, although it was clear that a 10-min trawl had a higher catch than a 5-min trawl. Trawls with durations of 4-6 min were lumped into a "5-min trawl" category and those of 9-12 min into a "10-min trawl" category. As the shorter trawls were in bays, we compared duplicate 5-min trawls at stations in Marina del Rey, California, to assess differences in catch (Appendix A4). In this analysis, the catch of the first 5-min trawl at a site was compared to the combined catch of both 5-min trawls. Fish and invertebrate abundance in 10-min trawls was about twice the abundance in 5-min trawls. The numbers of fish and invertebrate species were about 1.4 for fish and 1.8 for invertebrates. It was assumed that biomass would behave similarly to abundance. Based on this, we adjusted fish and invertebrate abundance and biomass values of 5-min trawls to 10-min trawl values by doubling the 5-min trawl values. We adjusted numbers of fish and invertebrate species between 5-min and 10-min trawls by multiplying species by 1.4. This latter adjustment was used for calculating subpopulation mean values. However, to determine the total species in a subpopulation, we used actual species (or taxa) rather than "virtual" species. This approach was also used to perform the diversity index calculations.

Population Attributes

The population attributes examined included abundance, biomass, number of species, and Shannon-Wiener diversity (Shannon and Weaver 1949), all expressed per haul. The Shannon-Wiener diversity index (H') is calculated by the following equation:

$$H' = -\sum_{j=1}^{S} \frac{n_j}{N} \ln \frac{n_j}{N}$$ **Equation 1**

where

n_j	=	Number of individuals of the species j in sample.
S	=	Total number of species in sample.
N	=	Total number of individuals in sample.

Population Summary Statistics

Trawl data were expressed as values per standard trawl haul (i.e., "per haul"). In this survey, the area sampled in this trawl haul was approximately 3,014 m^2. Because a stratified random survey design was used, different weighting factors were assigned to stations in some subpopulations (Appendix A2). These weighting factors were used in percent of area calculations (including medians) and in adjustment of mean values, standard deviations, and confidence limits. If it is stated that *x* percent of the area had a particular attribute value, this should be interpreted as meaning that the value is likely to occur in a standard trawl haul from *x* percent of the area.

Population data were analyzed in two ways: 1) calculation of medians, means, and 95% confidence intervals for population attributes in the SCB and in various subpopulations, and 2) assessment of the percent of area within each subpopulation above the SCB median.

Mean parameter values were calculated using a ratio estimator (Thompson 1992):

$$m = \frac{\sum_{i=1}^{n} (p_i * w_i)}{\sum_{i=1}^{n} w_i} \qquad \textbf{Equation 2}$$

where

m	=	Mean parameter value for population *j*.
p_i	=	Parameter value at station *i*.
w_i	=	Weighting factor for station *i,* equal to the inverse of the inclusion probability for the site.
n	=	Number of stations sampled in population *j*.

Weighting factors for each station are provided in Appendix A2. The ratio estimator was used in lieu of a stratified mean because an unknown fraction of each stratum could not be sampled (e.g., hard bottom). Thus, the estimated area was used as a divisor in place of the unknown true area. The standard deviation of the mean response was calculated as follows:

$$\text{Standard Deviation} = \sqrt{\frac{\sum_{i=1}^{n} (p_i - m)^2 * w_i}{\sum_{i=1}^{n} w_i}} \qquad \textbf{Equation 3}$$

The standard error of the mean response was calculated as follows:

$$\text{Standard Error} = \sqrt{\frac{\sum_{i=1}^{n} ((p_i - m) * w_i)^2}{\left(\sum_{i=1}^{n} w_i\right)^2}} \qquad \textbf{Equation 4}$$

The 95% confidence intervals were calculated as 1.96 times the standard error. The ratio estimator for the standard error approximates joint inclusion probabilities among samples and assumes a negligible spatial covariance, an assumption that appears warranted. However, the assumption is conservative because its violation would lead to overestimation of the confidence interval (Stevens and Kincaid 1997).

Percent of Area and Medians

As with the 1994 survey, the 1998 survey was specifically designed to address questions regarding the spatial distribution of the data. These issues included the determination of cumulative frequency distributions (CDFs) (Stevens and Olsen 1991). The CDFs provide graphical information on the percent of the survey area that lies below a given indicator value. A population attribute (e.g., abundance) value from a station has an associated weighting factor (Appendix A2). To calculate a CDF, indicator values were ranked from low to high. The weighting factors for stations with a given indicator value were then accumulated, giving a cumulative sum of weight at each ranked indicator value. Then each cumulative sum of weight was divided by the total area weight to give a cumulative frequency distribution (with proportions adding up to 1.0)**.** Medians can be determined from CDFs and compared among subpopulations and to those of the SCB as a whole. The median was the value of an attribute at which 50% of the area of a subpopulation lies above or below. This median thus differs from observation medians, defined as the value at which 50% of the observations lie above or below. Confidence limits of medians for population attribute data were determined by calculating 95% confidence limits of means on log-transformed data and back-transforming.

Comparisons Between 1994 and 1998 Results

Comparisons of population attribute values and percent of area between the 1994 survey (Allen *et al*. 1998) and the 1998 survey could only be made for the mainland shelf, as islands and bays/harbors were not sampled in 1994. To further complicate the comparison, some mainland subpopulation boundaries differed in 1998 from those used in 1994. In particular, large POTW areas were much larger in 1994 than in 1998, when they encompassed sites much nearer the discharge sites. In addition, there were slight modifications in depth zone subpopulation boundaries. The boundary of the inner shelf/middle shelf zone was at 25 m in 1994 and 30 m in 1998, and the middle shelf/outer shelf boundary was at 100 m in 1994 and 120 m in 1998. Thus, to make comparisons between the two periods (and in particular for POTW subpopulations), the 1994 data were reclassified to 1998 subpopulation boundaries. Original 1994 area weights were maintained for 1994 stations used in the 1998 comparison. Hence, 1994 stations falling within the 1998 POTW subpopulation boundaries were compared to 1998 POTW stations. Medians were calculated for middle shelf non-POTW subpopulations (regarded as reference areas) in 1994 and 1998. The POTW results were compared to the median of the appropriate year to give percent of area of attributes of POTW areas above the non-POTW medians.

Assemblage Analysis

Recurrent Group Analysis

Recurrent groups were determined independently for fish and invertebrates by first calculating the index of affinity of Fager (1963) and Fager and McGowan (1963) for all specie pairs. The index is based on the occurrence of each specie and co-occurrence of the two species being compared, and is defined by the following equation:

$$I.A. = \frac{c}{\sqrt{ab}} - \frac{1}{2\sqrt{b}}$$ **Equation 5**

where

I.A.	=	Index of affinity.
a	=	Number of samples in which Species A occurred.
b	=	Number of samples in which Species B occurred.
c	=	Number of joint occurrences of Species A and B.

In this equation, *b* is always greater than or equal to *a*. The first term is the ratio of joint occurrences of both species to the geometric mean of their individual occurrences. The second term is a correction factor to give weight to values of the first term based upon high occurrences of the more frequently occurring species.

The index was calculated for all pairs of species. Pairs of species with a predetermined level of affinity (e.g., I.A. = 0.50) were grouped following rules described in Fager (1957). A recurrent group was required to satisfy the following criteria: 1) All species in a group must have positive affinities with all other members of the group; 2) the group must contain the largest possible number of species; 3) if several possible groups containing the same number of species can be formed, those that contain the largest number of groups without species in common are chosen; and 4) if two or more groups with the same number of species and with members in common can be formed, the group that occurs most frequently will be chosen.

Species were grouped at an index of affinity of 0.50 (i.e., 0.495 or greater). Associates were defined as species that had positive affinities with one or more members of a recurrent group but not with all members of the group. A connex value defines the level of relationship. This number is the proportion of possible positive affinities (e.g., I. A. = 0.50 or greater) between members of two groups or between a group and an associate. The connex value is shown in recurrent group diagrams next to a line connecting different groups to each other or associate species to groups.

ClusterAnalysis

Abundance-based site and species groups were defined using cluster analysis. Prior to conducting the cluster analysis, the data were screened to reduce the confounding effect of very rare species, which do not facilitate comparison between stations. The screening process had two criteria: 1) each taxa had to have an abundance of 10 or more individuals and these must have occurred in at least five or more stations; and 2) each station had to have at least five or more individuals to be included in the cluster analysis. A separate analysis was conducted for fish, invertebrates, and combined fish and invertebrate data.

After the selection criteria were met, the abundance data were square-root transformed and standardized. The square-root transformation is generally applied to count data to reduce the importance of the most abundant taxa (Sokal and Rohlf 1981, Clarke and Green 1988, Smith *et al.* 1988). The data were standardized by dividing species abundance at a given otter trawl station by the mean abundance of that species over all stations. The benefit of standardization is that it has the effect of equalizing extreme abundance values and facilitates relative comparisons among species (Clarke 1993). The Bray-Curtis measure was used to convert the species composition and abundance data into a dissimilarity matrix (Bray and Curtis 1957, Clifford and Stephenson 1975). The clustering method was an agglomerative, hierarchical, flexible sorting method (SAS PROC CLUSTER 1989 [SAS Institute 1989]). The sorting coefficient Beta was set at the standard value of -0.25 (Tetra Tech 1985).

Each cluster analysis on abundance data for fish, invertebrates, or combined fish and invertebrates involved two approaches. First, a cluster procedure was used to identify groups of stations that exhibit similar species abundance patterns. Second, a cluster procedure was conducted to identify groups of species that occur in similar habitats (stations). In each approach, the results of the cluster analysis were used to produce a dendrogram, a structured two-dimensional hierarchical display of similar station and species groups. Furthermore, the station and species clusters for each taxonomic group were used to produce a two-way coincidence table, a matrix of species-importance values which optimally displays the patterns identified in the cluster analyses by the dendrograms (Kikkawa 1968, Clifford and Stephenson 1975, CSDOC 1994). The end result is a summary two-way table of observations, which corresponds to the order of similar station groups along one axis and similar species groups along the other axis. Major clusters were determined by evaluating the patterns and abundances that were summarized by the two-way table. This evaluation started with the most significant dendrogram separating dissimilar clusters. If the species abundance patterns showed that this separation was reflected in the two-way table, then this was considered a major cluster separation point. The evaluation continued to the next major separation point and the evaluation was continued until dendrogram separation points were not evident in the two-way table. All clusters not clearly evident as distinct in the two-way table were not considered as major cluster groupings and were not separated further into additional clusters.

The discussion for each cluster analysis begins with an overview of the analytical results, followed by a more detailed description of the site clusters, followed by the discussion of the species clusters, and finally followed by a comparison with the 1994 SCBPP regional cluster analysis. Throughout the discussion, whenever a number cluster is being discussed (i.e., Cluster 2), this is referring to the site clusters; and whenever a letter cluster is being discussed (i.e., Cluster F), this is referring to a species cluster.

Cladistic Analysis

Cladistic analysis is typically used to determine phylogenetic relationships among species. The relationship of species, linking those with shared characters, is described in a cladogram. Although typically used in taxonomic studies, it has also been used in describing assemblages of organisms.

In this study, abundance-based and binary (presence/absence) species data were used to develop cladograms of site groups using cladistic analysis. Cladograms were generated using the heuristic search Tree-Bisection and Reconnection algorithm, utilizing the recently published “New Search Strategy” for finding most parsimonious reconstructions with large data sets (Quicke *et al*. 2001). The “New Search Strategy” is designed to find optimal (most parsimonious) cladograms via an iterative weighting and nonweighting scheme that transforms treespace. This allows searches to escape from local optima (islands of equally parsimonious trees) and into new islands consisting of shorter trees, due to the greediness of the algorithms used.

All analyses were performed with the computer program PAUP* - Phylogenetic Analysis Using Parsimony (* and other methods) version 4.0b6 (Swofford 2000). Methods of calculation for measure-of-fit indices are presented in Kitching *et al.* (1998). The most parsimonious cladogram derived from these procedures delineated site or station relationships in the “Q-mode” analysis, and species associations in the “R-mode” analysis.

Analyses were conducted on data for fishes and data for combined fishes and invertebrates. Species (operational equivalent for character) that occurred at two or more sites (operational equivalent for taxa) were used in the analyses. Only supraspecific taxa that may have represented two or more distinct species were excluded. All other species were included, including species with only a single occurrence. The most removed, depauperate, and "monophyletic" clade consisting of the shallow dwelling elasmobranch species (round stingray, *Urolophus halleri*; diamond stingray, *Dasyatis dipterura*; and California butterfly ray, *Gymnura marmorata*) rooted the cladograms. All species were included in the analysis because 1) deleting rare descriptors can damage the sensitivity of community-based methods to detect ecological changes (Cao *et al.* 1998, 2001), and 2) taxon autochthony may be more informative than their abundance, especially in parsimony analyses (Perochon *et al.* 2001). Cladograms of species groups, showing the association of these descriptors or species with one another ("R-mode" analysis) were produced for all species of fish and for fishes and invertebrates combined.

Fish Population and Assemblage Biocriteria Analysis

The assessment of anthropogenic impact to demersal fish populations and assemblages requires that biocriteria be identified to describe reference (or normal) conditions to distinguish these from nonreference conditions. This assessment is enhanced if indicators are also identified that respond to impacted (or altered) conditions. While individual indicators are important in identifying anthropogenically altered habitats, a more valuable indicator of impacts to fish assemblages can be developed by combining these indicators into an index.

Since the 1994 regional survey (Allen *et al.* 1998), several biointegrity indices have been produced that can be applied to the data (Allen *et al.* 2001a). These include a fish response index (FRI), invertebrate response index (IRI), trawl response index (TRI), and fish foraging guild (FFG) index. The first three are based on a multivariate-weighted-average approach, the same used to develop a successful benthic response index for the 1994 regional survey (Smith *et al.* 1998, 2002). The FFG index was based on foraging guilds from Allen (1982) and the multimetric approach (Weisberg *et al.* 1997, Gibson *et al.* 2000). Detailed methods and testing of these indices are given in Allen *et al.* (2001a).

The multivariate-weighted-average indices (FRI, IRI, and TRI) were produced from an ordination analysis of calibrated (i.e., index development) species abundance data (Allen *et al.* 2001a). These ordination analyses determined a vector in ordination space that corresponded to the pollution gradient. Then all calibration observations were projected onto the pollution-effects gradient vector in the biological ordination space, rescaled, and species-tolerance scores (i.e., species positions along the gradient vector) were determined. From this, the index value for an observation (station-time) is the abundance-weighted-average pollution tolerance of all species in the observation.

The index value is calculated as follows:

$$I_s = \frac{\sum_{i=1}^{n} a_{si}^{f} p_i}{\sum_{i=1}^{n} a_{si}^{f}}, \qquad \textbf{Equation 6}$$

where

I_s = The index value for observation s .
n = The number of species in the observation s.

p_i = The position for species i on the pollution gradient (an indicator of the pollution tolerance of the species).

a_{si} = The abundance of species i in observation s.

The exponent f allows for transformation the abundance weights to prevent overemphasis on extreme abundances.

The application of these indices requires that species be from a similar area and habitat (i.e., the mainland shelf of southern California) as those used in developing the index. The new species abundance values are multiplied by the p_i determined in the index development analysis. Appendices A5, A6, and A7 give p_i values by species for FRI, IRI, and TRI indices.

With the multivariate approach producing the FFG index, 31 population and assemblage metrics were tested to determine metrics that differed significantly between reference and impact sites (Allen *et al.* 2001a). Combinations of responsive metrics were then scored and combined to form indices. Each index was the mean of the metric scores of the index (i.e., the sum of the scores of each component metric divided by the number of metrics in the index) or

$$MI = \frac{\sum_{i=1}^{n} MS}{n} \text{ ,} \qquad \textbf{Equation 7}$$

where

MI = Multimetric index.

MS = Metric score.

n = Number of metrics in index.

The foraging guilds that, in combination, formed the best index for the middle shelf, were the bottom-living benthic extractors (turbot guild, 2D1a); bottom-living pelagobenthivores (sanddab guild, 2B); and bottom-living pelagivores (benthic ambushers guild, 2A). Guild designations were based on Allen (1982). The turbot guild included C-O sole, curlfin sole, diamond turbot, Dover sole, hornyhead turbot, rock sole, and spotted turbot. The sanddab guild included gulf sanddab, longfin sanddab, slender sole, speckled sanddab, and small (<11 cm) California halibut and petrale sole. The benthic ambushers guild included California lizardfish (*Synodus lucioceps*), bigmouth sole (*Hippoglossina stomata*), lingcod (*Ophiodon elongatus*), and large (>11 cm) California halibut and petrale sole.

The turbot guild had high abundance in impact areas and low abundance in reference areas, whereas the sanddab and benthic ambusher guilds were in low abundance at impact areas and high abundance in reference areas.

To apply this index, the guilds receive the following scores at different abundance levels in a 10-min trawl:

- Guild 2D1a – score 1 (>32 fish); score 2 (32-11 fish); score 3 (10-0 fish).
- Guild 2B – score 1 (0-15 fish); score 2 (16-29 fish); score 3 (>29 fish).
- Guild 2A – score 1 (0 fish); score 2 (1 fish); score 3 (> 1 fish).

This guild tested successfully for use on the middle shelf of southern California.

Allen *et al.* (2001a) noted that based on overall performance in this study, the FRI index appeared to be an effective fish index, particularly in the middle shelf zone. The FFG index may have value in interpreting the ecological meaning of the FRI index response. The FFG index measures the relative importance of benthic pelagivore, benthic pelagobenthivore, and benthic-extracting benthivore guilds along the pollution gradient, which in turn reflect changes in the relative abundance of polychaetes and pericarid crustaceans (mysids and gammaridean amphipods) along the gradient. Although the IRI and TRI indices performed less well, they are the only attempt to produce indices for southern California using megabenthic invertebrates and fishes and invertebrates combined. Their performance was likely due to anomalous species abundances following the 1982-1983 El Niño.

In this study, we focused on the FRI index as the primary index for assessing percent of area that was not reference because it could be applied across most of the study area and because it showed the best test results in the index development study (Allen *et al.* 2001a). The other indices give different perspectives of reference areas from the invertebrate, fish and invertebrate, and fish-foraging guild perspectives.

Functional Organization of Fish Assemblage Analysis

The functional organization of the demersal fish assemblages identified in the 1994 survey was based on the methods used in Allen (1982), which described the functional organization of demersal fish communities on the central portion of the southern California shelf at depths of 10-200 m in 1972-1973. This organization was based on 342 trawl samples collected in the same manner as those in the 1994 and 1998 regional surveys. It identified 15 basic foraging guilds of demersal fishes on the soft-bottom habitat of the mainland shelf, with one guild consisting of four size divisions (bringing the total possible guild categories to 18) (Figure 5). Each guild consisted of two to four species, each dominant in a different depth zone. The functional structure of the community at a given depth is described in terms of the numbers and types of feeding guilds, whereas the species composition is described in terms of the dominant species of each guild (Figure 6).

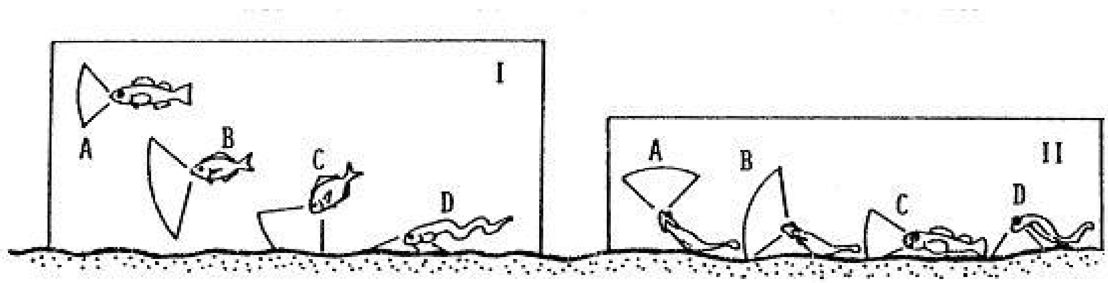
Species were sorted into 18 predefined foraging guilds. The guild classification of the most common species is defined in Allen (1982). The guild classification of other species was based on their known foraging behavior or on that inferred from their morphology and/or feeding habits. If more detailed information were available, some of the rarer species might be more appropriately classified into specialized guilds not defined in the above study. However, they are conservatively included here in the more general foraging orientation guilds.

The functional organization of the demersal fish assemblages in 1998 was described at 20-m depth intervals. This organization was compared to the model of functional organization for 1972-1973 (Allen 1982) and to 1994 (Allen *et al.* 1998) to assess how the organization of the community has changed during two decades.

Bioaccumulation Data Analysis

Percent Above Threshold

The focus of this analysis is to answer the question, “What is the extent of fish with contamination levels of concern?” Thus, data analysis focused on estimating the percent of area where contaminated fish were found and the percent of each fish population with contamination levels above a threshold of concern.



I. Water-column Fishes
- A. Pelagivores
  - 1. Schooling
  - 2. Bottom-refuge
    - a. Visual
    - b. Nonvisual
- B. Pelagobenthivores
- C. Benthopelagivores (Cruising)
  - 1. Diurnal
  - 2. Nocturnal
- D. Benthivores (Cruising Nonvisual)

II. Bottom-living Fishes
- A. Pelagivores
- B. Pelagobenthivores
- C. Benthopelagivores
  - 1. Pursuing
  - 2. Ambushing
- D. Benthivores
  - 1. Visual
    - a. Extracting
    - b. Excavating
  - 2. Nonvisual

Figure 5. Foraging guilds of soft-bottom fishes on the southern California shelf (from Allen 1982).

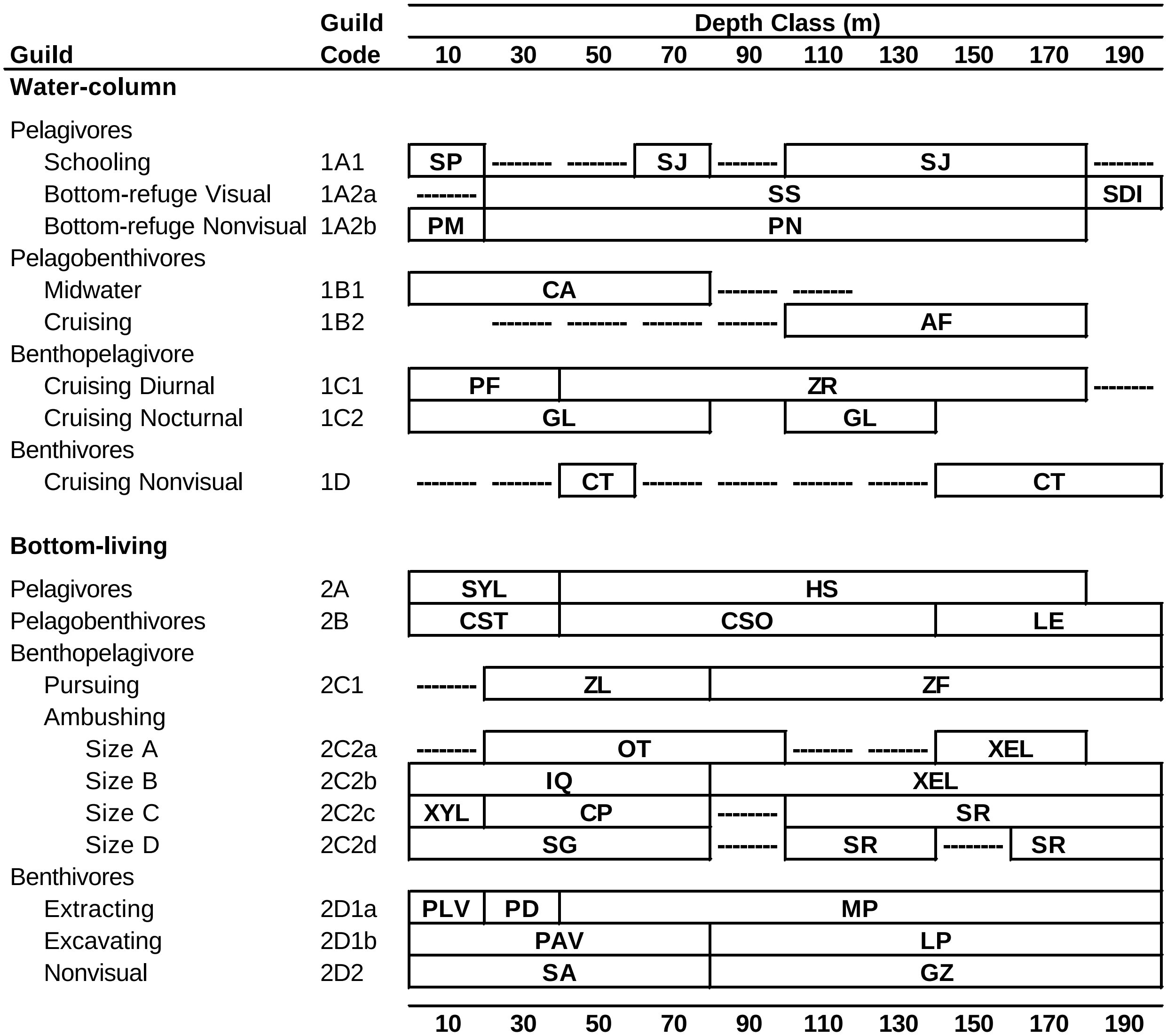
The sanddab guild was the focus of this analysis. As the species in this guild have similar uptake under similar conditions (Allen *et al.* 2002), the component species in combination were regarded as being functionally equivalent and the guild was treated as a ‘superspecies.’ Hence, contaminant concentrations from a site were likely to be about the same no matter which sanddab guild species were present. In this study, we chose the specie/age class composite that was the priority composite for chemical analysis (see Laboratory Methods, Bioaccumulation, above) for use in data analysis; hence, a single composite represented a station.

The thresholds of concern were predator-risk guidelines for aquatic and/or marine wildlife from the National Academy of Science (NAS 1974) and Environment Canada (1997, 1998). The guideline for chlordane was 50 µg/kg ww (NAS 1974). The guideline for total DDT was 14.0 µg/kg ww (Environment Canada 1997) and that for PCB was 0.79 ng (TEQ)/kg (Environment Canada 1998). The PCB guideline was based on the toxicity equivalent quotient (TEQ) of the products of the summed PCB congeners and their toxicity equivalency factors (TEFs). These TEFs were used to estimate the relative toxicity of PCBs based on their similarity to dioxin. Specifically, the TEFs are assigned to the congeners based on their ability to produce a response in the cytochrome system relative to the most potent inducer, 2,3,7,8-TCDD [a dioxin; TCDD = tetrachlorodibenzo-p-dioxin] (Environment Canada 1998). Thus, the TEQ is the total TCDD toxic equivalents concentration and is calculated as follows:

$$TEQ = S\,(PCB_i \times TEF_i) \qquad \textbf{Equation 8}$$

where

PCB_i = Individual PCB congener.
TEF_i = Toxicity of PCB congener relative to TCCD dioxin.



Size Classes (mouth length): A = 1-4 mm; B = 5-8 mm; C = 9-26 mm; and D ≥ 27 mm.

AF = *Anoplopoma fimbria*
CA = *Cymatogaster aggregata*
CP = *Chitonotus pugetensis*
CSO = *Citharichthys sordidus*
CST = *Citharichthys stigmaeus*
CT = *Chilara taylori*
GL = *Genyonemus lineatus*
GZ = *Glyptocephalus zachirus*
HS = *Hipposlossina stomata*
IQ = *Icelinus quadriseriatus*
LE = *Lyopsetta exilis*
LP = *Lycodes pacificus*
MP = *Microstomus pacificus*
OT = *Odontopyxis trispinosa*
PAV = *Parophrys vetulus*
PD = *Pleuronichthys decurrens*
PF = *Phanerodon furcatus*
PLV = *Pleuronichthys verticalis*
PM = *Porichthys myriaster*
PN = *Porichthys notatus*
SA = *Symphurus atricaudus*
SDI = *Sebastes diploproa*
SG = *Scorpaena guttata*
SJ = *Sebastes jordani*
SP = *Seriphus politus*
SR = *Sebastes rosenblatti*
SS = *Sebastes saxicola*
SYL = *Synodus lucioceps*
XEL = *Xeneretmus latifrons*
XYL = *Xystreurys liolepis*
ZF = *Zaniolepis frenata*
ZL = *Zaniolepis latipinnis*
ZR = *Zalembius rosaceus*

Boxes indicate where guild occurred in 20% or more of stations in depth class.

Figure 6. Functional structure and species composition of soft-bottom fish communities of the mainland shelf of southern California in 1972-1973 (modified from Allen 1982).

The TEFs used in this study were those recommended by the World Health Organization (Van den Berg *et al*. 1998). The TEFs were available for 12 PCB congeners found in this study, with TEFs differing for mammals and birds (Table 3).

Table 3. Summary of congener-specific toxicity equivalent factors (TEFs) for mammals and birds used in the Southern California Bight 1998 Regional Survey, July-September 1998.

	WHO Congener-specific TEFs[1]	
Congener	Mammals	Birds
PCB 77	0.00010	0.05000
PCB 81	0.00010	0.10000
PCB 105	0.00010	0.00010
PCB 114	0.00050	0.00010
PCB 118	0.00010	0.00001
PCB 123	0.00010	0.00001
PCB 126	0.10000	0.10000
PCB 156	0.00050	0.00010
PCB 157	0.00050	0.00010
PCB 167	0.00001	0.00001
PCB 169	0.01000	0.00100
PCB 189	0.00010	0.00001

WHO = World Health Organization.
[1] Van den Berg, *et al*. (1998).

Population Means

In addition, comparing mean and median concentrations of contaminants in fish tissues within the SCB was of interest. For these comparisons, mean and median concentrations, as well as percent of the area above threshold, were determined for subpopulations and for the SCB as a whole.

To compare contaminant concentrations in the sanddab guild, stratified summary statistics were used. Weighting factors were determined from probability distributions and sampling grid intensities. Mean values were calculated following Equation 9. To compare mean contaminant concentrations among or within fish populations, fish density weighting was required. Fish density weighting requires several assumptions (Heimbuch *et al*. 1995), the most important of which is the probability of individual fish capture being independent of area or the presence of other fish. Secondarily, it is assumed that tissue composite samples represent the site mean.

Fish densities were determined from trawl area and target species abundance as follows:

$$m = \frac{\sum_{i=1}^{n} (p_i * w_i) * (\text{abundance}_i / \text{trawl area}_i)}{\sum_{i=1}^{n} w_i * (\text{abundance}_i / \text{trawl area}_i)} \qquad \textbf{Equation 9}$$

where

m	=	Mean parameter value for population j.
p_i	=	Parameter value (concentration) at station i.
w_i	=	Weighting factor for station i, equal to the inverse of the inclusion probability for the site.
n	=	Number of stations for species (e.g., Pacific sanddab).
$abundance_i$	=	Abundance of target species at station I.
$trawl\ area_i$	=	Area trawled at station i.

Correlation/Regression Analysis

For deciphering sediment-tissue relationships, wet-weight tissue and lipid-normalized tissue concentrations were correlated with sediment concentrations normalized by TOC.

DNA Damage Data Analysis

The unit of exposure for DNA damage samples was the individual fish. Multiple fish were needed per station to conduct appropriate statistical analyses. Comet TM values were compared statistically by single-classification analysis of variance; Tukey-Kramer ANOVA (parametric); or, if assumptions of equal variance and Gaussian distribution were not satisfied, using the nonparametric Kruskal-Wallis Test. All statistical comparisons were performed using InStat7 (GraphPadJ, San Diego, CA) statistics software.

QUALITY ASSURANCE

INTRODUCTION

The goal of the Quality Assurance Plan for the Southern California Bight 1998 Regional Survey (B'98, SC 1998) was to ensure that the many participants of the survey produced data of comparable quality. This plan is summarized in the Materials and Methods Chapter of this report. Quality assurance (QA) and quality control (QC) activities and methods used for the assemblage, tissue chemistry, and biomarker parts of this study are also described in their respective section in that chapter. The following section describes results of the QA/QC activities conducted during the study. These results are evaluated relative to the measurement quality objectives (MQOs) described in the Quality Assurance Plan. In addition, the results of a postsurvey performance review using geographic information system (GIS) analysis is included to facilitate future discussions on field survey techniques and site criteria.

RESULTS

Assemblage Study

Trawl Sampling Success

The original stratified random survey design identified 354 trawl sites, which allowed for 10% over sampling in each subpopulation in case of low trawling success. However, additional sites were added in-survey to compensate for any untrawlable sites that were encountered, bringing the total sites attempted to 442. Trawl samples were collected from 314 (71%) of attempted trawl stations from Point Conception, California, to the United States-Mexico international border including the Channel Islands, Santa Barbara Island, and Santa Catalina Island (Table 4). Sampling depths ranged from 2 to 202 m (Appendix A1).

Trawl success varied by analytical subpopulation and was higher along the mainland shelf (80%) than at the islands (47%) (Table 4). Along the mainland shelf, trawl success decreased from north to south (89 to 71%, respectively). At the islands, it was highest at Santa Catalina Island (81%) and lowest at the northwest Channel Islands (33%). By depth zone, trawl success ranged from 62 to -81%, with success being lowest on the inner shelf and highest on the middle shelf. By subpopulation, sampling was most successful at middle-shelf small POTWs (100%) and least successful at the inner shelf of the islands (11%).

Of the attempted stations, 128 were abandoned for a variety of reasons (Appendix A1). The majority of stations were abandoned due to rocky bottoms (58%) and obstructions (31%).

Site Criteria Objectives for Trawl Station Locations

Although the QA/QC criterion for accepting a station for assemblage analysis required only that the station be within the original subpopulation, more precise field criteria were implemented to ensure that sampling would be conducted close to the assigned coordinates. The Bight'98 Field Operations Manual (B'98, FSLC 1998) specified guidelines that field crews should meet in collecting a sample at a sampling site. The trawl

Table 4. Distribution of sampling effort and success by analytical subpopulations in the Southern California Bight 1998 Regional Survey, July-September 1998.

	Number of Stations		Percent
Subpopulation	Attempted	Successful	Successful
Region			
Mainland	320	257	80
Northern	76	68	89
Central	139	114	82
Southern	105	75	71
Island	122	57	47
Cool (NW Channel Islands)	45	15	33
Warm	77	42	55
SE Channel Islands	45	16	36
Santa Catalina Island	32	26	81
Shelf Zone			
Bays and Harbors (2-30 m)	86	60	70
Ports	22	15	68
Marinas	22	18	82
Other Bay	42	27	64
Inner Shelf (2-30 m)	133	82	62
Small POTWs	20	15	75
River Mouths	39	31	79
Other Mainland	36	32	89
Island	38	4	11
Middle Shelf (31-120 m)	155	125	81
Large POTWs	38	32	84
Small POTWs	15	15	100
Mainland non-Large POTW	51	46	90
Island	51	32	63
Outer Shelf (121-202 m)	68	47	69
Mainland	35	26	74
Island	33	21	64
Total (all stations)	442	314	71

POTW = Pubicly owned treatment work monitoring area.

was to be taken within 100 m of the nominal location of a preassigned site and within 10% of the nominal depth of that site. Station depths were recommended to within the range of 6-220 m for coastal stations and, and 3 m for bay or harbors. Trawls were to be towed for 10 min on the coast and 5 min in harbor areas at a constant speed of 0.8-1.0 m/s (1.6-2.0 kn). Postsurvey quality control found that 310 of the 314 trawls had recorded adequate georeferences for GIS trawl analysis. These 310 sites were used to evaluate distance from nominal site, depth change criteria, tow distance, and speed.

Distance from Nominal Site. For the survey as a whole, 69% of the trawls were within 100 m of the original assigned station (nominal) coordinates. Of the trawls missing the 100 m diameter circle, database comments indicated a deliberate path alteration for 10 sites (3% of the total). B'98, FSLC (1998) allowed slight trawl path changes to avoid obstructions on the ocean surface (e.g., docks, land) or bottom (e.g., cables, pipes), but required that the path cross some point within the 100m circle. Additional trawl paths were probably moved deliberately, but no comments were recorded in the database. The trawls outside of the circle were distributed as follows: 31% within 50 m; 17% between 50 and 100 m; 24% between 100 and 200 m; and the remainder over 200 m. Five sites were over 1 km from the original location but were still within their proper subpopulation stratum. Stations 2339 and 2332 were 2600 m and 3540 m away from their nominal position, respectively. Bays and harbors were equally as likely to miss the 100 m circle as open coast sites (33 and 30%, respectively).

Depth Change Criteria. Demersal fish and invertebrate populations vary along depth gradients; hence, trawls were towed along isobaths. The goal (B'98, FSLC 1998) was to trawl within 10% of the nominal depth to ensure that animals caught in a trawl were collected from the same depth stratum. Grab samples, which record nominal depth, were not collected at all trawl sites. However, consistent data parameters recorded during a trawl event were beginning and ending depth. These can be checked against the average depth to evaluate the depth change criteria. For the survey, 85% of the trawls were within the targeted depth criterion. Of the 47 stations exceeding this criterion, 79% were in shallow water ranging in depth from 2-31 m. Two of the 6 middle-shelf trawls had 20-m depth changes. Three of the 4 outer-shelf trawls exceeded 15% of the mean depth. Site 2113 started at 147 m and ended at 113 m. Site 2534 started at 160 m and ended at 133 m. A plausible transcription error resulted in Site 2290 starting at 185 m and ending at 85 m; the depth of this site was assumed to be 185 m. The species composition of all sites exceeding the 10% depth criterion was examined for unexpected species; all sites had species compositions expected for their particular depth stratum.

Trawl Duration. Two categories of trawl duration times were observed in the data: 10-min trawls for coastal trawling; and 5-min trawls in bays and harbors, where space was limiting. Most (81%) were standard 10-min trawls (range of 8-13 min; mean of 10 min). Sixty sites were 5-min trawls (range of 4-6 min; mean of 5 min). All but five open coastal sites were trawled for 10 min. The GIS analysis revealed that these five sites were found inside a harbor. All but five bay and harbor sites were trawled for 5 min. These five sites had sufficient space for a standard trawl. All 5-min trawls were normalized to 10 min for data analysis (see Materials and Methods Chapter). Of these normalized trawls, 93% ended within 30 sec of a 10-min tow. None of the biological data from any site was excluded from any analysis because of trawl duration.

Tow Distance and Speed. Presurvey estimates of tow distances during optimal fieldwork conditions (1.0 m/s) were 300 m for 5-min trawls and 600 m for 10-min trawls. Boat captains were requested to maintain speeds of between 0.8-1.0 m/sec (1.6-2.0 kn) because fieldwork is seldom optimal. Under these restrictions, a 10-min trawl was expected to range from 464-618 m while 5-min tows were expected to be half of these values. Postsurvey analysis showed that 5-min trawls averaged 275 m (median of 267 m, range of 29-415 m) in distance with an average speed of 0.92 m/sec. Ten-minute trawls averaged 634 m (median of 601 m, range of 380-2375 m) with an average speed of 1.0 m/sec. Normalizing 5-min trawl distances to those of 10-min trawl distances (551 m average) resulted in 95% confidence limits of 519-582 m (within theoretical limits). Bays and harbors appear to provide working conditions sheltered from the atmospheric and oceanographic events found in open-water areas. For the survey, 50% of the sites had speeds within the requested limits. No station with abnormal distance or speed was eliminated from the report analysis, because transcription errors could not be distinguished from boat errors.

Examination of data from unusually short or long tows showed nothing abnormal. Assemblage data were within the expected ranges. Unusual trawl distances were arbitrarily selected at 10% above or below the recommended speed bracket, assuming a 10-min tow duration. Regarding tow distances, 4 sites had tow lengths of 417 m or less and 72 sites had tow lengths of 680 m or greater. Nine sites had distances greater than 900 m, with Stations 2087 and 2365 having tow lengths greater than 2000 m. Regarding tow speeds, Station 2129 had a calculated speed of 0.1 m/s (0.2 kn) and 12% of the sites had speeds greater than 1.2 m/sec (2.4 kn) - 20% over the recommendation. Because tow distances and calculated speeds (length divided by time) require accurate recording of GPS positions and trawl durations, sites with unusually short or long trawls were likely the result of plausible transcription errors.

Equipment and Trawl Protocol Audits

All sampling organizations were audited for compliance with vessel equipment and trawling protocols during the survey (Appendix B1); all were found to be in compliance. Minor but acceptable deviations were found in the trawl boards, nets, bridles, and available weighing scales. Some trawl processing procedures were not evaluated because the audit trawls lacked the appropriate animals. Auditors would select a trawl to evaluate for QC purposes, but would assist the crew throughout the day on protocols and identification.

Catch Processing Protocol Audits

Taxonomic Identification. A presurvey bucket intercalibration exercise demonstrated that participating organizations had less than a 5% error rate for species identification. Two organizations with identification problems (greater or equal to 5%) were requested to submit a voucher specimen for each species from each station surveyed. Taxonomists verified voucher identities from all organizations and corrected any errors. Misidentified vouchers and species needing further laboratory identification are listed in Appendix B2. Three organizations had initial voucher identification error rates greater than or equal to 7%. Problematic fish species for the survey included rockfishes (Sebastes spp.), juvenile fish, and pipefishes (Syngnathidae). Problematic invertebrate species for the survey included ascidians, sponges, hermit crabs, and octopus.

Field crews were required to preserve specimens chemically for vouchers, but some voucher specimens were photographed. Most organizations preserved more than 90% of their vouchers, with fewer than 10% being photographed. One organization preserved 69% and photographed 31% of its voucher specimens. Voucher verification concluded that many taxonomic characteristics were not visible on submitted photos (21%), and 4% of these specimens were misidentified. Photo vouchering was recommended only for large animals and animals with color characteristics that disappear after preservation. It was not recommended for the overwhelming majority of the animals, particularly for rare, unusual, or small voucher specimens.

The field manual requested all organizations voucher one specimen of every taxon they identified during the survey. Organization success rates ranged from 75 to 99%, with all but three organizations having greater than 94% of their specimen vouchers returned for taxonomic verification. The regional survey had 151 different species of fish and invertebrate vouchers from the southern California shelf.

Abundance. All of the fishes and invertebrates collected in the survey were noted and counted. Colonial, parasitic, or pelagic invertebrates were noted as present and counted as one. Forty-eight stations with 80 species of invertebrates had abundances represented as present. Animals eliminated from analysis were invertebrates with inconsistent reporting, such as Pacific fish louse (Elthusa [=Livoneca] vulgaris), infauna, planktonic types, and fouling organisms. Field QC audits on fish counts showed nine errors (13%). The assumption was that QC auditors were always correct. Errors ranged from an overcount of two to an undercount of three with 56% representing undercounts. The QC audits on invertebrates were sparse because audit triggers were based on abundances greater than 10.

Some species abundance was estimated from weights. Six fish abundance records had counts based on the aliquot technique described in B'98, FSLC (1998). White croaker (Genyonemus lineatus) represented 83% of the total, with six stations affected. Thirty-five invertebrate records had estimated counts. White sea urchin (Lytechinus pictus) represented 49% of the total, with 23 stations affected. One California skate (Raja inornata) from Station 2116 had biomass data but no count (qualifier of greater than one).

Length. Quality control audits for length measurements showed relatively poor agreement between auditors and field crew. The auditor agreed with the size class field measurements 164 out of 380 (43%) times. The errors were generally plus or minus one centimeter size class. Note that one millimeter above or below the correct size class division on a measuring board can change the measurement by one centimeter. While the total abundance counts by field crews agreed relatively well with the counts by auditors, size categorization within the total count ranged from an overcount of 10 fish to an undercount of 10 fish for a given size class. Most QC audits were triggered by fish abundances much greater than 10.

In the survey, fish were generally the only animals measured for length, although California sea cucumbers were measured at some sites. The database had 18 fish records without size class information. Six of these records were the result of the aliquot technique for abundance counts. One species was not measured but was returned to laboratory for further identification. The remainder resulted from one organization's invalid size-classing technique. White croaker represented 61% of the missing length data.

Biomass. Quality control audits for biomass measurements were not done as frequently (67%) as for counts and lengths. Weight measurements between auditors and field crews showed a 67% agreement. The errors ranged from a gain of 0.2 kg to a loss of 0.1 kg. Most of the errors had an absolute difference of 0.1 kg or less (93%), with 20% losing weight.

During the survey, not all fish and invertebrate species were accurately weighed at a station. B'98, FSLC (1998) allowed for one bucket of fish and one bucket of invertebrates per station to accumulate all species less than 0.1 kg. These were weighed as a composite category to be used in calculating total biomass of the trawl catch. For fish, 1,217 species-site combinations from 282 sites had a biomass qualifier of less than 0.1 kg. Only 217 stations had a fish composite weight category. A total of 8 (3%) of 314 sites had zero or a qualifier of less than 0.1 kg for fish biomass. For invertebrates, 1,957 species-site combinations from 305 sites had a biomass of less than 0.1 kg. Only 234 stations had an invertebrate composite weight category. A total of 74 (24%) of 314 sites had zero, -99, or a qualifier of less then 0.1 kg of invertebrate biomass. One fish species, sarcastic fringehead (Neoclinus blanchardi), from Station 2493 was counted but not weighed. Four invertebrate species - a glass sponge, Rhabdocalyptus dawsoni; California sea slug (Pleurobranchaea californica); Lewis moon snail (Euspira [=Polinices] lewisii) egg cluster; and hermitcrab sponge (Suberites suberea) from Stations 2095, 2104, 2152, and 2537, respectively, were counted but not weighed.

Anomalies. Quality control audits on anomalies were limited during the survey. The available information showed that the surveying organizations correctly identified the gross pathology for fishes and invertebrates. Seven organizations with audit data examined 140 species of fish for anomalies such as ambicoloration, albinism, deformities (skeletal), fin erosion, lesions, parasites, and tumors. For invertebrates, three organizations had audit data. Fifty-five species were examined for parasites and burnspot disease during audits.

Success at Meeting Measurement Quality Objectives

A large number of the randomly selected nominal sites were untrawlable. The Channel Islands and San Diego Bay were the least successful strata. The resulting 69% completion success was below the targeted 90% (Table 5), which affected the expected number of tissue chemistry samples. All chemistry samples were processed in the field using United States Environmental Protection Agency (USEPA) guidelines for quality assurance and quality control (USEPA 1995). Nearly all animals were identified, weighed, and measured. Ten organization audits and 69 in-survey field audits were done during the survey. These audits on fish showed that precision objectives were below those expected. Size-class lengths were plus or minus one centimeter. Weights varied slightly, but 100% were within 0.2 kg of initial field measurements. Invertebrates proved difficult to audit because of low abundance and general lack of significant weight.

Bioaccumulation Study

Sampling Success

Trawl tissue samples were collected from 309 (98%) of the 314 successful trawl sites. Because sufficient numbers of sanddab guild samples were collected, the turbot guild samples that had been collected as an alternate guild were not analyzed. A total of 275 composite fish tissue samples were sent to various participating laboratories. Of these composites, 35% were from the non-POTW mainland shelf, 28% from the islands, 15% from large POTW areas, 10% from small POTW areas, 7% from bays and harbors, and 6% from river mouth areas.

Of the 275 assigned composites, 270 (99%) composites, representing 225 stations, were chemically analyzed (Tables 6 and 7). Of these, 197 composites from the mainland and 72 composites from the islands were analyzed (Table 6). By depth, 132 composites were analyzed from the middle shelf, 72 from the outer shelf, 48 from the inner shelf, and 18 from bays and harbors. By species, 30% were Pacific sanddab, 30% longfin sanddab, 19% speckled sanddab, 11% slender sole, and 9% small California halibut. The majority of Pacific sanddab composites were from the islands but the majority of composites for the other species were from the mainland shelf. By shelf zone, the majority of Pacific sanddab and longfin sanddab composites were from the middle shelf; for California halibut, bays and harbors; for speckled sanddab, inner shelf; and for slender sole, outer shelf.

Table 5. Success at meeting measurement quality objectives (MQO) in the Southern California Bight 1998 Regional Survey, July-September 1998.

	Percent for Field Audit				Survey	
	Accuracy		Precision		Completeness	
Data Type	Goal[a]	Result[a]	Goal[a]	Result[a]	Goal	Result
Sample Collection	NA	NA	NA	NA	90	69
Catch Processing						
Fish						
Identification	5	3	NA	NA	90	100[e]
Count	NA	NA	10	13	90	100
Biomass	NA	NA	10	33	90	100
Gross Pathology	5	0[b]	NA	NA	NA	NA
Length	NA	NA	10	57	90	99
Invertebrates						
Identification	5	0[b]	NA	NA	90	100[f]
Count	NA	NA	10	0[d]	90	99
Biomass	NA	NA	10	0[d]	90	99
Gross Pathology	5	0[c]	NA	NA	NA	NA
Contaminants in fish	30	NA	30	NA	90	68

[a]Percent of error
[b]Data from seven agencies
[c]Data from two agencies
[d]Data from one agency
[e]99 percent identified to species
[f]79 percent identified to species

NA = Not available.

By age class, Age-1 fish comprised 87% of the samples (Table 8). Of the total samples, 29% of the Age-1 fish composites were longfin sanddabs, 28% Pacific sanddabs, and 16% speckled sanddabs.

Quality Control Results for Chemical Analyses

Data quality objectives for all except one parameter were achieved with complete success (Table 9). Among these, the difference from CARP-1 certified reference material (CRM) (Figure 7) was within acceptable ranges. The single exception was precision for duplicate analyses (Table 9). Approximately 60% of the duplicate analyses were within the specified limit of 30% relative percent difference (RPD) (Figure 8). Further evaluation showed that 90% of the analyses were within 60% RPD. Although no specific instructions were given to perform matrix spike studies, some laboratories did perform matrix spike analyses to further evaluate their performance. Data for the matrix spike experiments (Figure 9) are consistent with the precision observed for the duplicate analyses (Figure 8). The greatest variability in results occurred at lower analyte concentrations (i.e., < 20 ng/g). These data suggest that an RPD of up to 60% may be as good as can be expected for the observed concentration range of the analytes, and for the analytical methodologies used in this study.

Table 6. Number of bioaccumulation study composites analyzed by species and subpopulation during the Southern California Bight 1998 Regional Survey, July-September 1998.

	Species Name[a]					
Subpopulation	CX	CSo	CSt	PC	LE	Total
Region						
Mainland	76	36	42	25	18	197
Northern	4	22	20	1	10	57
Central	37	6	16	13	5	77
Southern	35	8	6	11	3	63
Island	5	46	9	0	13	73
Cool (NW Channel Islands)	0	10	6	0	1	17
Warm	5	36	2	0	12	55
SE Channel Islands	0	14	1	0	6	21
Santa Catalina Island	5	22	2	0	6	35
Shelf Zone						
Bays and Harbors (2-30 m)	0	0	0	18	0	18
Ports	0	0	0	3	0	3
Marinas	0	0	0	9	0	9
Other Bay	0	0	0	6	0	6
Inner Shelf (2-30 m)	5	1	35	7	0	48
Small POTWs	2	0	6	1	0	9
River Mouths	0	0	4	4	0	8
Other Mainland	3	1	21	2	0	27
Island	0	0	4	0	0	4
Middle Shelf (31-120 m)	74	42	16	0	0	132
Large POTWs	27	6	5	0	0	38
Mainland non-LPOTW	28	12	6	0	0	46
Small POTWs	14	0	0	0	0	14
Island	5	24	5	0	0	34
Outer Shelf (121-202 m)	2	39	0	0	31	72
Mainland	2	17	0	0	18	37
Island	0	22	0	0	13	35
Total	81	82	51	25	31	270

[a] CX = *Citharichthys xanthostigma* ; CSo = *Citharichthys sordidus* ; CSt = *Citharichthys stigmaeus;* PC = *Paralichthys californicus* ; LE = *Lyopsetta exilis*

POTW = Pubicly owned treatment work monitoring area.

BIOMARKER STUDY

Sampling Success

Of the 154 sites targeted for biomarker assessment, 48 (31%) yielded useable samples. Gall bladders were successfully collected from target species at 15 sites of the 76 Channel Island stations. Of the 78 bay/harbor sites, gall bladders were successfully collected at 33 sites. Mission Bay was the only location where no gall

Table 7. Number of stations by subpopulation and species with analyzed sanddab-guild composites, Southern California Bight 1998 Regional Survey, July-September 1998.

Subpopulation	Species Name[a]					Total
	CX	CSo	CSt	PC	LE	
Region						
Mainland	76	32	42	25	14	170
Northern	4	18	20	1	6	42
Central	37	6	16	13	5	71
Southern	35	8	6	11	3	57
Island	5	40	9	0	10	55
Cool (NW Channel Islands)	0	10	6	0	1	14
Warm	5	30	3	0	9	41
SE Channel Islands	0	12	1	0	4	15
Santa Catalina Island	5	18	2	0	5	26
Shelf Zone						
Bays and Harbors (2-30 m)	0	0	0	18	0	18
Ports	0	0	0	3	0	3
Marinas	0	0	0	9	0	9
Other Bay	0	0	0	6	0	6
Inner Shelf (2-30 m)	5	1	35	7	0	46
Small POTWs	2	0	6	1	0	9
River Mouths	0	0	4	4	0	8
Other Mainland	3	1	21	2	0	25
Island	0	0	4	0	0	4
Middle Shelf (31-120 m)	74	42	15	0	0	119
Large POTWs	27	6	5	0	0	14
Mainland non-LPOTW	28	12	6	0	0	32
Small POTWs	14	0	0	0	0	42
Island	5	24	5	0	0	31
Outer Shelf (121-202 m)	2	29	0	0	24	42
Mainland	2	13	0	0	14	22
Island	0	16	1	0	10	20
Total (all stations)	81	72	51	25	24	225

[a] CX = *Citharichthys xanthostigma*; CSo = *Citharichthys sordidus*; CSt = *Citharichthys stigmaeus;* PC = *Paralichthys californicus*; LE = *Lyopsetta exilis*

POTW = Pubicly owned treatment work monitoring area.

bladders were collected; a high volume of recreational boating activity in Mission Bay precluded sample collection. The fish from San Diego Bay exceeded the 20-cm size class by 1 cm. However, because the FAC results for these fish were not outside the range of the other fish collected, the results for San Diego Bay were included with the other data. The reduced sampling success at both strata was due to two factors: (1) target species were not collected at all stations; (2) the same species of fish were also being collected for tissue chemical analysis, and therefore were not available for dissection (the first six fish for each target species at each site were saved for bioaccumulation analysis).

Table 8. Age classes of sanddab guild fish composites distributed for chemical whole fish analysis in the Southern California Bight 1998 Regional Survey, July-September 1998.

Common Name	Scientific Name	Age Class	No. of Composites	% Total
California halibut	*Paralichthys californicus*	0	3	1
		1	22	8
speckled sanddab	*Citharichthys stigmaeus*	0	7	3
		1	44	16
longfin sanddab	*Citharichthys xanthostigma*	0	1	0
		1	79	29
		2	1	0
Pacific sanddab	*Citharichthys sordidus*	0	1	0
		1	69	26
		2	12	4
slender sole	*Lyopsetta exilis*	1	22	8
		2	9	3
All species combined		0	12	4
		1	236	87
		2	22	8
Total			270	

Table 9. Quality assurance/quality control (QA/QC) results for chemical analysis of whole fish samples in the Southern California Bight 1998 Regional Survey, July-September 1998.

QA/QC Parameter	Data Quality Objective	% Success
Completeness	? 90%	100
Holding Time	< 1 year	100
CRM Frequency [1]	1 per batch	100
CRM Accuracy	within specified ranges[2]	100
Duplicate Frequency	1 per batch	100
Duplicate Precision	< 30% RPD[3]	58 [4]
Blank Frequency	1 per batch	100
Blank Accuracy	No analytes > 3 MDL	100

[1] CRM = Certified Reference Material; CARP-1, National Research Council of Canada

[2] A mean value and an acceptable range were specified for each analyte.

[3] RPD = relative percent difference (i.e., the difference between two measurements, divided by the average value and presented as a percentage)

[4] In addition, 90% of the duplicate analyses were <60% RPD.

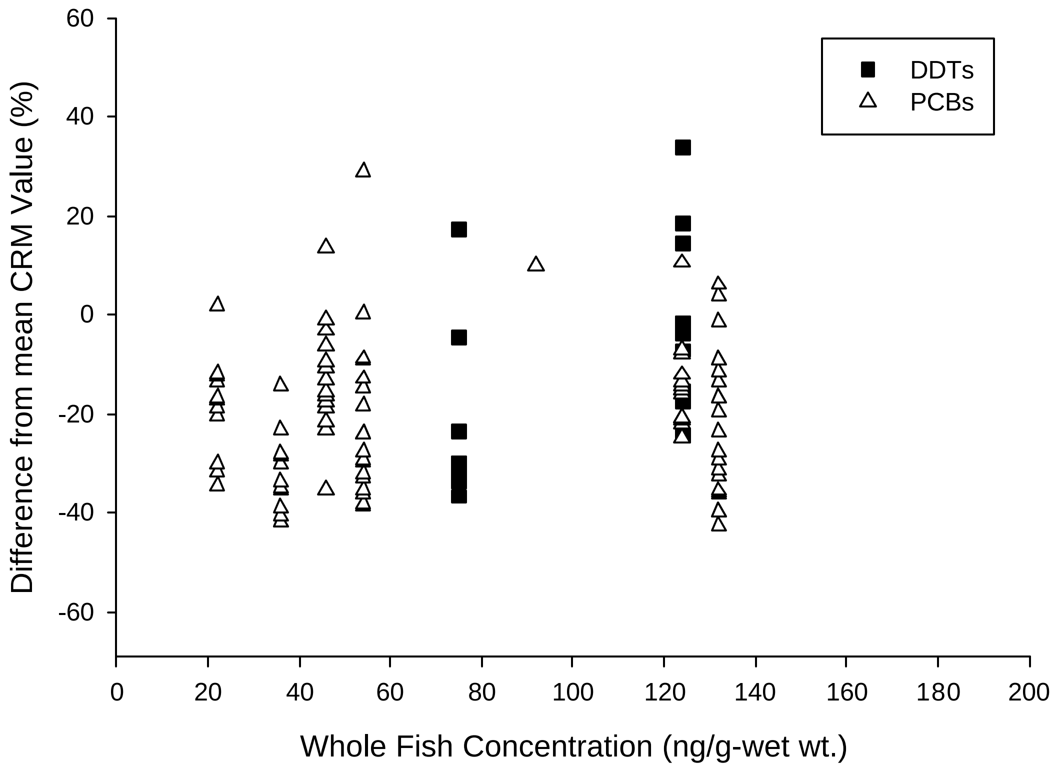


Figure 7. Difference from CARP-1 certified reference material (CRM) as a function of concentration and analyte (DDT and PCBs), Southern California Bight 1998 Regional Survey, July-September 1998.

Fish from the Channel Islands were originally targeted to represent the reference condition, to compare with the PAH exposure in bay/harbor fish. However, because there was no overlap of species in the two strata (Table 10), selection of the species for biomarker analysis was based on the abundance and distribution of each species collected, and the species selected for tissue chemistry analysis. For the bay/harbor stratum, the species selected was California halibut. This species was caught at 17 stations from 8 bay/harbor locations, including Ventura Harbor, Channel Islands Harbor, Marina del Rey, King Harbor, Long Beach Harbor, Alamitos Bay, Newport Bay, and San Diego Bay (Figure 4, Material and Methods chapter). For the Channel Islands, the species selected was Pacific sanddab, which was collected at 11 Channel Island stations.

FAC Analysis

All QA objectives were met for FAC analysis. The calibration response was linear, indicating an acceptable calibration. Values for all analyses of the reference bile measured at the start of each sample batch were within two standard deviations of the original value, indicating the method was reproducible. The BaP standard measured after every 7 samples was not always within 10% of the expected value (2 out of 21 samples were out of compliance). However, the bile samples in these batches were reanalyzed, and the BaP standards met the acceptance criteria.

DNA Damage Analysis

Collection of fish for DNA damage analysis was attempted at 154 stations; successful samples were obtained from 74 sites (48%) (Table 11). Samples were collected at 56 sites in the marina/harbor areas

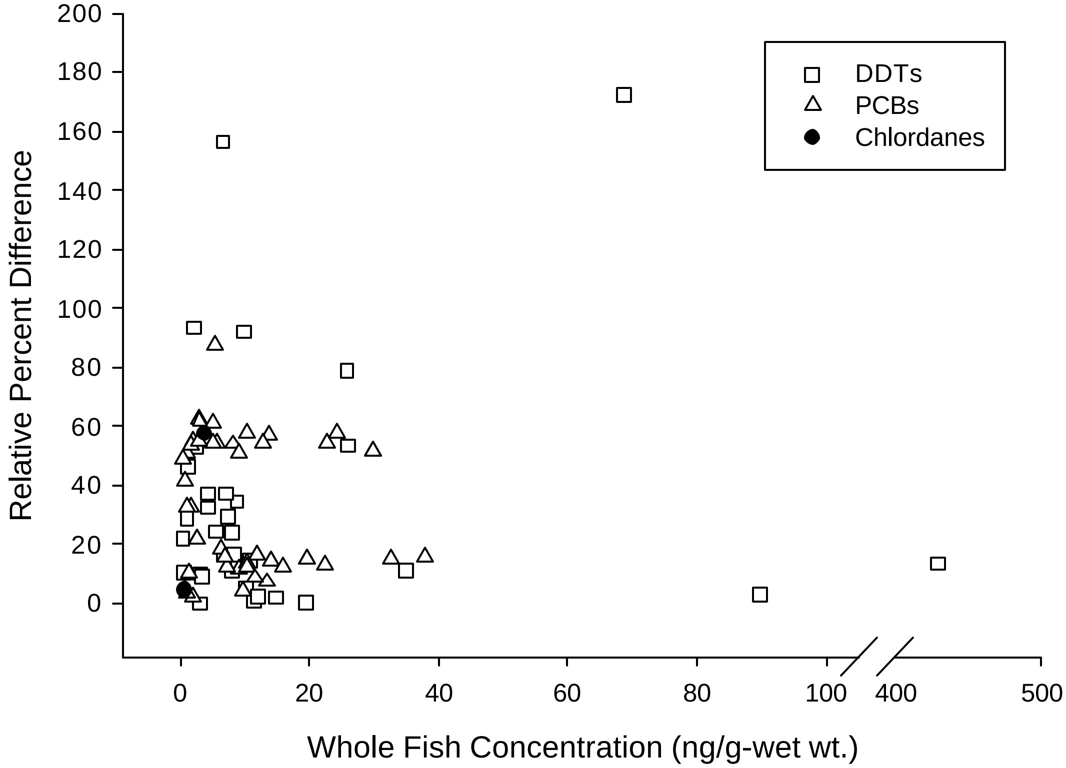


Figure 8. Relative percent difference in fish duplicate analyses as a function of concentration and analyte for duplicate whole fish composite samples, Southern California Bight 1998 Regional Survey, July-September 1998.

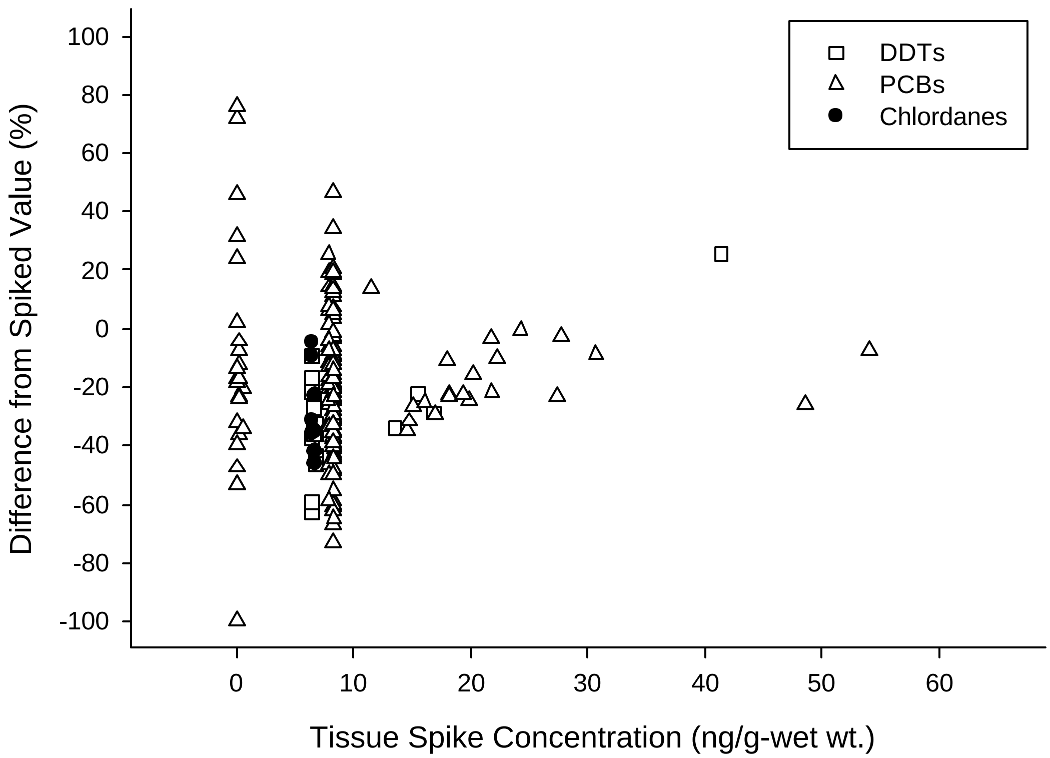


Figure 9. Analytical results from spiked fish tissues as a function of analyte and spike concentration. Orange roughy (*Hoplostethus atlanticus*) fillets were used for the fish tissues in the spiking experiments, Southern California Bight 1998 Regional Survey, July-September 1998.

Table 10. Sampling success for gall bladders in Bays/Harbors and Channel Islands subpopulations in the biomarker study of the Southern Bight 1998 Regional Survey, July-September 1998.

		Bays/Harbors		Channel Islands	
Scientific Name	Common Name	No. of Fish	No. of Stations	No. of Fish	No. of Stations
*Paralichthys californicus**	California halibut	58	21	-	-
Pleuronichthys ritteri	spotted turbot	17	11	-	-
Pleuronichthys guttulatus	diamond turbot	16	9	-	-
Pleuronichthys verticalis	hornyhead turbot	4	3	-	-
*Citharichthys sordidus**	Pacific sanddab	-	-	52	13
Citharichthys stigmaeus	speckled sanddab	-	-	11	3
Lyopsetta exilis	slender sole	-	-	8	2

* Species selected for analysis of fluorescent aromatic compounds FACs in fish bile. The number of fish collected does not reflect the number of FAC measurements because some fish had an insufficient volume of bile for analysis.

and at 18 sites off the Channel Islands. A total of 259 fish representing eight species of sanddab and turbot guild species were sampled; 159 were sanddab and turbot guild species in the marinas and 100 were sanddab guild species from the Channel Islands. In the marina stratum, California halibut comprised the most samples (99 specimens, or 62%) whereas Pacific sanddab comprised the most at the Channel Islands (76 specimens, or 76%).

Fish blood samples were all run with bird blood QA samples. All of the QA samples were within the acceptance range (Table 12). DNA damage was not detected in 38 fish samples (Table 13); 82% of these were Pacific sanddab.

DISCUSSION

Beneficial Features of the Quality Assurance Program for the Survey

Although quality control for organizations that routinely monitor demersal fish and invertebrates is typically defined within each organization, protocols and standards may vary between organizations. The success of a survey with participation by several organizations (in this case, nine) in the collection of trawl samples required a quality assurance program that would ensure data of good quality and comparability. The Quality Assurance Plan (B'98, SC 1998) for the study provided measurement quality objectives and general guidelines (e.g., field manual, quality control checks, etc.). These guidelines were reasonable and provided a method for assessing data quality.

A common field sampling method established the basic protocol for conducting the trawl survey and provided standard field data sheets. All participating agencies contributed persons with field sampling experience to assist in the development of the manual, and hence, all parties were bought into the protocol prescribed by the manual. This manual and the sampling plan were communicated to the chief scientists and boat captains to clarify any misunderstandings that might occur during the survey. The chief scientists were to communicate the protocol to their field crews prior to the survey. In general, this procedure worked well;

Table 11. Success at collecting fish samples for DNA damage analysis by subpopulation, Southern California Bight 1998 Regional Survey, July-September 1998.

a) Success at collected DNA samples

	Number of Stations		
	Bays/ Harbors	Channel Islands	Total
Attempted	78	76	154
Successful (for DNA samples)	56	18	74
Unsuccessful (no DNA samples)	22	58	80

b) Number of fish collected by species and number of sites

		Bays/Harbors		Channel Islands	
Scientific Name	Common Name	No. of Fish	No. of Stations	No. of Fish	No. of Stations
Paralichthys californicus	California halibut	99	26		
Pleuronichthys ritteri	spotted turbot	30	15		
Pleuronichthys guttulatus	diamond turbot	22	10		
Pleuronichthys verticalis	hornyhead turbot	6	4		
Citharichthys sordidus	Pacific sanddab			76	13
Citharichthys stigmaeus	speckled sanddab			14	3
Lyopsetta exilis	slender sole			10	2
Citharichthys xanthostigma	longfin sanddab	2	1		
	Total	159	56	100	18

but in some cases, field crews of previously participating organizations assumed procedures in the 1998 field manual (B'98, FSLC 1998) were the same as in the 1994 regional survey field manual (SCBPP 1994a), although slight changes were made between surveys. In addition, the field manual alone was not sufficient for organizations that did not participate in the 1994 survey and which were less familiar with procedures. As a result, some departures from gear type or sampling protocol occurred during the survey. Although there were individual equipment variations among the organizations, the basic trawling and processing procedures were the same. Future surveys should include additional time for presurvey quality assurance checks on both new and experienced organizations to ensure that proper gear types and protocol are used from the start of the survey.

Success at Meeting Measurement Quality Objectives

Trawl Sampling Success

Overall, the trawl survey was successful in meeting most of its MQOs (Table 5). As in 1994 (Allen et al. 1998), the survey was least successful at getting successful samples at nominal trawl stations (81%

Table 12. Quality assurance/quality control (QA*/QC) results for DNA damage study, Southern California Bight 1998 Regional Survey, July-September 1998.

Criterion	Count	Percent Total
Total number of fish sampled for comet analysis	261	100.0
Fish alive at time of dissection	192	73.6
Fish dead at time of dissection	69	26.4
Unreadable samples	2	0.8
Mislabeled samples (discarded[b])	2	0.8
Samples not received	2	0.8
Samples lost	2	0.8
Samples rerun	40	15.3
Samples with detectable nuclei	217	83.1
Samples with no detectable nuclei	38	14.6
Total Samples Run[c]	255	97.7

[a]All QA standards ran within the acceptable range.

[b]There were no samples discarded due to QA standard exceedence.

[c]Each set of samples run included bird blood QA standards.

Table 13. Number and characteristics of nondetectable DNA damage samples, Southern California Bight 1998 Regional Survey, July-September 1998.

Scientific Name	Common Name	# ND	% Total ND	# ND & Dead	% ND by Species
Paralichthys californicus	California halibut	3	8	0	3
Pleuronichthys ritteri	spotted turbot	0	-	0	-
Pleuronichthys guttulatus	diamond turbot	0	-	0	-
Pleuronichthys verticalis	hornyhead turbot	0	-	0	-
Citharichthys xanthostigma	longfin sanddab	0	-	0	-
Citharichthys stigmaeus	speckled sanddab	1	3	0	7
Citharichthys sordidus	Pacific sanddab	31	82	22	40
Lyopsetta exilis	slender sole	3	8	1	30
Total		38	100	23	-

ND = Nondetectable.

successful in 1994, and 69% in 1998). Success in collected fish tissue composites was similarly low (68%) in 1998, and reflects the success rate of sampling the nominal trawls. In both 1994 and 1998, the reduced success was due to lack of adequate prior knowledge of bottom trawlability prior to survey design. Much of the difficulty in 1998 occurred on the inner shelf of the Channel Islands, where most of the bottom consists of rocky reefs and outcroppings. In 1994, trawl success was least in the southern mainland region, due to sampling sites falling within the Point Loma kelp bed or obstructive debris offshore of San Diego Bay. In both surveys, trawl stations were selected from a stratified random sampling design, without prior knowledge of bottom conditions at a site. Hence, there was no assurance that a nominal site was a trawlable site. In contrast, trawl stations selected in routine POTW monitoring programs are selected in part due to their ability to be sampled as well as for their value in assessing wastewater discharge effects in the area. Such problems could be alleviated in the future by mapping hard-bottom areas and areas with failed trawls in previous surveys and excluding these areas from the trawl survey design.

Field sampling for the biomarker survey had limited success. Success at collecting fish livers and blood for biomarker studies was affected at the Channel Islands by a low number of field personnel due to limited onboard accommodations. Thus, it was difficult to dedicate one person for the dissection of live fish. Since obtaining assemblage trawl data had priority at a site, the processing of large catches often resulted in target fish dying before a dissector was available. In contrast, bay surveys had dedicated dissectors on hand but often were not able to collect the target species at a site. In addition to these problems, fish for DNA analysis were also affected by fish stress prior to and during dissections.

Taxonomic Goals

Prior to the survey, verification of taxonomic expertise among the agencies established a quality framework for biological data. We attempted to verify potential taxonomic problems prior to conducting the survey. Taxonomic workshops solidified agreement among various taxonomists regarding common and unusual species. More importantly, these workshops identified problematic species that should always be returned to laboratory for further identification. These procedures allowed postsurvey taxonomic verification to concentrate on questionable species rather than common ones. Postsurvey voucher verification added another layer of quality assurance to the data. The end result was fewer organisms that could not be identified to species.

Overall, the taxonomic identification success was above MQOs of 90% (Table 5). However, a large number of species were misidentified during audits or during postsurvey voucher checks (Appendix B2). In most cases, these were specimens from uncommon or rare species that were not abundant in the survey. Further, a relatively large number of unidentified specimens were submitted with vouchers. These had not been identified in the field and were sent to the collecting organization's laboratory for identification but could not be identified there. Future surveys should allow more time prior to sampling to help field workers improve their taxonomic skills, particularly with less commonly caught species.

Other Fish Processing Goals

Quality control auditors assessed the accuracy and precision of data collection in the field. Accuracy goals were met for enumeration, biomass, length, and examination of gross pathology (Table 5). However, while precision goals were generally met, goals for biomass and length were not. Biomass of a fish species placed in a bucket was measured using spring scales on a rocking boat. Although measurement limits were to the nearest 0.1 kg, boat motion may have reduced the precision of these measurements. Hosaka and Cassell (1996), comparing field bulk weights with laboratory bulk weights of the same sample, did not find that the method for recording bulk weight in the field was significantly affected by factors outside normal sampling error. Nevertheless, they suggested that many of the factors influencing biomass precision (i.e., vessel pitching and rolling, movement of spring scale) might be amplified during rough ocean conditions.

In addition, there was relatively low precision (high error) for length measurements (Table 5). Although measuring to centimeter size class might be assumed to have high precision, an individual's interpretation of size category might vary for lengths bordering two centimeter classes. A millimeter on one side or the other of the size class boundary results in a difference in reported length of one centimeter. However, centimeter size classing versus reporting of lengths in millimeters increases the speed of shipboard size measurements (which results in more trawls per day) and thus increases the ability to measure all fish collected.

Problems Associated with Sampling

Although site sampling by otter trawl appears to be simple, trawling in a consistent manner is not. Even under good conditions, the net does not catch everything in its path. The doors of the net sometimes do not drag on the bottom simultaneously. Ocean currents, sea surface swell, and weather may also hamper trawling. In some cases, the net may not be on the bottom when the chief scientist signals to begin or end a trawl. Recent GPS technology has provided a means to evaluate trawling variability under the assumption that the net is fishing properly and that geographic coordinates are recorded correctly. Nevertheless, in this survey, 69% of the trawls were within 100 m of the nominal site, 85% of the time within the depth criteria, and 50% of the time within 0.75-1.0 m/sec (1.5-2.0 kn) and 79% if increased to 1.2 m/sec (2.4 kn).

Nominal station coordinates were extracted from a geographic information system (GIS) program enhanced with strata (layers) representing the various subpopulations of interest. The underlying assumption was that the GIS layer accurately reflects true environmental conditions and the boat's navigation system can accurately guide the boat captain to the station. In both cases, the systems closely approximate the truth (good precision) but are not completely accurate. Human error in both systems can never be ruled out and would reduce precision. During trawling, the boat crew first deployed the net and then, once the net was on bottom, tried to ensure that the trawl path was as close as possible to the targeted station. Additional constraints included time, speed, and depth limits for each assemblage trawl.

By convention, the trawl path was represented by a beginning and ending trawl location. For assessment purposes, a straight line was drawn between the two points; but actual sampling conditions may have resulted in a trawl following an isobath that was not a straight line. The beginning location of a trawl only reflects the point where the field crew has let out the proper amount of wire for a station's depth. The ending location reflects the time the field crew began retrieving the wire. The assessment assumes the net starts and stops fishing at these two points. However, the actual scenario was likely that the net was not yet on the bottom at the start location and was still fishing at the end location. The assumption was that these two variables balance each other out.

To define a station as belonging to a stratum, any part of the trawl path must cross the assigned GIS layer originally designated during the design. Postsurvey analysis showed that two sites were not sampled within the assigned stratum. These stratum assignments were subsequently changed in the database from a "marina" site to an "other" site and from a "historical inner shelf" site to a "historical middle shelf" site.

Trawling random sites in shallow areas proved to be the least successful field sampling activity. In bays and harbors, shoals and anchorages were unaccounted for in the GIS layers during site selection. Hostile debris (resulting in torn nets) was a common occurrence. In the depth range between 6 and 30 m, islands typically had rocky reefs. Even deeper portions of the islands had rocky outcrops not noted on nautical charts. Bays/harbors and islands were new strata to this survey. Hostile debris was typically not noticed on boat fathometers and will remain an unavoidable problem in future surveys. To increase the sampling success rate in shallow areas, better quality GIS layers are needed to delineate trawlable versus untrawlable locations prior to sample allocation during the design phase of the study.

Vessel characteristics can affect speeds. Some boats had idle speeds greater than the trawling criteria, so they were put in and out of gear to slow their speeds. Chief scientists ended the trawl 93% of the time within 30 sec of 10 min. For the report, no sites were discarded due to undertrawling or overtrawling because they all fell within their assigned subpopulation. The true issues were data comparability among agencies and acceptable variability. The subpopulations were sampled using the same methodology. This trawling variability could be assumed for many historical sites with data. Historical trawling methodology was concerned about being in the right area rather than 100 m from a specific location and towing the net for 10 min along the same isobath. Investigators need to define a comfort level for acceptable variations and assume greater variability was associated with the historical data.

A presurvey discussion within the group revolved around the use of the historical 10-min trawls versus a 600-m trawl. The advent of GPS, signal receivers on boats, and removal of selective availability signal alteration has changed predicted accuracies to 10 m or better. The survey showed that field crews were not perfect in achieving a 10-min duration and boats had speed variability issues between sheltered areas (bays/harbors) and open coastal sites. Extrapolating trawl duration, from a perfect 600-m tow and average speeds demonstrated in the survey, would predict protected areas having 10.9-min trawls and open coast sites having 9.5-min trawls. A likely scenario would be that field crews could not achieve a perfect 600-m tow. The data does not resolve this issue of standardizing to distance with improving technologies or keeping the traditional timed tow. It shows that the trawl methodology was difficult to standardize because of environmental (e.g., wind, currents, swell, bottom structures) and physical (e.g., boat and field crew inconsistencies) factors.

DEMERSAL FISH POPULATIONS

INTRODUCTION

Demersal fishes (i.e., fishes living on or near the sea floor) occupy the soft-bottom habitat, the most widespread benthic habitat on the southern California mainland shelf. The soft-bottom habitat has been the focus of historic trawl studies because it can be easily sampled by trawl and it is also where most wastewater outfalls are placed. Demersal fishes are relatively sedentary compared to pelagic species; hence, they respond more readily to changes in the benthic environment and provide the best fish data for assessing the areal distribution of human effects on the southern California mainland shelf.

Local demersal fish populations have been studied extensively for more than 30 years (e.g., Carlisle 1969b; CSDLAC 1990; CLAEMD 1994a,b; CSDMWWD 1995; Stull 1995; CSDOC 1996; Stull and Tang 1996), but little was known about their spatial and temporal variability throughout the SCB. Past regional studies compiled trawl data from various times and places (SCCWRP 1973, Mearns *et al.* 1976, Allen and Voglin 1976, Allen 1977, Allen 1982) or collected data in reference surveys of limited scope (Allen and Mearns 1977, Word *et al.* 1977, Love *et al.* 1986, Thompson *et al*. 1987, 1993b). The first synoptic regional survey of this fauna in southern California was conducted in 1994 (Allen *et al*. 1998). Although this study provided substantial background information on the fauna of the southern California mainland shelf (10-200 m depth), it did not assess fish populations in bays and harbors or the islands located offshore of the SCB. A second regional survey was conducted in 1998 to provide additional region-wide background information on the status and health of fish populations, as well as to assess fish populations not only on the mainland shelf but also in bays and harbors and the offshore islands.

The objectives of this chapter are 1) to describe the distribution, relative importance (areal coverage, abundance, and biomass), and health of the dominant fish species of the southern California mainland shelf (including bays/harbors and islands), and of predetermined geographic, depth, and human influence subpopulations in 1998; 2) to assess population changes since 1994; and 3) to examine historical trends based on earlier studies. This information will provide a context for understanding local population patterns in routine monitoring studies to assess human impact. Other aspects of this fauna are presented in the Assemblages, Bioaccumulation, and Biomarkers chapters of this report.

RESULTS

Population Attributes

Abundance per Haul

A total of 62,265 fish were collected during the survey (Table 14). The number of fish collected per haul ranged from 0 to 2,102. The lowest individual value occurred at a station in the northern mainland region within the outer shelf zone (offshore of Santa Barbara), and the highest value occurred in the central mainland region within the bays/harbors subpopulation in Los Angeles/Long Beach (LA/LB) Harbor (Figure 10, Table 14). The median for the Bight as a whole was 136 individuals per haul, with subpopulation medians ranging from 20 (inner shelf, island region) to 226 (outer shelf, island region). Fish abundance was higher (more area above the Bight median) in the island region than in the mainland region (Table 14, Appendix

Table 14. Demersal fish abundance by subpopulation at depths of 2-202 m on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Total	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Abundance (no. individuals/haul)*									
Region									
Mainland	257	50,701	0	2,102	126	157	154	22	45.8
Northern	68	10,321	0	1,491	132	138	114	30	46.1
Central	114	28,532	2	2,102	111	162	198	40	35.0
Southern	75	11,848	6	1,208	145	186	136	49	58.0
Island	57	11,564	5	763	142	185	129	46	56.8
Cool (NW Channel Islands)	15	2,296	11	375	136	174	112	62	49.7
Warm	42	9,268	5	763	159	205	153	61	57.3
SE Channel Islands	16	3,318	5	554	144	196	146	80	52.7
Santa Catalina Island	26	5,950	25	763	207	229	168	65	67.3
Shelf Zone									
Bays and Harbors (2-30 m)	60	15,675	2	2,102	80	347	514	149	33.1
Ports	15	5,742	2	2,102	84	421	696	369	22.0
Marinas	18	1,757	2	464	64	97	120	56	11.0
Other Bay	27	8,176	6	1,612	85	415	477	205	47.0
Inner Shelf (2-30 m)	82	14,709	4	1,674	73	114	148	40	19.7
Small POTWs	15	1,690	6	584	37	120	165	83	21.0
River Mouths	31	9,435	4	1,674	138	302	409	143	51.4
Other Mainland	32	3,438	8	584	76	110	125	44	19.0
Island	4	146	11	71	20	36	24	24	0.0
Middle Shelf (31-120 m)	125	21,923	5	775	141	168	108	29	56.9
Large POTWs	32	6,997	23	775	169	219	182	63	56.3
Small POTWs	15	2,052	19	269	137	145	62	35	51.5
Mainland non-POTW	46	6,935	6	371	141	160	87	30	56.5
Island	32	5,939	5	554	139	174	119	55	53.6
Outer Shelf (121-202 m)	47	9,958	0	763	213	202	149	52	59.5
Mainland	26	4,479	0	569	132	170	147	59	45.9
Island	21	5,479	19	763	226	228	146	82	69.3
Total (all stations)	314	62,265	0	2,102	136	168	146	22	50.0

* The average area sampled during a trawl tow was 3,014 m^2.

CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number; SD = Standard deviation.

POTW = Publicly owned treatment work monitoring areas.

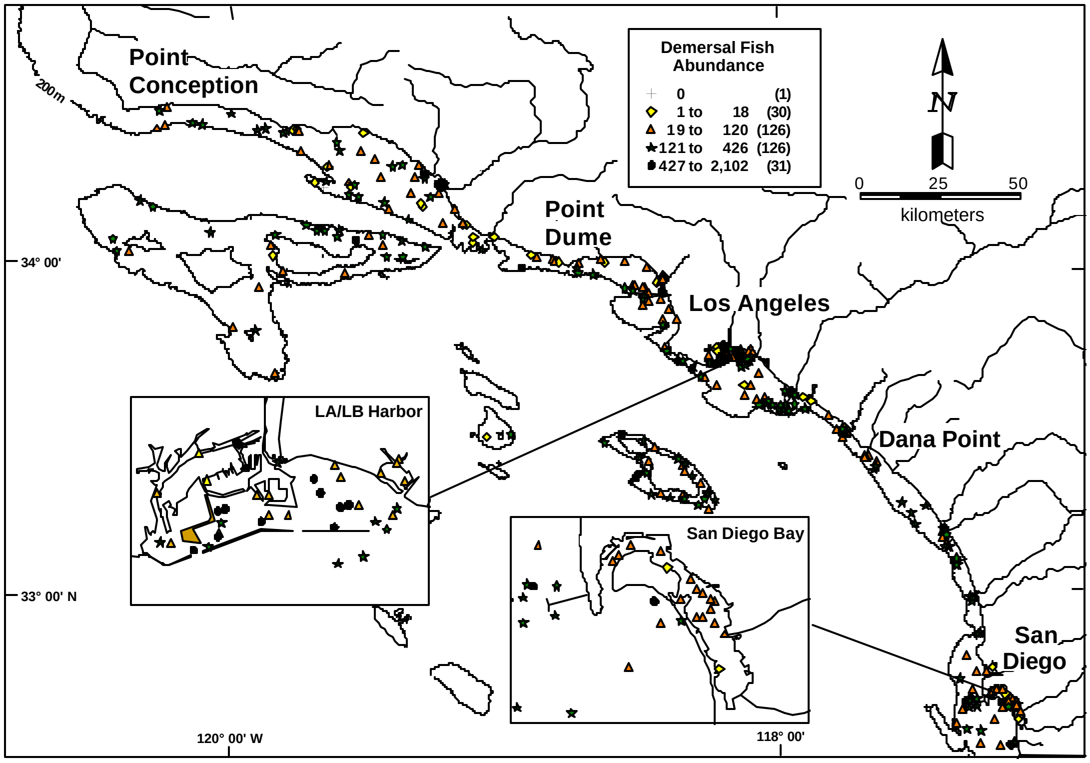


Figure 10. Distribution of fish abundance per haul at depths of 2-202 m on the southern California shelf, July-September 1998.

C1). The island region (all depths combined) had a median near or above the Bight median. Among these island subpopulations, the warm islands had higher fish abundance than the cool islands; median numbers of fish were 159 and 136, respectively. Among the mainland region subpopulations, the southern region had a higher median number of fish (145) than the northern (132) and central regions (111). When the different shelf zones were compared, the outer shelf had the highest median fish abundance, followed by the middle shelf, bays/harbors, and the inner shelf; median numbers of fish were 213, 141, 80, and 73, respectively. Within the outer shelf zone, the island region had higher catches than the mainland region (Table 14, Appendix C2). Within the middle shelf zone subpopulations, the large POTWs had the highest abundance and the small POTWs the lowest. Within the bays and harbors, the "other bays" subpopulation had more fish than the marinas and ports. The inner shelf zone had very low abundance overall except for the river mouth subpopulation, which had a relatively high median abundance of 138 (Table 14). Comparison of regions within shelf zones revealed that the highest median fish abundance (259) was found in the central mainland region within the outer shelf zone, followed by the southeast Channel Islands (240) within the outer shelf zone (Table 15, Appendix C3). At least 251 fish per haul were caught at 4 central mainland region outer shelf stations (Table 15). Overall, 31 stations had demersal fish abundance greater than or equal to 427 individuals per haul; these stations were concentrated in LA/LB Harbor (Figure 10).

Biomass per Haul

A total of 1,925.9 kg of fish were taken during the survey (Table 16). The biomass of fish per haul ranged from 0 (absent) to 60.4 kg. Fishes were absent from one trawl on the outer shelf off Santa Barbara (Figure 11). Values of 0.0 kg (i.e., <0.1 kg) occurred in the northern and central mainland regions within the outer shelf zone, as well as in ports and marinas within the bays/harbors subpopulation (Table 16). The highest

Table 15. Demersal fish abundance by region within shelf zone subpopulations on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Total	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Abundance (no. of individuals/haul)*									
Shelf Zone									
Bays and Harbors (2-30 m)	60	15,675	2	2,102	80	347	514	149	33.0
Northern Region	3	504	38	376	62	163	147	164	26.6
Central Region	36	13,831	2	2,102	105	295	374	136	44.0
Southern Region	21	1,340	6	464	33	60	92	40	8.8
Inner Shelf (2-30 m)	82	14,709	4	1,674	73	114	148	40	20.0
Northern Region	30	4,802	6	1,491	42	79	111	40	8.3
Central Region	30	6,321	4	1,674	77	130	146	64	28.8
Southern Region	18	3,440	23	1,208	105	180	199	139	33.0
NW Channel Islands	3	103	11	71	16	34	26	30	0.0
SE Channel Islands	0	0	0	0	0	0	0	0	0.0
Santa Catalina Island	1	43	43	43	43	43	0	0	0.0
Middle Shelf (31-120 m)	125	21,923	5	775	141	168	108	29	57.0
Northern Region	17	2,323	6	279	152	168	75	40	69.0
Central Region	44	7,185	12	598	113	134	107	48	30.7
Southern Region	32	6,476	62	775	171	202	101	49	65.0
NW Channel Islands	7	1,189	57	375	134	170	99	74	47.9
SE Channel Islands	10	1,750	5	554	125	178	152	98	43.0
Santa Catalina Island	15	3,000	39	489	164	200	127	64	56.8
Outer Shelf (121-202 m)	47	9,958	0	763	213	202	149	52	60.0
Northern Region	18	2,692	0	569	103	150	152	70	38.1
Central Region	4	1,195	251	383	259	299	52	51	100.0
Southern Region	4	592	43	240	50	97	54	61	80.9
NW Channel Islands	5	1,004	19	352	146	201	138	121	51.1
SE Channel Islands	6	1,568	63	417	240	264	96	65	80.9
Santa Catalina Island	10	2,907	25	763	212	291	201	125	81.3
Total (all stations)	314	62,265	0	2,102	136	168	146	22	50.0

* The average area sampled during a trawl tow was 3,014 m^2.

CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number; SD = Standard deviation.

POTW = Publicly owned treatment work monitoring areas.

biomass occurred in the southern mainland region within the inner shelf zone near a river mouth. The median for the Bight as a whole was 3.8 kg per haul, with subpopulation medians ranging from 0.4 kg (inner shelf, island region) to 9.5 kg ("other bays" in bays/harbors subpopulation). Fish biomass was higher (more area above the Bight median) at the islands than in the mainland region (Table 16, Appendix C4). However, only the cool northwest Channel Islands had greater than 50% area above the Bight median. The warm island

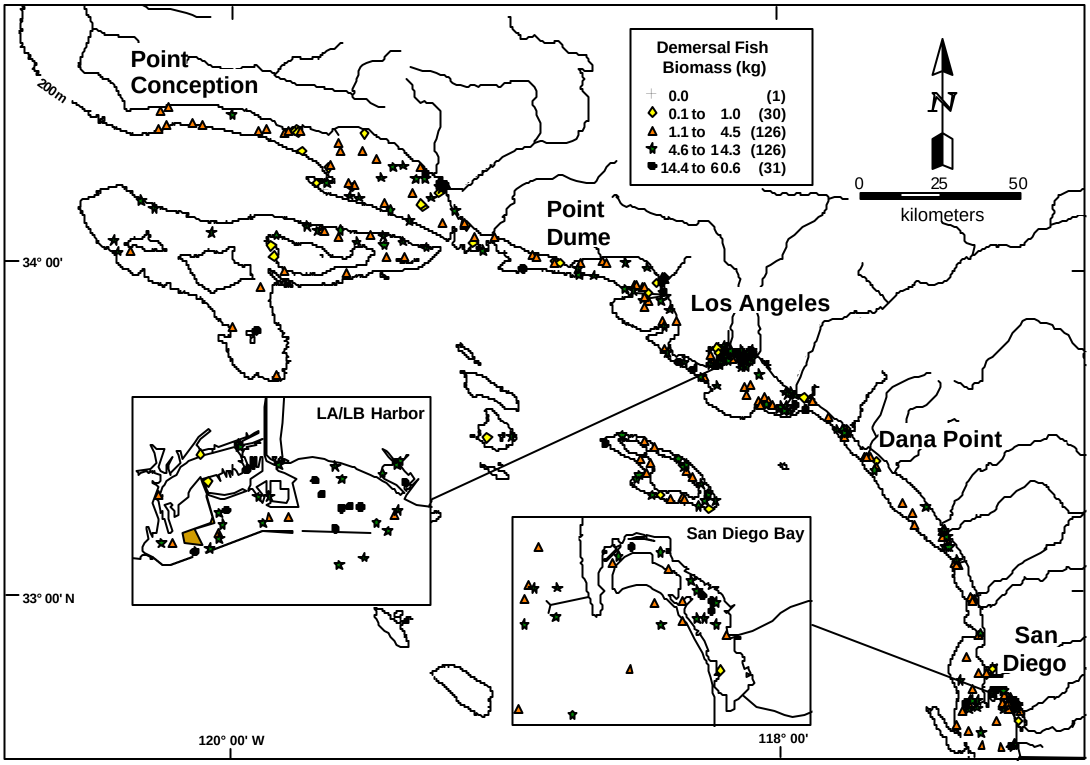


Figure 11. Distribution of fish biomass per haul at depths of 2-202 m on the southern California shelf, July-September 1998.

subpopulations (i.e., southeast Channel Islands and Santa Catalina Island) had medians of 3.5 and 3.7 kg, respectively, slightly below the Bight median. Among the mainland regions, the central region had a higher median fish biomass (4.7 kg) than the southern (3.6 kg) and northern regions (3.4 kg). The bays/harbors subpopulation had the highest median biomass (7.5 kg), followed by the outer shelf (5.4 kg), middle shelf(3.7 k), and inner shelf zones (2.9 kg) (Appendix C4). In the bays/harbors subpopulation, "other bays" had a higher median biomass than did the marinas and ports (Appendix C5). In the outer shelf zone, the island region had higher catches than the mainland region. In the middle shelf zone, the island region had the highest biomass and the mainland non-POTW subpopulation had the lowest. Overall, the inner shelf zone had low median biomass except for river mouths, which had a high median of 7.4 kg. Comparing regions within the shelf zones revealed that the highest median biomass (8.6 kg) was taken in the central mainland region within the bays/harbors subpopulation (Table 17, Appendix C6). A total of 353.9 kg of fish was taken from the 36 stations of the central mainland region. Overall, 31 stations had total fish biomass greater than or equal to 14.4 kg; most of these stations were again located in or around LA/LB Harbor (Figure 11).

Species Richness (Number of Species per Haul)

A total of 143 species of fish were taken during the survey (Table 18). The number of fish species per haul ranged from 0 to 26. The lowest value occurred in the northern mainland region within the outer shelf zone and the highest number of species occurred in the central mainland region within the middle shelf zone in the large POTW subpopulation. The median for the Bight as a whole was 11 species per haul, with subpopulation medians ranging from 5 (inner shelf, island region) to 14 (southeast Channel Islands, island region). More of the area with species richness above the Bight median occurred in the mainland region than in the island region (Table 18, Appendix C7). Among the islands, the southeast Channel Islands had more fish

Table 16. Demersal fish biomass by subpopulation at depths of 2-202 m on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Total	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Biomass (kg/haul)*									
Region									
Mainland	257	1651.9	0.0	60.4	3.6	4.5	4.9	0.9	41.0
Northern	68	302.6	0.0	25.0	3.4	3.4	3.7	1.0	28.1
Central	114	894.5	0.0	40.3	4.7	6.9	6.4	2.2	59.8
Southern	75	454.8	0.4	60.4	3.6	3.9	3.3	0.8	36.1
Island	57	274.0	0.2	17.6	5.1	5.2	3.6	1.3	59.4
Cool (NW Channel Islands)	15	81.4	0.3	17.6	5.6	5.9	3.8	1.8	64.6
Warm	42	192.7	0.2	14.8	3.7	4.0	2.8	1.0	45.3
SE Channel Islands	16	64.5	0.2	8.3	3.5	3.6	2.3	1.2	43.4
Santa Catalina Island	26	128.1	0.3	14.8	3.7	4.9	3.8	1.5	49.8
Shelf Zone									
Bays and Harbors (2-30 m)	60	559.3	0.0	48.3	7.5	9.7	8.5	2.3	70.9
Ports	15	87.8	0.0	18.0	4.2	5.8	4.8	2.4	68.6
Marinas	18	164.8	0.0	40.3	4.2	9.0	10.6	4.8	52.1
Other Bay	27	306.6	0.4	27.2	9.5	11.9	8.2	3.4	77.9
Inner Shelf (2-30 m)	82	504.3	0.0	60.4	2.9	3.6	3.8	0.9	40.5
Small POTWs	15	41.7	0.0	12.9	1.5	2.8	3.3	1.6	12.2
River Mouths	31	349.6	0.3	60.4	7.4	11.3	12.2	4.4	73.1
Other Mainland	32	108.2	0.1	13.7	3.2	3.5	2.8	1.0	41.9
Island	4	4.8	0.3	2.6	0.4	1.1	0.9	0.9	0.0
Middle Shelf (31-120 m)	125	571.5	0.1	26.3	3.7	4.4	3.8	0.9	46.9
Large POTWs	32	208.7	0.8	24.5	4.0	6.5	6.0	2.1	53.1
Small POTWs	15	64.1	0.2	10.9	3.6	4.2	2.4	1.2	42.1
Mainland non-POTW	46	183.7	0.1	26.3	3.4	4.2	4.5	1.6	37.4
Island	32	115.0	0.2	10.9	5.0	4.4	2.3	1.2	57.1
Outer Shelf (121-202 m)	47	291.0	0.0	24.6	5.4	6.7	5.8	2.2	57.7
Mainland	26	136.8	0.0	24.6	3.7	5.3	6.2	2.5	42.0
Island	21	154.2	0.3	17.6	6.4	7.9	5.0	3.3	70.2
Total (all stations)	314	1925.9	0.0	60.4	3.8	5.3	4.8	0.8	50.0

* The average area sampled during a trawl tow was 3,014 m^2.
CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number;
SD = Standard deviation.
POTW = Publicly owned treatment work monitoring areas.

species than both Santa Catalina Island and the northwest Channel Islands, with median numbers of species of 14, 12, and 10, respectively. Among the mainland region subpopulations, only the southern region had a median (12) above that of the Bight median, while the northern region (11) and central region (10) were slightly lower. Of the three shelf zones, the middle shelf and the outer shelf had the highest median number of species, followed by the bays and harbors and the inner shelf; with medians of 11, 11, 9, and 8, respectively (Table 18, Appendix C8). Within the mainland middle shelf zone, the non-large POTW subpopulation had the highest median number of species. Within the outer shelf zone, the mainland region had greater species richness than the island region. Within the bays and harbors subpopulation, ports had the highest median

Table 17. Demersal fish biomass by region within shelf zone subpopulations on the southern California shelf, July-September 1998.

					Area-Weighted Values				Percent
	No. of		Range					95%	Above Bight
Subpopulation	Stations	Total	Min.	Max.	Median	Mean	SD	CL	Median
Biomass (kg/haul)*									
Shelf Zone									
Bays and Harbors (2-30 m)	60	559.3	0.0	48.3	7.5	9.7	8.5	2.3	70.9
Northern Region	3	31.80	4.20	11.68	7.70	10.27	4.60	5.21	100.0
Central Region	36	353.91	0.00	40.28	8.60	8.37	6.70	2.43	76.1
Southern Region	21	174.04	0.40	27.20	4.30	7.22	7.50	3.29	50.9
Inner Shelf (2-30 m)	82	504.3	0.0	60.4	2.9	3.6	3.8	0.9	40.5
Northern Region	30	139.3	0.0	25.0	1.3	2.2	2.7	0.9	15.2
Central Region	30	234.4	0.4	39.9	4.9	5.7	3.7	1.7	78.8
Southern Region	18	125.8	0.8	60.4	3.3	3.6	4.7	1.6	34.1
NW Channel Islands	3	2.3	0.3	1.6	0.3	0.8	0.6	0.7	0.0
SE Channel Islands	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Santa Catalina Island	1	2.6	2.6	2.6	2.6	2.6	0.0	0.0	0.0
Middle Shelf (31-120 m)	125	571.5	0.1	26.3	3.7	4.4	3.8	0.9	46.9
Northern Region	17	50.2	0.1	9.9	2.6	3.7	2.7	1.5	28.8
Central Region	44	266.8	0.5	26.3	3.7	5.5	6.7	3.4	46.9
Southern Region	32	139.6	1.0	15.3	3.6	4.0	2.1	1.0	38.1
NW Channel Islands	7	35.7	1.8	8.7	5.2	5.1	2.1	1.6	65.7
SE Channel Islands	10	30.3	0.2	6.1	3.1	3.0	2.0	1.3	28.7
Santa Catalina Island	15	49.1	0.8	10.9	2.6	3.3	2.6	1.3	26.0
Outer Shelf (121-202 m)	47	291.0	0.0	24.6	5.4	6.7	5.8	2.2	57.7
Northern Region	18	82.0	0.0	24.6	3.7	4.6	5.7	2.6	38.4
Central Region	4	39.5	3.7	23.4	5.3	9.9	7.9	7.7	73.4
Southern Region	4	15.4	2.4	5.2	2.5	3.2	0.8	0.8	6.2
NW Channel Island	5	43.5	2.7	17.6	5.1	8.7	5.8	5.1	57.4
SE Channel Island	6	34.2	1.4	8.3	5.9	5.8	1.8	1.2	81.2
Santa Catalina Island	10	76.5	0.3	14.8	6.1	7.7	3.9	2.4	83.1
Total (all stations)	314	1,925.9	0.0	60.4	3.8	5.3	4.8	0.8	50.0

* The average area sampled during a trawl tow was 3,014 m^2.

CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number; SD = Standard deviation.

number of species followed by the "other bays" and lastly, marinas. The inner shelf zone had low median values, with river mouth and "other mainland" subpopulations having the highest median number of species (8). Comparing the regions within the shelf zones (Table 19) revealed that the highest median number of species (15) occurred on the outer shelf of the southeast Channel Islands (Appendix C9). Overall, 25 stations had catches greater than or equal to 17 species of fish. These stations were not concentrated in one area, but rather were distributed throughout the Bight as a whole (Figure 12). This was not the case in LA/LB Harbor (Figure 12), where the number of species per haul ranged from 5 to 16 species.

Table 18. Number of demersal fish species by subpopulation at depths of 2-202 m on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Total	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Number of Species (no. of Species/haul)*									
Region									
Mainland	257	126	0	26	11	11	5	1	45.1
Northern	68	76	0	23	11	11	5	2	50.3
Central	114	93	1	26	10	10	3	1	32.4
Southern	75	88	3	21	12	12	4	2	55.2
Island	57	79	1	21	11	11	4	1	33.9
Cool (NW Channel Islands)	15	49	2	18	10	10	3	2	15.4
Warm	42	69	1	21	13	12	5	2	68.0
SE Channel Islands	16	52	1	20	14	13	5	3	70.8
Santa Catalina Island	26	57	5	21	12	12	4	2	57.7
Shelf Zone									
Bays and Harbors (2-30 m)	60	49	1	15	9	9	3	1	31.2
Ports	15	24	1	14	10	9	4	2	44.0
Marinas	18	34	1	15	8	9	4	2	33.4
Other Bay	27	31	3	14	9	9	3	1	19.9
Inner Shelf (2-30 m)	82	61	1	16	8	8	3	1	9.6
Small POTWs	15	27	1	14	6	6	3	2	6.2
River Mouths	31	47	2	16	8	8	3	1	20.0
Other Mainland	32	43	2	14	8	8	3	1	10.0
Island	4	12	2	6	5	4	2	2	0.0
Middle Shelf (31-120 m)	125	89	1	26	11	12	4	1	48.0
Large POTWs	32	51	5	26	11	12	5	2	44.0
Small POTWs	15	33	4	18	8	9	3	2	19.0
Mainland non-POTW	46	56	3	23	12	13	4	1	62.0
Island	32	62	1	21	11	11	4	2	33.0
Outer Shelf (121-202 m)	47	62	0	21	11	12	5	2	48.0
Mainland	26	57	0	21	12	12	6	2	59.0
Island	21	45	6	18	10	12	4	2	39.0
Total (all stations)	314	143	0	26	11	10	4	1	50.0

* The average area sampled during a trawl tow was 3,014 m^2.

CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number; SD = Standard deviation.

POTW = Publicly owned treatment work monitoring areas.

Diversity per Haul

Fish diversity ranged from 0.00 to 2.43 bits/individual/haul (Table 20). Values of 0.00 occurred in the northern and central mainland regions, the the southeast Channel Islands, and in each shelf zone. By sub-population, these values were found in the port and marina subpopulations within bays and harbors; the inner shelf zone small POTW subpopulation; the middle shelf zone island subpopulation; and the outer shelf zone mainland subpopulation. The highest value (2.43) occurred in the central mainland region at

Table 19. Number of demersal fish species by region within shelf zone subpopulations on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Total	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Number of Species (no. of Species/haul)*									
Shelf Zone									
Bays and Harbors (2-30 m)	60	49	1	15	9	9	3	1	1.2
Northern Region	3	11	7	13	7	9	3	3	9.0
Central Region	36	39	1	15	10	8	3	1	36.6
Southern Region	21	26	3	15	7	8	3	2	13.1
Inner Shelf (2-30 m)	82	61	1	16	8	8	3	1	9.0
Northern Region	30	33	1	13	6	6	3	2	6.8
Central Region	30	42	2	16	9	9	2	1	1.3
Southern Region	18	39	3	15	9	9	4	3	31.8
NW Channel Islands	3	9	2	6	4	4	2	2	0.0
SE Channel Islands	0	0	0	0	0	0	0	0	0.0
Santa Catalina Island	1	5	5	5	5	5	0	0	0.0
Middle Shelf (31-120m)	125	89	1	26	11	12	4	1	48.0
Northern Region	17	39	3	23	14	14	3	2	76.4
Central Region	44	49	5	26	9	10	4	2	42.5
Southern Region	32	52	5	21	12	14	4	2	62.5
NW Channel Islands	7	30	5	15	9	10	3	2	14.3
SE Channel Islands	10	41	1	20	13	12	5	3	64.1
Santa Catalina Island	15	47	5	21	12	13	4	2	66.7
Outer Shelf (121-202m)	47	62	0	21	11	12	5	2	48.0
Northern Region	18	39	1	20	10	11	6	3	47.2
Central Region	4	29	11	21	14	15	4	4	75.0
Southern Region	4	33	12	19	12	14	2	2	100.0
NW Channel Islands	5	29	6	18	10	11	4	3	20.0
SE Channel Islands	6	31	8	16	15	14	3	2	79.2
Santa Catalina Island	10	30	6	17	10	11	3	2	55.0
Total (all stations)	314	143	0	26	11	10	4	1	50.0

* The average area sampled during a trawl tow was 3,014 m^2.
CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number;
SD = Standard deviation.
POTW = Publicly owned treatment work monitoring areas.

a middle shelf large POTW site. The median for the Bight as a whole was 1.53, with subpopulation medians ranging from 0.68 (inner shelf, island region) to 1.81 (southeast Channel Islands, island region). Diversity was higher (more area above the Bight median) in the mainland region than in the island region (Table 20, Appendix C10). Among the mainland region subpopulations, only the northern region had a median (1.80) above that of the Bight median, while the central (1.50) and southern regions (1.40) were slightly less. Among the islands, the southeast Channel Islands had greater diversity of fish than both Santa Catalina Island and the northwest Channel Islands; with median diversity numbers of 1.81, 1.45, and 1.26, respectively (Table 20). Comparing among shelf zones, the middle shelf had the greatest median number of species, followed by the outer shelf, inner shelf, and bays and harbors; with medians of 1.64, 1.57, 1.17, and 1.11, respectively (Table 20, Appendix C11). Within the mainland middle shelf

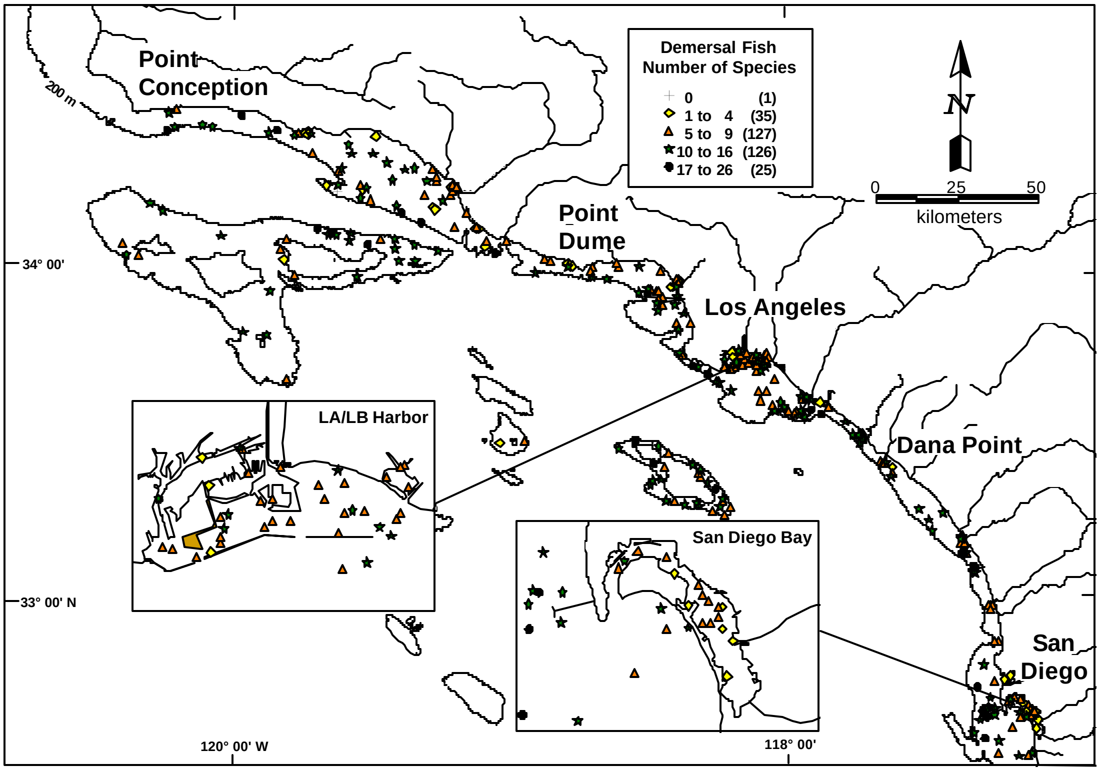


Figure 12. Distribution of number of fish species per haul at depths of 2-202 m on the southern California shelf, July-September 1998.

zone, the non-large POTW subpopulation had the highest median diversity. In the outer shelf zone, the mainland had higher diversity than the island . Within the bays and harbors subpopulation, the marinas had the highest diversity followed by the ports and lastly the “other bays”. The inner shelf zone had low median values for diversity, but the “other mainland” subpopulation had the highest diversity median of 1.26. The regions within the shelf zones were also compared (Table 21, Appendix C12). This comparison revealed the greatest median diversity (1.97) was in the northern mainland region within the middle shelf zone (Appendix C12). Overall, 31 stations had median diversity values greater than or equal to 2.012. The stations were spread along the range of the Bight; only one was found in LA/LB Harbor (Figure 13).

Species Composition

Taxonomic Composition

At least 142 species of fish, representing 4 classes and 57 families, were collected during the trawl survey (Appendix C13; alphabetical lists of species by common and scientific name are given in Glossary G2 and G3). These consisted of at least 123 species of ray-finned fishes (Actinopterygii), 17 species of cartilaginous fishes (Elasmobranchii), 1 species of hagfish (Myxini), and 1 species of ratfish (Holocephali). The most diverse families were Sebastidae (=Scorpaenidae, part; rockfishes) with 24 species; Pleuronectidae (right-eye flounders) with 11 species; and Paralichthyidae (sand Flounders), Cottidae (sculpins), Sciaenidae (drums), and Embiotocidae (surfperches) with 7 species. Two species, blacklip dragonet (*Synchiropus atrilabiatus*) and speckletail flounder (*Engyophrys sanctilaurentii*) were taken for the first time in California during this survey.

Table 20. Demersal fish diversity by subpopulation at depths of 2-202 m on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Shannon-Wiener Diversity (bits/individual/haul)								
Region								
Mainland	257	0.00	2.43	1.63	1.56	0.49	0.09	55.4
Northern	68	0.00	2.27	1.80	1.66	0.53	0.15	66.6
Central	114	0.00	2.43	1.50	1.52	0.44	0.14	48.4
Southern	75	0.10	2.38	1.40	1.45	0.47	0.20	40.3
Island	57	0.00	2.06	1.43	1.42	0.43	0.16	40.0
Cool (NW Channel Islands)	15	0.47	2.02	1.26	1.36	0.36	0.22	28.9
Warm	42	0.00	2.06	1.60	1.52	0.50	0.23	57.2
SE Channel Islands	16	0.00	2.05	1.81	1.56	0.55	0.31	64.4
Santa Catalina Island	26	0.65	2.06	1.45	1.43	0.36	0.14	34.3
Shelf Zone								
Bays and Harbors (2-30 m)	60	0.00	2.09	1.11	1.11	0.53	0.15	22.4
Ports	15	0.00	1.92	1.20	1.12	0.58	0.31	31.5
Marinas	18	0.00	1.93	1.34	1.26	0.54	0.25	30.0
Other Bay	27	0.15	2.09	0.99	1.04	0.49	0.20	15.9
Inner Shelf (2-30 m)	82	0.00	2.22	1.17	1.23	0.47	0.15	23.4
Small POTWs	15	0.00	2.22	0.87	0.92	0.62	0.32	15.3
River Mouths	31	0.10	2.20	1.17	1.12	0.50	0.18	18.3
Other Mainland	32	0.33	2.20	1.26	1.26	0.46	0.16	23.5
Island	4	0.47	1.04	0.68	0.78	0.23	0.23	0.0
Middle Shelf (31-120 m)	125	0.00	2.43	1.64	1.59	0.45	0.13	57.8
Large POTWs	32	0.61	2.43	1.62	1.63	0.39	0.13	63.8
Small POTWs	15	0.72	1.94	1.15	1.21	0.40	0.21	25.0
Mainland non-POTW	46	0.46	2.30	1.76	1.75	0.36	0.12	68.8
Island	32	0.00	2.06	1.35	1.40	0.46	0.22	40.6
Outer Shelf (121-202 m)	47	0.00	2.38	1.57	1.54	0.44	0.13	52.3
Mainland	26	0.00	2.38	1.76	1.59	0.60	0.24	65.5
Island	21	0.90	1.90	1.51	1.50	0.23	0.12	40.3
Total (all stations)	314	0.00	2.43	1.53	1.51	0.47	0.09	50.0

* The average area sampled during a trawl tow was 3,014 m^2.
CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number;
SD = Standard deviation.
POTW = Publicly owned treatment work monitoring areas.

Species Areal Occurrence

Of 142 species, relatively few occurred over a large proportion of the mainland shelf of the SCB. The equitability curve for areal occurrence was hyperbolic with a step-like appearance. The curve shows a sharp change in slope at 15 species with sharply increasing percent of area to the left and gradual decreasing percent of area to the right (Figure 14, Appendix C14). Individually, 17 species (12% of all species) occurred in over 20% and only 1 in over 50% of the total area (Table 22). The 6 most widely distributed species were Pacific sanddab, California lizardfish, plainfin midshipman (*Porichthys notatus*), bigmouth sole, California tonguefish (*Symphurus atricaudus*), and hornyhead turbot.

Table 21. Demersal fish diversity by region within shelf zone subpopulations on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Shannon-Wiener Diversity (bits/individual/haul)								
Shelf Zone								
Bays and Harbors (2-30 m)	60	0.00	2.09	1.11	1.11	0.53	0.15	22.4
Northern Region	3	0.68	1.47	0.99	1.15	0.33	0.37	0.0
Central Region	36	0.00	2.09	1.05	0.87	0.51	0.16	21.4
Southern Region	21	0.64	1.94	1.32	1.28	0.37	0.18	25.7
Inner Shelf (2-30 m)	82	0.00	2.22	1.17	1.23	0.47	0.15	23.4
Northern Region	30	0.00	2.20	1.08	1.23	0.47	0.23	21.6
Central Region	30	0.19	2.11	1.45	1.35	0.45	0.25	31.4
Southern Region	18	0.10	2.22	1.06	1.10	0.45	0.30	2.8
NW Channel Islands	3	0.47	1.04	0.70	0.81	0.24	0.28	0.0
SE Channel Islands	0	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Santa Catalina Island	1	0.65	0.65	0.65	0.65	0.00	0.00	0.0
Middle Shelf (31-120 m)	125	0.00	2.43	1.64	1.59	0.45	0.13	57.8
Northern Region	17	0.87	2.25	1.97	1.96	0.22	0.12	92.1
Central Region	44	0.61	2.43	1.63	1.64	0.35	0.17	54.8
Southern Region	32	0.46	2.30	1.58	1.56	0.40	0.24	50.7
NW Channel Islands	7	0.85	2.02	1.15	1.33	0.38	0.28	23.5
SE Channel Islands	10	0.00	2.05	1.74	1.53	0.61	0.39	60.0
Santa Catalina Island	15	1.09	2.06	1.52	1.58	0.31	0.16	46.5
Outer Shelf (121-202 m)	47	0.00	2.38	1.57	1.54	0.44	0.13	52.3
Northern Region	18	0.00	2.27	1.75	1.56	0.64	0.30	59.8
Central Region	4	0.83	1.96	1.63	1.56	0.44	0.43	62.5
Southern Region	4	1.63	2.38	1.67	1.90	0.26	0.31	100.0
NW Channel Islands	5	1.22	1.81	1.45	1.51	0.20	0.17	32.5
SE Channel Islands	6	1.46	1.90	1.55	1.64	0.17	0.17	51.7
Santa Catalina Island	10	0.90	1.83	1.26	1.28	0.27	0.17	13.5
Total (all stations)	314	0.00	2.43	1.53	1.51	0.47	0.09	50.0

* The average area sampled during a trawl tow was 3,014 m^2.

CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number; SD = Standard deviation.

POTW = Publicly owned treatment work monitoring areas.

Twenty species occurred in more than 50% of the area in at least one subpopulation (Table 23). A mean of 6 species occurred in more than 50% of the area of each subpopulation in the mainland and island regions, and a mean of 6 species occurred in more than 50% of the area of each shelf zone. Among the mainland and island regions, the southeast Channel Islands had the highest number of species (7) while the northern and central mainland regions and the northwest Channel Islands had the lowest (all with 5). Among the 3 shelf zones, the middle shelf had the highest number of species occurring in 50% or more of the area (9) and the bays and harbors had the least (2). Geographically, California lizardfish was the most common species in the northern and central mainland regions, whereas longfin sanddab was the most common species in

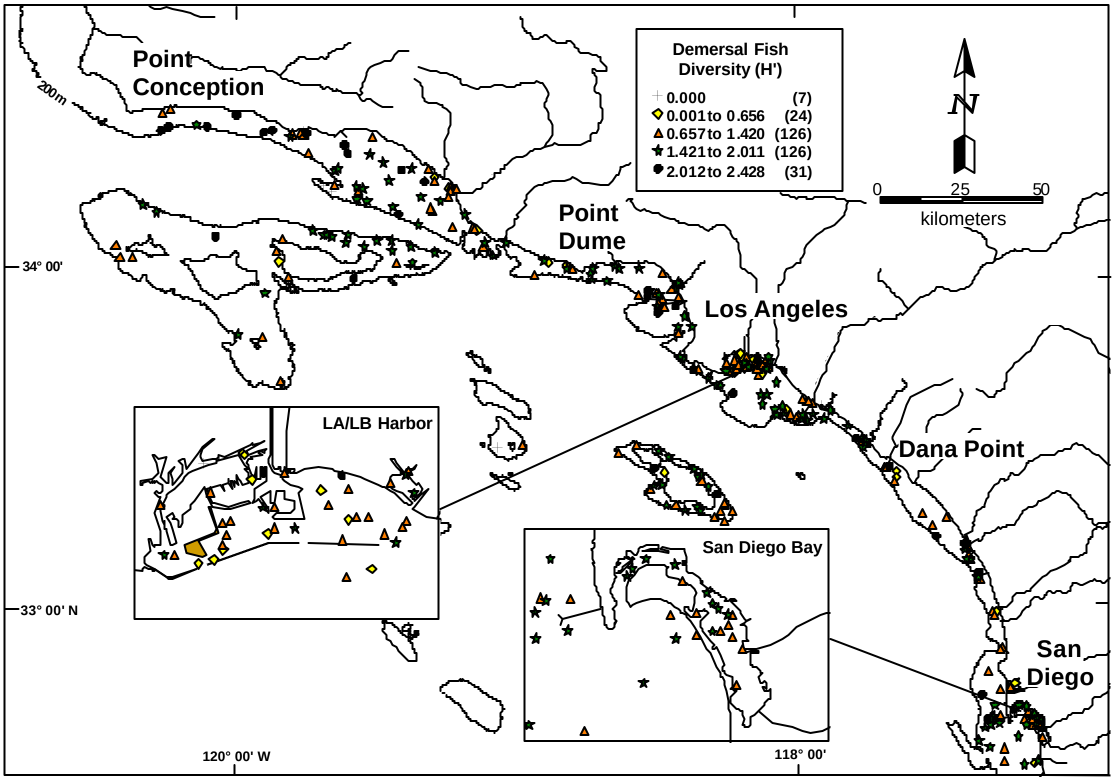


Figure 13. Distribution of fish diversity (Shannon-Wiener) per haul at depths of 2-202 m on the southern California shelf, July-September 1998.

the southern mainland region. Bathymetrically, speckled sanddab was the most common species in the inner shelf zone, Pacific sanddab in the middle and outer shelf zones, and California halibut in the bays and harbors. Pacific sanddab was the most common fish found on all of the islands. The most widespread species, Pacific sanddab, inhabited more than 50% of the area in 6 of the subpopulations, followed by the California lizardfish and the California tonguefish (5 subpopulations each). Six species occurred in more than 50% of the area of only a single subpopulation (by region and depth). Regional specificity occurred in curlfin sole (northwest Channel Islands); and spotfin sculpin (*Icelinus tenuis*) (Santa Catalina Island). Shelf zone specificity occurred in speckled sanddab, inner shelf zone; stripetail rockfish (*Sebastes saxicola*) and slender sole, both outer shelf zone; and white croaker, bays/harbors.

Species Abundance

The equitability curve of species abundance approximated a tight hyperbola that was much smoother than the areal occurrence curve (Figure 14), indicating that relatively few species dominated the overall abundance. There was a sharp change of slope at species 14, with those ranking to the left sharply increasing in abundance and those to the right gradually decreasing (Figure 14, Appendix C15). The 32 most abundant species (23% of all species) together accounted for 95% of abundance in the survey (Table 24). Four species accounted for approximately 50% of the total fish abundance: white croaker, Pacific sanddab, California lizardfish, and queenfish (*Seriphus politus*).

Combinations of 22 species comprised the top 80% of the abundance in each subpopulation (Table 25), with a mean of 9 species per subpopulation in the mainland and island regions. A mean of 6 species per subpopulation comprised 80% of the abundance in the shelf zones. On the mainland shelf, more species com-

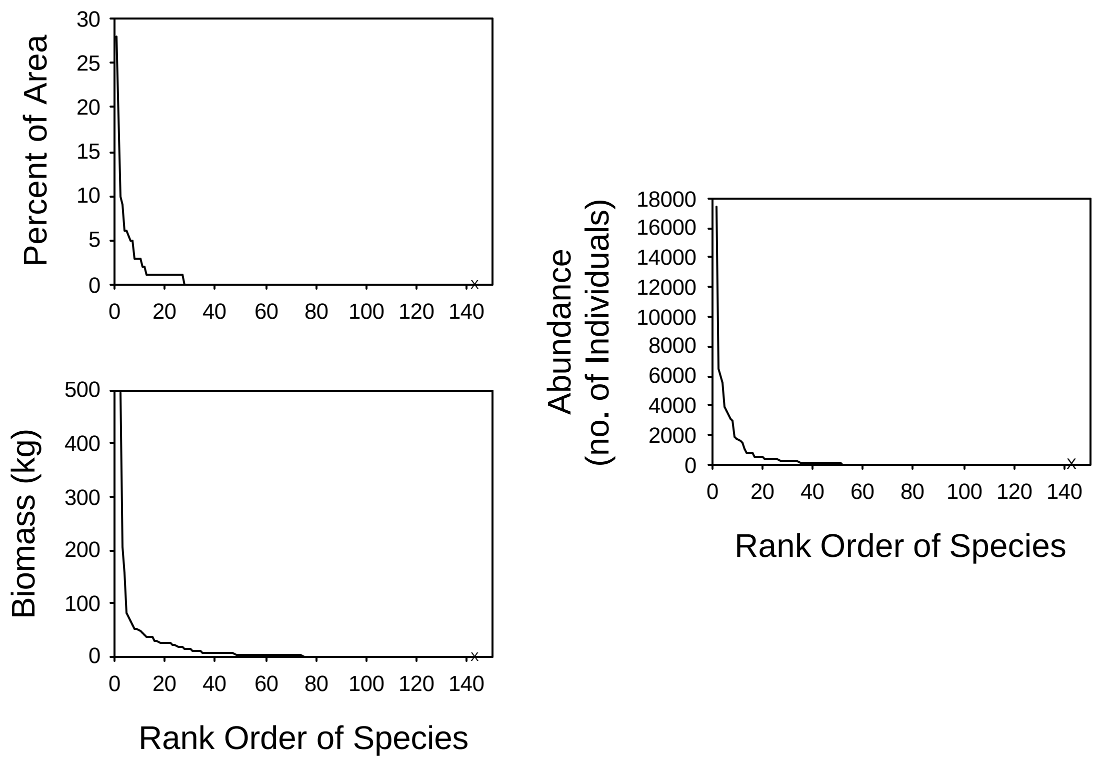


Figure 14. Equitability curves of fish occurrence, abundance, and biomass by species at depths of 2-202 m on the southern California shelf, July-September 1998. x=143rd species.

Table 22. Demersal fish species occurring in 20% or more of the area of the southern California shelf at depths of 2-202 m, July-September 1998.

Scientific Name	Common Name	No. of Stations	Percent of Stations	Percent of Area*
Citharichthys sordidus	Pacific sanddab	125	40	64.9
Synodus lucioceps	California lizardfish	167	53	49.9
Porichthys notatus	plainfin midshipman	86	27	48.8
Hippoglossina stomata	bigmouth sole	115	37	45.4
Symphurus atricaudus	California tonguefish	140	45	44.1
Pleuronichthys verticalis	hornyhead turbot	112	36	43.8
Zalembius rosaceus	pink seaperch	84	27	43.7
Microstomus pacificus	Dover sole	78	25	42.2
Zaniolepis latipinnis	longspine combfish	66	21	41.8
Parophrys vetulus	English sole	81	26	41.8
Icelinus quadriseriatus	yellowchin sculpin	89	28	39.4
Citharichthys stigmaeus	speckled sanddab	83	26	36.5
Sebastes saxicola	stripetail rockfish	70	22	35.0
Citharichthys xanthostigma	longfin sanddab	109	35	33.4
Zaniolepis frenata	shortspine combfish	58	18	30.2
Paralichthys californicus	California halibut	120	38	20.6
Chitonotus pugetensis	roughback sculpin	26	8	19.8

Total stations = 314.

Total area = 5,548 km^2.

*Based on area-weighted frequency of occurrences.

Table 23. Demersal fish species comprising 50% or more of the area by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	Percent of Area										
	Region										
	Mainland			Island			Shelf Zone				
Species*	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Pacific sanddab	55	-	-	98	98	85	-	-	77	91	65
California lizardfish	68	80	72	-	-	-	-	75	56	-	50
plainfin midshipman	-	-	-	72	72	-	-	-	56	81	-
bigmouth sole	-	61	61	-	51	73	-	-	64	-	-
California tonguefish	62	72	65	-	-	-	-	53	54	-	-
hornyhead turbot	-	68	-	-	-	-	-	53	54	-	-
pink seaperch	-	-	58	52	-	65	-	-	58	-	-
Dover sole	-	-	-	66	74	62	-	-	-	94	-
longspine combfish	55	-	-	-	62	-	-	-	59	-	-
English sole	56	-	-	-	57	-	-	-	-	60	-
yellowchin sculpin	-	-	65	-	-	-	-	-	61	-	-
speckled sanddab	-	-	-	-	-	-	-	79	-	-	-
stripetail rockfish	-	-	-	-	-	-	-	-	-	59	-
longfin sanddab	-	67	73	-	-	-	-	-	-	-	-
shortspine combfish	-	-	-	-	83	58	-	-	-	82	-
California halibut	-	-	-	-	-	-	66	73	-	-	-
slender sole	-	-	-	-	-	-	-	-	-	75	-
white croaker	-	-	-	-	-	-	62	-	-	-	-
curlfin sole	-	-	-	52	-	-	-	-	-	-	-
spotfin sculpin	-	-	-	-	-	50	-	-	-	-	-

* See Glossary G3 for scientific names of fish species.

"-"Species not occurring in at least 50% of the area, or absent.

N = Northern; C = Central; Southern; NWI = Northwest Channel Islands; SEI = Southeast Islands; CAT = Santa Catalina Island; B&H = Bays and Harbors; IS = Inner Shelf; MS = OS = Outer Shelf.

Total area (km^2) by subpopulation; N = 1,478; C = 1,214; S = 752; NWI = 1,365; SEI = 535; Cat = 205; SCB = 5,548.

prised 80% of the abundance in the southern region (12) and the northern region (10), while only 6 species comprised this abundance in the central region. Within the shelf zones, the middle shelf had the highest number of species (10), comprising 80% of the abundance. Fewer species made up this abundance on the inner shelf (3) and the bays and harbors (4). White croaker was the most abundant species in the northern and central mainland regions as well as the bays and harbors and the inner shelf zone. California lizardfish was the most abundant species in the southern mainland region and within the middle shelf zone. Slender sole was the most abundant species within the outer shelf zone, and Pacific sanddab was the most abundant species at the islands.

Species Biomass

The equitability curve of species biomass approximated a smooth hyperbola, similar to that for species abundance (Figure 14), although the curve for biomass was slightly more concave than the curve for

Table 24. Demersal fish species comprising 95% or more of the total fish abundance on the southern California shelf at depths of 2-202 m, July-September 1998.

Scientific Name	Common Name	Abundance	Total Percent	Cumulative Percent
Genyonemus lineatus	white croaker	17,442	28.0	28.0
Citharichthys sordidus	Pacific sanddab	6,450	10.4	38.4
Synodus lucioceps	California lizardfish	5,573	9.0	47.3
Seriphus politus	queenfish	3,854	6.2	53.5
Citharichthys xanthostigma	longfin sanddab	3,579	5.7	59.3
Engraulis mordax	northern anchovy	3,105	5.0	64.2
Lyopsetta exilis	slender sole	2,949	4.7	69.0
Symphurus atricaudus	California tonguefish	1,862	3.0	72.0
Icelinus quadriseriatus	yellowchin sculpin	1,747	2.8	74.8
Microstomus pacificus	Dover sole	1,635	2.6	77.4
Porichthys notatus	plainfin midshipman	1,459	2.3	79.7
Citharichthys stigmaeus	speckled sanddab	1,105	1.8	81.5
Sebastes saxicola	stripetail rockfish	822	1.3	82.8
Zaniolepis frenata	shortspine combfish	774	1.2	84.1
Zaniolepis latipinnis	longspine combfish	759	1.2	85.3
Zalembius rosaceus	pink seaperch	538	0.9	86.2
Anchoa compressa	deepbody anchovy	520	0.8	87.0
Lepidogobius lepidus	bay goby	480	0.8	87.8
Paralichthys californicus	California halibut	474	0.8	88.5
Paralabrax nebulifer	barred sand bass	440	0.7	89.2
Cymatogaster aggregata	shiner perch	405	0.7	89.9
Parophrys vetulus	English sole	397	0.6	90.5
Hippoglossina stomata	bigmouth sole	396	0.6	91.2
Pleuronichthys verticalis	hornyhead turbot	393	0.6	91.8
Argentina sialis	Pacific argentine	361	0.6	92.4
Sardinops sagax	Pacific sardine	319	0.5	92.9
Lycodes pacificus	blackbelly eelpout	317	0.5	93.4
Phanerodon furcatus	white seaperch	302	0.5	93.9
Icelinus tenuis	spotfin sculpin	297	0.5	94.4
Xeneretmus latifrons	blacktip poacher	259	0.4	94.8
Urolophus halleri	round stingray	201	0.3	95.1
Porichthys myriaster	specklefin midshipman	196	0.3	95.4

Total abundance = 62,265 fish

species abundance. There was a sharp change of slope at species 7, with those ranking to the left sharply increasing in biomass and those to the right gradually decreasing (Figure 14, Appendix C16). As with the percent of area and abundance curves, relatively few species dominated the overall biomass. Forty-four species (31% of all species) accounted for the top 95% of biomass in the survey (Table 26). Five species accounted for approximately 50% of the total fish biomass: white croaker, Pacific sanddab, California halibut, longfin sanddab, and queenfish.

Combinations of 30 species also made up the top 80% of the biomass in each subpopulation (Table 27), with a mean of 10 species per subpopulation in the mainland and island regions and a mean of 9 species in the shelf zones. More species (16) comprised 80% of the biomass in the southern mainland region, followed by the central mainland region (13). Fewer species comprised this biomass at Santa Catalina Island (5).

Table 25. Demersal fish species comprising 80% or more of the fish abundance by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	Percent of Catch Abundance										
	Region										
	Mainland			Island			Shelf Zone				
Species*	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
white croaker	24	45	17	-	-	-	55	56	2	-	28
Pacific sanddab	13	-	3	36	30	38	-	-	17	27	10
California lizardfish	6	8	22	-	-	-	-	7	20	-	9
queenfish	17	6	3	-	-	-	6	20	-	-	6
longfin sanddab	-	5	15	-	-	3	-	-	16	-	6
northern anchovy	-	11	-	-	-	-	18	-	-	-	5
slender sole	7	-	-	6	13	16	-	-	-	29	5
California tonguefish	2	5	-	-	-	-	3	-	5	-	3
yellowchin sculpin	3	-	3	3	6	7	-	-	8	-	3
Dover sole	3	-	2	-	12	6	-	-	3	10	3
plainfin midshipman	2	-	6	4	6	-	-	-	5	4	2
speckled sanddab	3	-	-	15	-	-	-	-	2	-	-
stripetail rockfish	-	-	-	-	4	-	-	-	-	5	-
shortspine combfish	-	-	-	11	8	-	-	-	-	6	-
longspine combfish	-	-	2	-	3	-	-	-	3	-	-
pink seaperch	-	-	2	-	-	-	-	-	-	-	-
deepbody anchovy	-	-	4	-	-	-	-	-	-	-	-
bay goby	-	-	-	-	-	7	-	-	-	-	-
Pacific argentine	-	-	-	-	-	3	-	-	-	-	-
spotfin sculpin	-	-	-	4	-	-	-	-	-	-	-
blacktip poacher	-	-	-	4	-	-	-	-	-	-	-
round stingray	-	-	2	-	-	-	-	-	-	-	-

* See Glossary G3 for scientific names of fish species.
"-" = Species absent or not included in the top 80%.
N = Northern; C = Central; S = Southern; NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; CAT = Santa Catalina Island; B&H = Bays and Harbors; IS = Inner Shelf; MS = Middle Shelf; OS = Outer Shelf; SCB = Southern California Bight.
Total catch abundance (no. of individuals) by subpopulation: N = 10,321; C = 28,532; S = 11,848; NWI = 2,296; SEI = 3,318; CAT = 5,950; B & H = 15,675; IS = 14,709; MS = 21,923; OS = 9,958; SCB = 62,265.

Among the shelf zones, the middle shelf had the highest number of species (13) while the inner shelf had the least (5) number of species, comprising 80% of the abundance. Geographically, white croaker was the biomass dominant in the northern, central, and southern mainland regions. For the island stations, Pacific sanddab was the biomass dominant in all regions. Bathymetrically, white croaker dominated both the bays/harbors and the inner shelf zone, while Pacific sanddab dominated the middle shelf and outer shelf zones.

Table 26. Demersal fish species comprising 95% or more of the total fish biomass on the southern California shelf at depths of 2-202 m, July-September 1998.

Scientific Name	Common Name	Biomass (kg)	Percent	Cumulative Percent
Genyonemus lineatus	white croaker	494.4	25.7	25.7
Citharichthys sordidus	Pacific sanddab	204.4	10.6	36.3
Paralichthys californicus	California halibut	156.4	8.1	44.4
Citharichthys xanthostigma	longfin sanddab	83.4	4.3	48.7
Seriphus politus	queenfish	67.2	3.5	52.2
Synodus lucioceps	California lizardfish	60.9	3.2	55.4
Urolophus halleri	round stingray	50.6	2.6	58.0
Squatina californica	Pacific angel shark	50.3	2.6	60.6
Lyopsetta exilis	slender sole	48.0	2.5	63.1
Paralabrax nebulifer	barred sand bass	42.5	2.2	65.3
Parophrys vetulus	English sole	41.4	2.1	67.5
Paralabrax maculatofasciatus	spotted sand bass	37.9	2.0	69.4
Pleuronichthys verticalis	hornyhead turbot	37.1	1.9	71.4
Myliobatis californica	bat ray	36.1	1.9	73.2
Microstomus pacificus	Dover sole	30.2	1.6	74.8
Porichthys notatus	plainfin midshipman	27.4	1.4	76.2
Raja inornata	California skate	26.6	1.4	77.6
Hippoglossina stomata	bigmouth sole	25.8	1.3	79.0
Symphurus atricaudus	California tonguefish	24.6	1.3	80.2
Dasyatis dipterura	diamond stingray	24.0	1.2	81.5
Scorpaena guttata	California scorpionfish	23.4	1.2	82.7
Phanerodon furcatus	white seaperch	20.0	1.0	83.7
Xystreurys liolepis	fantail sole	19.9	1.0	84.8
Zaniolepis latipinnis	longspine combfish	16.8	0.9	85.6
Sebastes saxicola	stripetail rockfish	16.8	0.9	86.5
Pleuronichthys guttulatus	diamond turbot	16.3	0.8	87.3
Zaniolepis frenata	shortspine combfish	15.7	0.8	88.2
Porichthys myriaster	specklefin midshipman	14.3	0.7	88.9
Pleuronichthys ritteri	spotted turbot	11.9	0.6	89.5
Cheilotrema saturnum	black croaker	10.1	0.5	90.0
Citharichthys stigmaeus	speckled sanddab	9.4	0.5	90.5
Torpedo californica	Pacific electric ray	9.1	0.5	91.0
Zalembius rosaceus	pink seaperch	8.5	0.4	91.4
Sardinops sagax	Pacific sardine	7.5	0.4	91.8
Roncador stearnsii	spotfin croaker	7.3	0.4	92.2
Lycodes pacificus	blackbelly eelpout	7.2	0.4	92.6
Cymatogaster aggregata	shiner perch	7.0	0.4	93.0
Umbrina roncador	yellowfin croaker	6.5	0.3	93.3
Rhinobatos productus	shovelnose guitarfish	6.5	0.3	93.6
Icelinus quadriseriatus	yellowchin sculpin	5.9	0.3	93.9
Menticirrhus undulatus	California corbina	5.8	0.3	94.2
Engraulis mordax	northern anchovy	5.7	0.3	94.5
Merluccius productus	Pacific hake	5.5	0.3	94.8
Platyrhinoidis triseriata	thornback	5.0	0.3	95.1

Total biomass = 1,925.9 kg.

Table 27. Demersal fish species comprising 80% or more of the fish biomass by sub-population on the southern California shelf at depths of 2-202 m, July-September 1998.

	Percent of Catch Biomass (kg)										
	Region										
	Mainland			Island			Shelf Zone				
Species*	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
white croaker	34	35	17	-	-	-	32	55	7	-	26
Pacific sanddab	14	-	1	57	42	56	-	-	15	41	11
California halibut	4	11	8	-	-	-	8	11	9	-	8
longfin sanddab	1	4	8	-	-	4	-	-	14	-	4
queenfish	8	4	-	-	-	-	3	10	-	-	3
California lizardfish	2	3	5	-	-	-	-	2	9	-	3
roung stingray	-	-	11	-	-	-	9	-	-	-	3
Pacific angel shark	-	6	-	-	-	-	9	-	-	-	3
slender sole	3	-	-	-	9	13	-	-	-	16	2
barred sand bass	-	3	3	-	-	-	5	-	-	-	2
English sole	4	2	1	3	6	-	-	-	4	6	2
spotted sand bass	-	-	8	-	-	-	7	-	-	-	2
hornyhead turbot	-	3	-	-	-	-	-	2	4	-	2
bat ray	4	3	-	-	-	-	5	-	-	-	2
Dover sole	-	-	-	4	7	4	-	-	-	7	2
plainfin midshipman	2	-	2	3	5	-	-	-	3	4	1
California skate	-	2	1	-	-	-	-	-	3	-	1
bigmouth sole	-	2	-	-	-	-	-	-	4	-	1
California tonguefish	-	2	-	-	-	-	-	-	3	-	-
diamond stingray	-	-	5	-	-	-	4	-	-	-	-
California scorpionfish	-	-	2	-	-	-	-	-	4	-	-
white seaperch	3	-	-	-	-	-	-	-	-	-	-
longspine combfish	-	-	2	-	-	-	-	-	3	-	-
stripetail rockfish	-	-	-	-	4	-	-	-	-	4	-
diamond turbot	-	-	1	-	-	-	-	-	-	-	-
shortspine combfish	-	-	-	7	6	-	-	-	-	4	-
black croaker	-	-	2	-	-	-	-	-	-	-	-
speckled sanddab	-	-	-	4	-	-	-	-	-	-	-
petrale sole	-	-	-	-	-	3	-	-	-	-	-
swell shark	-	-	-	3	-	-	-	-	-	-	-

* See Glossary G3 for scientific names of fish species.
"-" = Species absent or not included in the top 80%.
N = Northern; C = Central; S = Southern; NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; CAT = Santa Catalina Island; B&H = Bays and Harbors; IS = Inner Shelf; MS = Middle Shelf; OS = Outer Shelf; SCB = Southern California Bight.
Total catch biomass (kg) by subpopulation; N = 302.6; C = 894.5; S = 454.8; NWI = 81.4; SEI = 64.5; CAT = 128.1; B&H = 559.1; IS = 504.3; MS = 571.5; OS = 291.0; SCB = 1,925.0 kg.

Species Distributions

The distributions of 10 species with high occurrence, abundance, and/or biomass are described below. Each paragraph describes the distribution and habitat preference of the 10 selected species. The numbers following each species' name are the abundance rank and the biomass rank, respectively.

Pacific Sanddab (*Citharichthys sordidus*) (2, 2). Pacific sanddab is a middle shelf and outer shelf species that occurred in 65% of the area and represented 10% of the fish abundance and 11% of the biomass

(Tables 22, 24, and 26). Pacific sanddab was the numerical dominant at the islands (Table 25) and was the top biomass contributor in the middle and outer shelf zones, and at the islands (Table 27). It accounted for 38% of the catch at Santa Catalina Island (Table 25) and comprised 57% of the biomass at the northwest Channel Islands (Table 27). Over 157 fish were taken from 9 stations, mainly located around the islands, except for 1 station located off San Diego Bay and 1 site located northwest of Point Dume. Over 283 fish were taken at 1 station, also located northwest of Point Dume (Appendix C17). The largest amount of biomass, 15.4 kg, was taken from a station located northwest of Point Dume off Ventura.

White Croaker (*Genyonemus lineatus*) (1, 1). White croaker is an inner shelf species that occurred in 17% of the area and represented 28% of the total abundance and 26% of the total biomass (Appendix C14; Tables 24 and 26). White croaker was the numerical dominant in the northern and central mainland regions, as well as within the bays/harbors and inner shelf zone (Table 25). It was also a main contributor of biomass in all mainland regions and in the bays /harbors and inner shelf zone (Table 27). White croaker was found in all mainland regions and within most shelf zones, excluding the outer shelf; but it was not found at any island station (Appendix C18). Over 987 fish were taken from 3 stations; 2 were located in LA/LB Harbor and the other was located south of San Diego. The largest catch (1,776 individuals) was taken at 1 station in LA/LB Harbor. The largest biomass, 53.7 kg, was taken at a coastal station located south of San Diego.

Longfin Sanddab (*Citharichthys xanthostigma*) (5, 4). Longfin sanddab is a middle shelf species that occurred in 33% of the area and contributed 6% of the total abundance and 4% of the biomass (Tables 22, 24, and 26). Longfin sanddab was not the numerical dominant in any of the regions or shelf zones but was the second highest contributor of biomass in the middle shelf zone (Tables 25 and 27). It was found in all the mainland regions, at Santa Catalina Island, and in all of the shelf zones except bays and harbors (Appendix C19). More than 76 fish per station were taken from 9 stations located off the mainland between Los Angeles and southern San Diego. The largest catch (139 fish) was taken just south of San Diego Bay. The largest biomass of at least 3.3 kg was taken from 1 site located south of San Diego.

California Halibut (*Paralichthys californicus*) (19, 3). California halibut is an inner shelf species that was not a numerically dominant species (0.8%); but it accounted for 8% of the total biomass and was found in 21% of the area (Tables 22, 24, and 26). California halibut was found in all mainland regions, at Santa Catalina Island, and in all shelf zones except the outer shelf (Appendix C16). It was the second highest contributor of biomass in the central mainland region and the inner shelf zone (Table 27). The second largest catch of 14 individuals occurred in 6 sites, 4 of which were located in LA/LB Harbor. The largest catch (24 individuals) occurred at 1 site located in the San Diego Bay (Appendix C20). The largest biomass of 8.7 kg was taken at 1 station located in LA/LB Harbor.

Plainfin Midshipman (*Porichthys notatus*) (11, 17). Plainfin midshipman is a middle shelf species that occurred in 49% of the area and represented only 2% of the total abundance and 1% of the biomass (Tables 22, 24, and 26). This species occurred in more than 50% of the area at the northwest Channel Islands, the southeast Channel Islands, the middle shelf zone, and the outer shelf zone (Table 23). The largest catch of 267 specimens was taken from 1 site off San Diego Bay. Over 149 fish were taken from 1 location off San Diego Bay (Appendix C21).

California Lizardfish (*Synodus lucioceps*) (3, 6). California lizardfish is an inner shelf and middle shelf species that occurred in 50% of the area and contributed 9% of the total abundance and only 3% of the biomass (Tables 22, 24, and 26). While California lizardfish was the numerical dominant in both the southern mainland region and the middle shelf zone (Table 25), it was not a dominant biomass contributor in any region or shelf zone (Table 27). The largest abundance of 275 fish was taken from 1 site located north of San Diego at approximately 33° N. The largest biomass (4.5 kg) was at a site just north of LA/LB Harbor (Appendix C22).

California Tonguefish (*Symphurus atricaudus*) (8, 20). California tonguefish is a middle shelf species that occurred in 44% of the area and contributed 3% of the total abundance and 1% of the biomass (Tables 22, 24, and26). California tonguefish was not a numerical dominant of abundance or biomass in any region or shelf zone (Tables 25 and 27). The largest number taken by trawl was 89 from a site located off Whites Point, near the end of the Los Angeles County Sanitation District diffuser pipe. At least 50 fish were taken from 6 different sites clustered in and around LA/LB Harbor (Appendix C23). The largest biomass (1.7 kg) was taken from a site located off LA/LB Harbor.

Bigmouth Sole (*Hippoglossina stomata*) (23, 19). Bigmouth sole is a middle shelf species that occurred in 45% of the area but represented only 0.6% of the total abundance and 1% of the biomass (Tables 22, 24, and 26). While this species occurred in a large area, it was not found in the top 80% of fish abundance in any subpopulation (Table 25) and accounted for a small amount of the biomass in only the central mainland region and middle shelf zone subpopulations (Table 27). The largest single catch of 23 individuals was taken from a site located slightly south of Point Dume (Appendix C24). The largest biomass collected from a station was 1.1 kg.

Queenfish (*Seriphus politus*) (4, 5). Queenfish is an inner shelf and middle shelf species that occurred in 10% of the area and represented 6% of the total abundance and 4% of the biomass (Appendix C14; Tables 24 and 26). This species was the second most abundant fish in both the northern mainland regions and the inner shelf zone (Table 25) and was the third highest contributor of biomass in the inner shelf zone (Table 27). The largest single catch of 957 fish was taken from 1 site located northwest of Point Dume. The second largest catch of at least 107 individuals was taken from 8 different sites, spanning the coastline from south of Point Conception to north of Dana Point (Appendix C25). The largest biomass of 12.2 kg was taken from the site with the largest catch.

Hornyhead Turbot (*Pleuronichthys verticalis*) (25, 13). Hornyhead turbot is an inner shelf and middle shelf species that occurred in 44% of the area and comprised 0.6% of the total abundance and 2% of the biomass (Tables 22, 24, and 26). The hornyhead turbot occurred in a large area but was not found in the top 80% of the fish abundance in any subpopulation (Table 25); it accounted for a small fraction of the biomass in the central mainland region and the inner and middle shelf zones (Table 27). The largest number taken by trawl was 15 from 2 sites, 1 located outside LA/LB Harbor and the other located off Los Angeles. The next largest catch of at least 9 fish was taken from 7 sites, most of which are located near Los Angeles and the LA/LB Harbor, with 1 site found south of San Diego (Appendix C26). The highest biomass (1.8 kg) was taken at 1 site located outside of LA/LB Harbor.

Species Size (Length) Distribution

All Fish

Fish captured in this survey ranged in size from 3.5 cm (midpoint of size class 4) to 106.5 cm (Figure 15). Most of the fish were small, ranging in length from 4.5-18.5 cm. The modal size class of the fish was 7.5 cm, comprising 12% of the catch. The length-frequency distribution was skewed to the right and strongly trun-

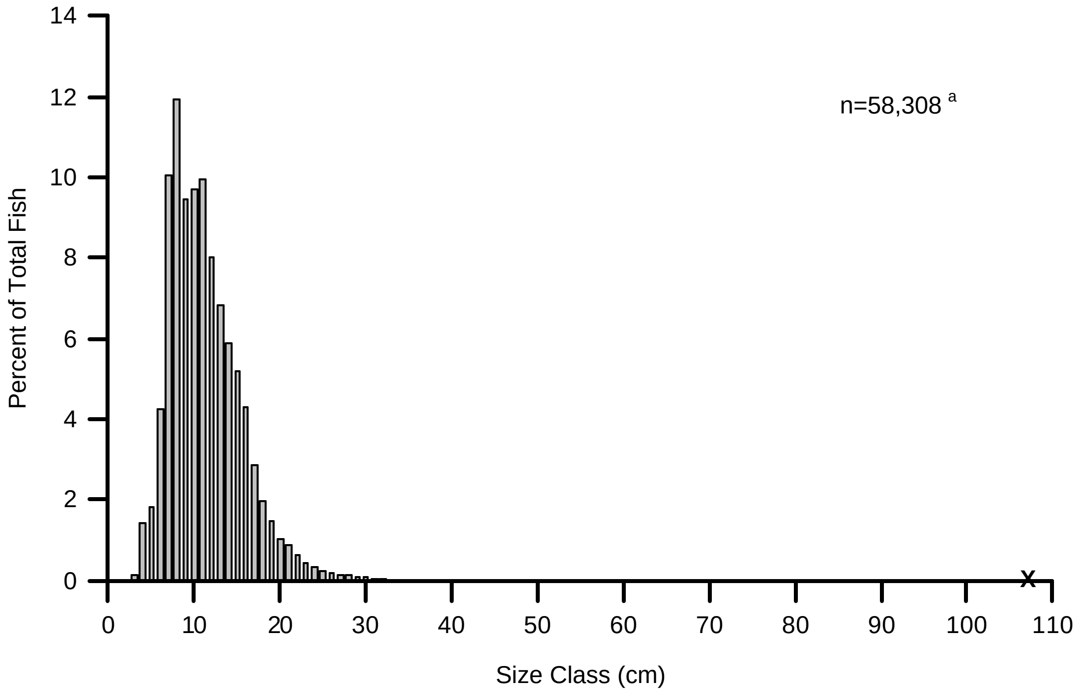


Figure 15. Length-frequency distribution of all fish collected by trawl at depths of 2-202 m on the southern California shelf, July-September 1998. n = Number of fish measured; x = Largest fish (size class 107). [a]3,957 not measured, not included.

cated to the left at 4.5 cm.

In the mainland region, length-frequency distributions of all fish were most highly peaked, with the highest modal abundance in the central mainland region bays/harbors subpopulation (presumably LA/LB Harbor). Length-frequency distributions showed relatively high peaks in the northern and southern mainland region bays, the central and southern mainland region inner shelf zone, and the central mainland region outer shelf zone (Figure 16). At the islands, the distributions were most peaked in the middle shelf of the southeast Channel Islands and at Santa Catalina Island (Figure 17). Modal lengths were lowest in the southern mainland region inner shelf zone, but were similar at other regional depth subpopulations. In general, length-frequency distributions were similarly skewed to the right in all region /shelf zone subpopulations. The lengths of the smallest fish captured did not differ between regions or by depth. A few large fish were found in many subpopulations, with the largest fish in the survey from bays and harbors within the central mainland region.

Individual Species

Fish caught in the survey ranged in length from 2-107 cm (Table 28). The largest species by mean length were generally cartilaginous fishes, with the California halibut being the only ray-finned fish among the 10 largest species. In contrast, species with the shortest mean body length were ray-finned fishes.

The species with the largest mean size were the Pacific angel shark *(Squatina californica)*, gray smoothhound (*Mustelus californicus*), brown smoothhound (*Mustelus henlei*), and spiny dogfish (*Squalus acanthias*),

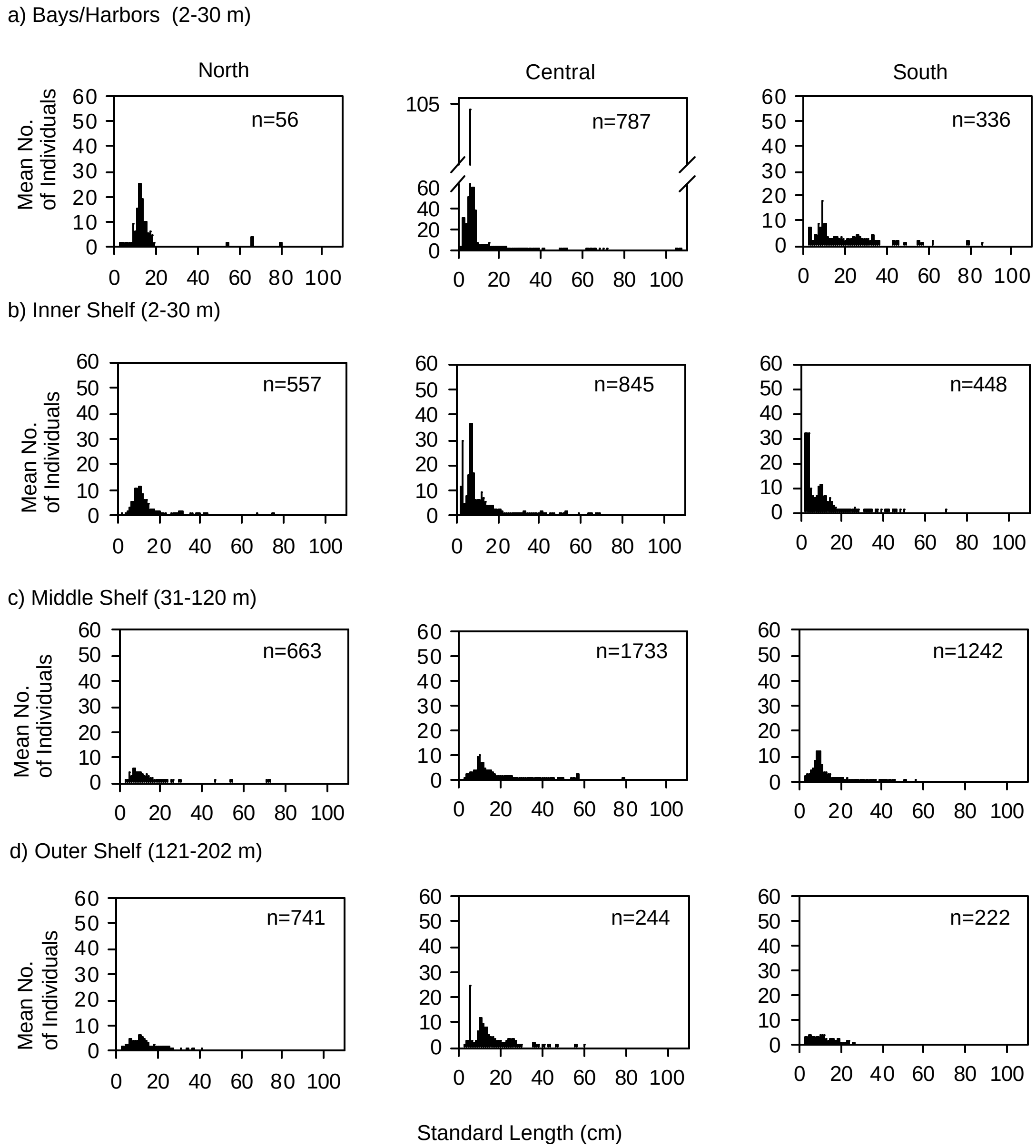


Figure 16. Length-frequency distribution (mean number of fish per size class) of all fish collected by trawl in bays and harbors and on the mainland shelf by shelf zone and regional subpopulation on the southern California shelf, July-September 1998.

with mean lengths of 90, 66, 65, and 65 cm, respectively (Table 28). The largest individual fish was a Pacific angel shark of 107 cm total length (TL). Most of the large species were not represented by many individuals. Six or fewer individuals were collected for 7 of the 10 largest species.

The species with the smallest mean size were bay goby (*Lepidogobius lepidus*), northern anchovy (*Engraulis mordax*), and bull sculpin (*Enophrys taurina*), with mean lengths of 6, 6, and 7 cm, respectively. The smallest individual fishes were bay goby and northern anchovy, with lengths of 2 cm SL. Whereas most of the larger species were represented by few individuals, most of the smaller species were represented by many individuals. More than 1,000 individuals were collected for 6 of the 10 smallest species.

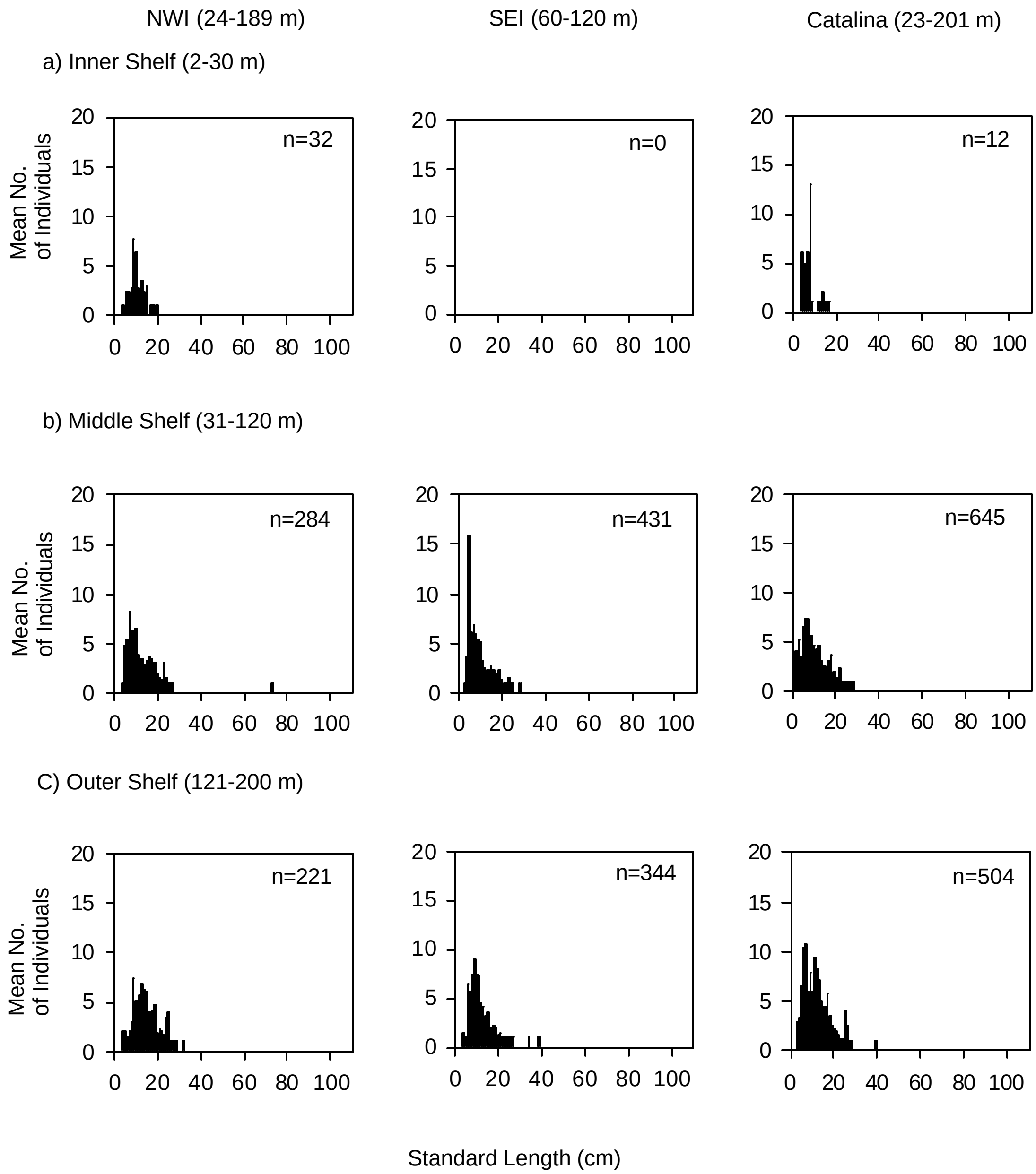


Figure 17. Length-frequency distribution (mean number of fish per size class) of all fish collected by trawl at southern California islands by shelf zone and regional subpopulation on the southern California shelf, July-September 1998. NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; Catalina = Santa Catalina Island.

Population Structure

Overall length-frequency distributions of the 10 most abundant species in the survey varied in shape (Figure 18). Size distributions of white croaker, Pacific sanddab, queenfish, and California tonguefish were strongly bimodal; that of Dover sole was slightly bimodal. California lizardfish, longfin sanddab, northern anchovy, slender sole, and yellowchin sculpin had unimodal distributions. All of the 10 species had primary modes at lengths of 10.5 cm (size class 11) or less. The top 10 species had size distributions within the range of 2.5-27.5 cm; only size distributions of northern anchovy and yellowchin sculpin were entirely below 10 cm. Recent recruitment of small juveniles (as indicated by fish length less than 5.5 cm) was apparent in all of the

Table 28. Demersal fish species with greatest and least lengths collected on the southern California shelf at depths of 2-202 m, July-September 1998.

		Length (cm)			Total
Scientific Name	Common Name	Min.	Max.	Mean	Number
(a) Largest Species					
Squatina californica	Pacific angel shark	27	107	90	5
Mustelus californicus	gray smoothhound	66	66	66	1
Mustelus henlei	brown smoothhound	42	75	65	4
Squalus acanthias	spiny dogfish	65	65	65	1
Myliobatis californica	bat ray	35	80	62	30
Dasyatis dipterura	diamond stingray	43	79	61	4
Torpedo californica	Pacific electric ray	29	79	46	3
Rhinobatos productus	shovelnose guitarfish	23	86	37	15
Cephaloscyllium ventriosum	swell shark	20	73	32	6
Paralichthys californicus	California halibut	4	67	22	474
(b) Smallest Species					
Cheilotrema saturnum	black croaker	3	25	17	59
Citharichthys sordidus	Pacific sanddab	3	27	12	6450
Porichthys notatus	plainfin midshipman	3	23	11	1459
Lyopsetta exilis	slender sole	3	19	11	2949
Sebastes chlorostictus	greenspotted rockfish	3	20	11	24
Seriphus politus	queenfish	2	21	9	2960[a]
Genyonemus lineatus	white croaker	3	27	9	14538[b]
Enophrys taurina	bull sculpin	2	11	7	3
Engraulis mordax	northern anchovy	2	12	6	3029[c]
Lepidogobius lepidus	bay goby	2	9	6	480

Min.=Minimum; Max.=Maximum.
Fish not measured, not included: [a] 894; [b] 2904; [c] 76

10 most abundant species except California lizardfish.

Size distributions of species differed by region and depth (Figures 19, 20, and 21; Appendices C27 through C47). Of the 10 most abundant species in bays and harbors (Figure 19), white croaker, queenfish, California halibut, and Pacific sardine (*Sardinops sagax*) showed bimodal distributions; whereas northern anchovy, deepbody anchovy (*Anchoa compressa*), California tonguefish, barred sand bass (*Paralabrax nebulifer*), round stingray, and shiner perch (*Cymatogaster aggregata*) showed unimodal distributions. All individuals of northern anchovy and shiner perch were below 10 cm in length; all individuals of barred sand bass and round stingray were 9 cm or above in length. Note that bays and harbors include coastal harbors (e.g., LA/LB Harbor) and natural embayments (e.g., San Diego Bay), and that some species shown here often occur in one or the other but not both.

Shelf (mainland and island) populations (Figure 20) showed better-developed size distributions than

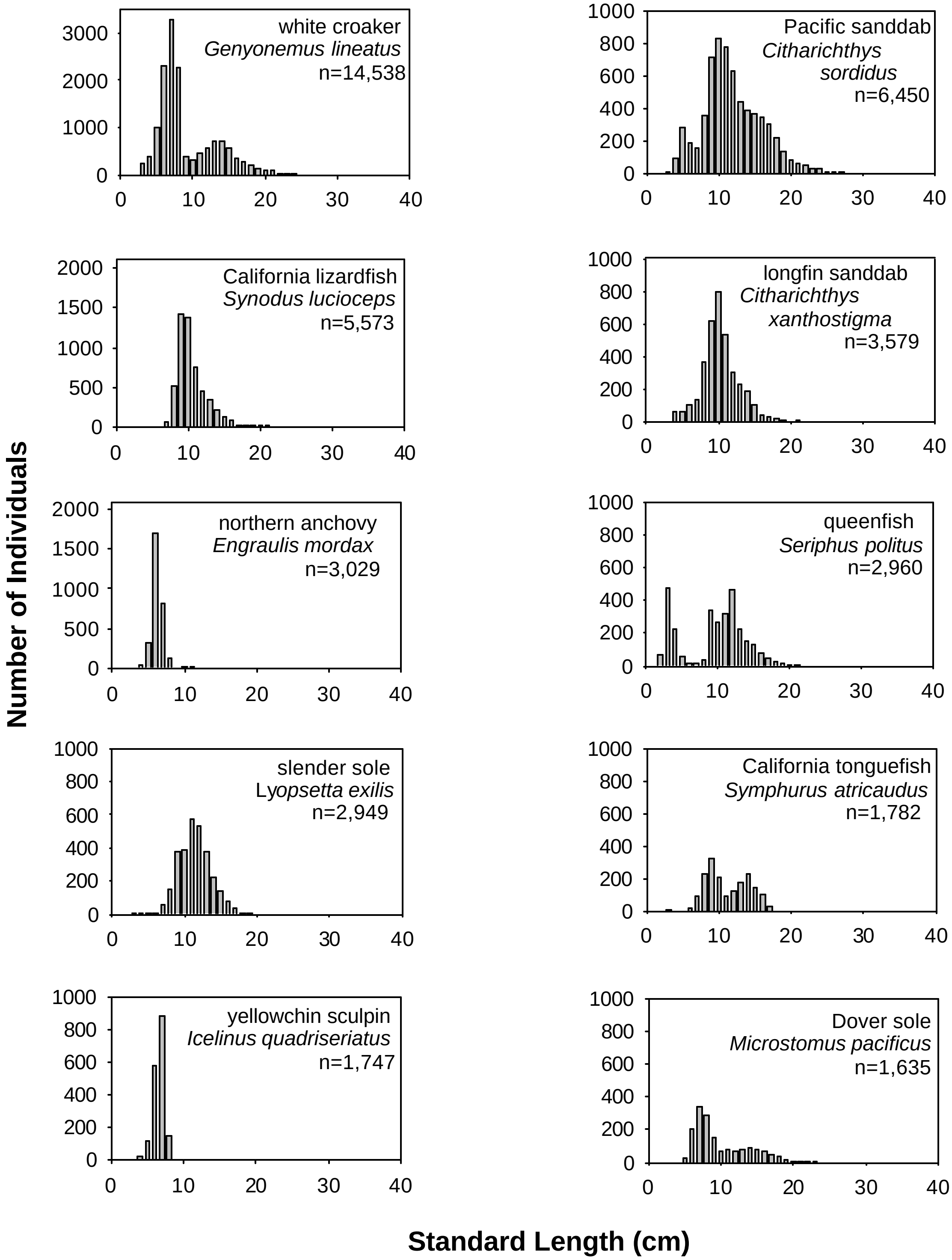


Figure 18. Length-frequency distributions of the 10 most abundant fish species collected by trawl at depths of 2-202 m on the southern California shelf, July-September 1998. n = Number of fish measured.

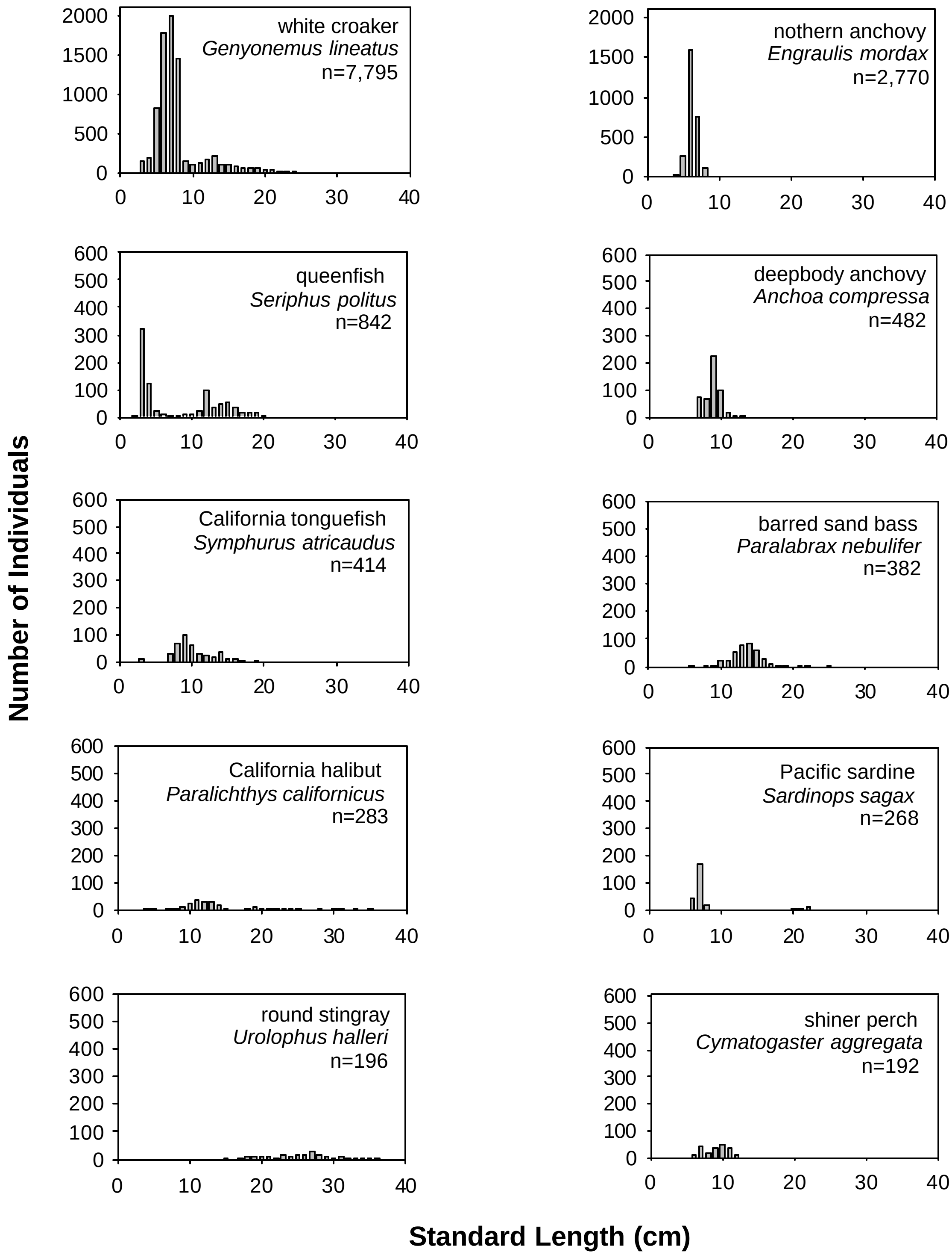


Figure 19. Length-frequency distributions of the 10 most abundant fish species collected by trawl within bays and harbors on the southern California shelf, July-September 1998. n = Number of fish measured.

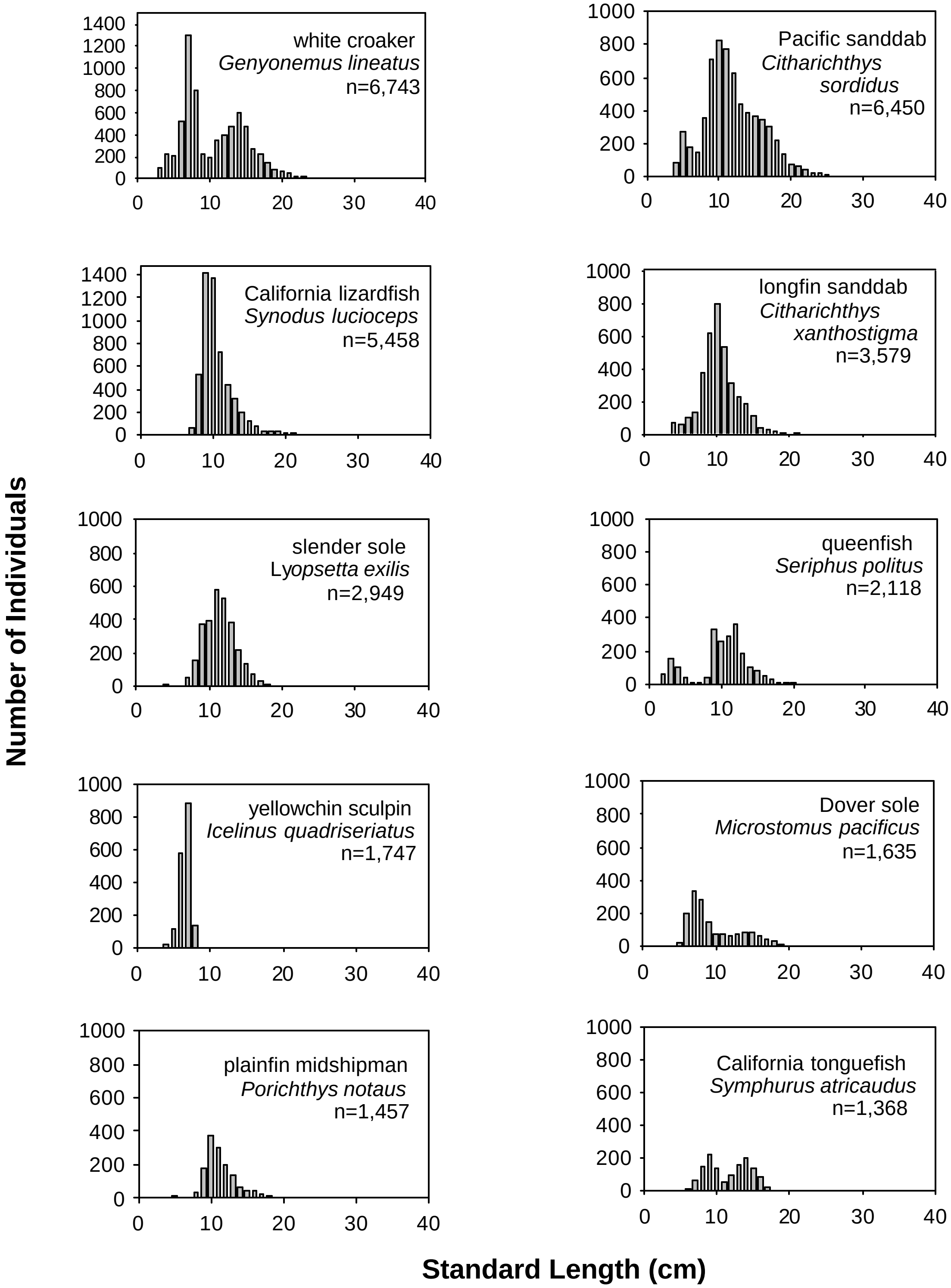


Figure 20. Length-frequency distributions of the 10 most abundant fish species collected by trawl on the mainland and island shelf of southern California shelf at depths of 2-202 m, July-September 1998. Bays and harbors not included. n = Number of fish measured.

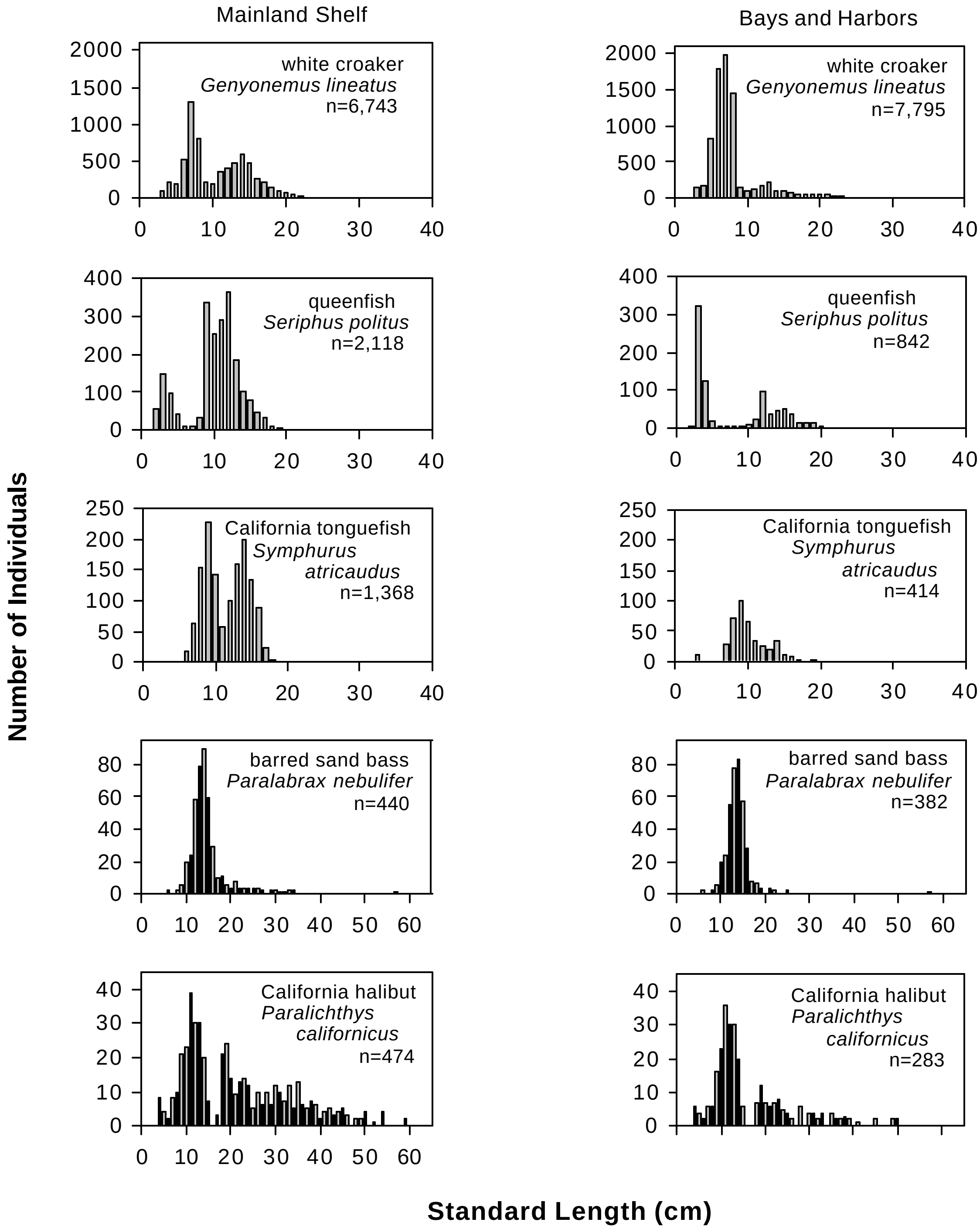


Figure 21. Length-frequency distributions for five species collected by trawl both the mainland shelf and within bays and harbors on the southern California shelf, July-September 1998. n = Number of fish measured.

those in bays and harbors (Figure 19). Most of the top 10 species had broader size ranges. White croaker (not found at the islands; Appendix C14), Pacific sanddab, queenfish, Dover sole, and California tonguefish had bimodal distributions. All yellowchin sculpin were less than 10 cm; almost all of plainfin midshipman and slender sole were 9 cm or larger.

The five most abundant species varied in their population structure in the bay/harbor zone and in the mainland region (Figure 21). White croaker was bimodal on the inner shelf and slightly bimodal in bays/harbors, with the primary mode being less than 10 cm. Queenfish was also bimodal in both areas, with the primary mode being less than 10 cm in bays/harbors and greater than 10 cm on the inner shelf. California tonguefish had a bimodal distribution on the inner shelf and unimodal distribution in bays/harbors. Barred sand bass showed a similar, unimodal distribution in both bays/harbors and in the inner shelf zone. Similarly, the California halibut distribution was similar both on the inner shelf and bays/harbors, with a primary mode of 10 cm, and a skew to the right.

Length-frequency distributions of the 10 most abundant species in bays/harbors by region showed differences in general abundance patterns as well as in population structure (Appendix C27). Five species (white croaker, northern anchovy, queenfish, California tonguefish, and Pacific sardine) were clearly more abundant in the central mainland region harbors (e.g., LA/LB Harbor) and were generally dominated by fish length less than 10 cm, with no such peak in other regions. Deepbody anchovy and round stingray were most abundant in the southern mainland region bays/harbors (e.g., San Diego Bay). Barred sand bass was abundant in central and southern mainland region bays/harbors, whereas California halibut and shiner perch were relatively abundant and with similar size distributions (by species) across all regions.

The population structures (by shelf zone) of the top 10 species in the mainland and island regions are shown in Appendices C28 through C37 and C38 through C47, respectively. In most cases, the population structure is similar within a species by region within a shelf zone (Appendices C28 through C37); however, queenfish (Appendix C32) had distinct bimodal distributions in the central and southern mainland region inner shelf zone, but was unimodal in the north mainland region. Plainfin midshipman distributions were generally truncated below 9 or 10 cm (Appendix C35). Dover sole showed strong recruitment in the southern mainland region middle shelf zone (Appendix C37). Island populations typically showed similar patterns within a shelf zone across the island region (Appendices C38 through C47).

Anomalies and Parasites

The prevalence of fish anomalies and parasites was low and incidences were scattered throughout the SCB. A total of 329 (0.5%) of 62,265 fish had anomalies or parasites (Table 29). Anomalies were found in 22 (15%) of the 143 species. Anomalies and parasites identified in the study included parasites (the eye copepod, *Phrixocephalus cincinnatus*, a pennellid copepod; cymothoid isopods; and leeches), tumors, lesions, skeletal deformities, albinism, ambicoloration, and diffuse pigmentation. Most (88%) of these were parasites. Of the remaining anomalies, ambicoloration was most abundant, followed by epidermal tumors, lesions, and skeletal deformity. In the survey, 27 fish had ambicoloration; 11 of these were hornyhead turbot and 8 were California tonguefish. Fifteen fish (12 of which were Dover sole) had epidermal tumors. Five fish each had lesions and diffuse pigmentation. One fish (a spotted turbot) had albinism. Fin erosion was not found in the survey.

Table 29. Number of fish species with different anomaly types collected on the southern California shelf at depths of 2-202 m, July-September 1998.

					Pigmentation			Total		
Scientific Name	Common Name	Par	Tu	Le	Amb	Alb	De	OvAn	OvTotFi	%An
Amphistichus argenteus	barred surfperch	1	-	-	-	-	-	1	3	33.33
Phanerodon furcatus	white seaperch	18	-	-	-	-	-	18	302	5.96
Pleuronichthys verticalis	hornyhead turbot	11	-	-	11	-	-	22	393	5.60
Raja inornata	California skate	2	-	-		-	-	2	44	4.55
Hippoglossina stomata	bigmouth sole	13	-	-	3	-	-	16	396	4.04
Citharichthys sordidus	Pacific sanddab	223	-	-		-	3	226	6,450	3.50
Pleuronichthys ritteri	spotted turbot	1	-	-	2	1	1	4[a]	146	2.70
Pleuronichthys decurrens	curlfin sole	1	-	-	-	-	-	1	60	1.67
Hyperprosopon argenteum	walleye surfperch	1	-	-	-	-	-	1	77	1.30
Paralichthys californicus	California halibut	3	-	-	2	-	-	5	474	1.05
Microstomus pacificus	Dover sole	1	12	2	-	-	-	15	1,635	0.92
Scorpaena guttata	California scorpionfish	1	-	-	-	-	-	1	116	0.86
Citharichthys stigmaeus	speckled sanddab	6	-	1	1	-	-	8	1,105	0.72
Sebastes eos	pink rockfish	-	1	-	-	-	-	1	182	0.55
Symphurus atricaudus	California tonguefish	-	1	1	8	-	-	9[a]	1,862	0.50
Paralabrax nebulifer	barred sand bass	2	-	-	-	-	-	2	440	0.45
Lycodes pacificus	blackbelly eelpout	1	-	-	-	-	-	1	317	0.32
Parophrys vetulus	English sole	1	-	-	-	-	-	1	397	0.25
Cymatogaster aggregata	shiner perch	1	-	-	-	-	-	1	405	0.25
Zaniolepis latipinnis	longspine combfish	-	1	-	-	-	-	1	759	0.13
Genyonemus lineatus	white croaker	3	-	1	-	-	1	5	17,442	0.03
Synodus lucioceps	California lizardfish	1	-	-	-	-	-	1	5,573	0.02
Total		291	15	5	27	1	5	329[a]	62,265[b]	0.53

[a] Total reflects number of fish with anomalies. Nine fish had two anomalies.

[b] Total of all fish in survey.

Par = Parasite; Tu = Tumor; Le = Lesion; Amb = Ambicoloration; Alb = Albinism; De = Deformities; OvAn = Overall anomalous; OvTotFis = Overall total fish; %An = Percent anomalous.

Although more (226) Pacific sanddab individuals had parasites or anomalies (of which 223 had parasites), barred surfperch (*Amphistichus argenteus*) had the highest prevalence (33.3% with parasitism), but this was only 1 of 3 fish caught (Table 29). White seaperch (*Phanerodon furcatus*) and hornyhead turbot had anomaly rates of 6.0 and 5.6%, respectively; all 18 white seaperch were parasitized, whereas anomalies in hornyhead turbot were split between parasites and ambicoloration (11 of each). Although most afflicted species had a single type of anomaly, 9 fish (2.7%) had 2 anomalies. Most of these were a parasite and another anomaly, but one was ambicoloration and skeletal deformity.

Anomalies occurred in 40.7% of the area of the mainland shelf of southern California (Table 30). They were most widespread at the southeast Channel Islands (92.5%), followed by the island region middle shelf zone

Table 30. Percent of area by subpopulation of fish with different anomaly types collected on the southern California shelf at depths of 2-202

Subpopulation	No. of Stations	Par	Tu	Le	Amb	Alb	De	Other	Overall
Region									
Mainland	256								
Northern	67	11.0	1.2	4.5	---	---	---	---	16.7
Central	114	25.1	1.1	0.3	33.2	2.3	2.3	4.4	68.7
Southern	75	6.6	---	---	---	---	---	---	6.6
Island	57								
NW Channel Islands	15	51.8	---	---	---	---	13.9	---	65.7
SE Channel Islands	16	73.0	11.0	---	---	---	8.5	---	92.5
Santa Catalina Island	26	46.4	---	---	---	---	---	---	46.4
Shelf Zone									
Bays and Harbors (2-30 m)	60								
Ports	15	7.6	---	---	---	---	---	---	7.6
Marinas	18	5.5	---	---	---	---	---	---	5.5
Other Bay	27	5.3	---	---	---	---	---	---	5.3
Inner Shelf (2-30 m)	82								
Small POTWs	15	---	---	---	---	---	---	---	---
River Mouths	31	9.8	---	---	---	---	---	---	9.8
Other Mainland	32	9.7	---	3.2	9.7	3.2	---	---	25.8
Island	4	---	---	---	---	---	---	---	---
Middle Shelf (31-120 m)	124								
Large POTWs	14	19.7	---	---	---	---	---	---	19.7
Small POTWs	32	32.1	6.9	2.3	6.9	---	---	---	52.8
Mainland non-POTW	46	18.6	---	---	15.5	---	---	3.1	37.2
Island	32	72.0	3.0	---	---	---	12.2	---	87.1
Outer Shelf (121-202 m)	47								
Mainland	26	4.3	4.3	8.6	---	---	---	---	17.3
Island	21	10.1	---	---	---	---	---	---	10.1
Total all stations	313	32.3	1.6	1.3	7.5	0.5	1.1	1.0	40.7

Par = Parasite; Tu = Tumor; Le = Lesion; Amb = Ambicoloration; Alb = Albinism;
De = Deformities; POTW = Publicly owned treatment work monitoring areas.

(87.1%) and the central mainland region (68.7%) (Table 30, Figure 22). They were absent from the inner shelf small POTW and island subpopulations, and were otherwise least widespread in the “other bays” subpopulation (5.3%). Parasites occurred in 32.3% of the area, followed by ambicoloration (7.5%), tumors (1.6%), lesions (1.3%), skeletal deformities (1.1%), and albinism (0.5%). Parasites were the most widespread anomaly at the southeast Channel Islands, in the island region middle shelf zone , and at the northwest Channel Islands (73.0, 72.0, and 51.8%, respectively) (Table 30, Figure 23). Ambicoloration was most widespread (33.2%) in the central mainland region within the middle-shelf non-LPOTW subpopula-

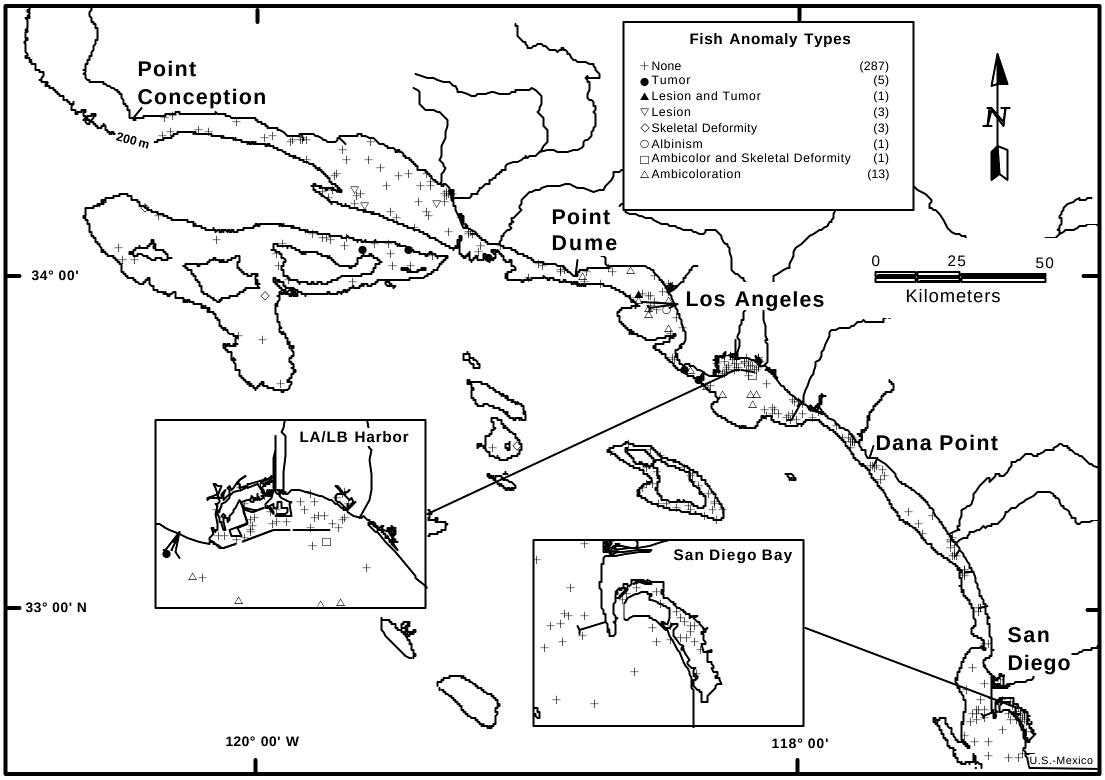


Figure 22. Distribution of fish anomalies on the southern California shelf at depths of 2-202 m, July-September 2002.

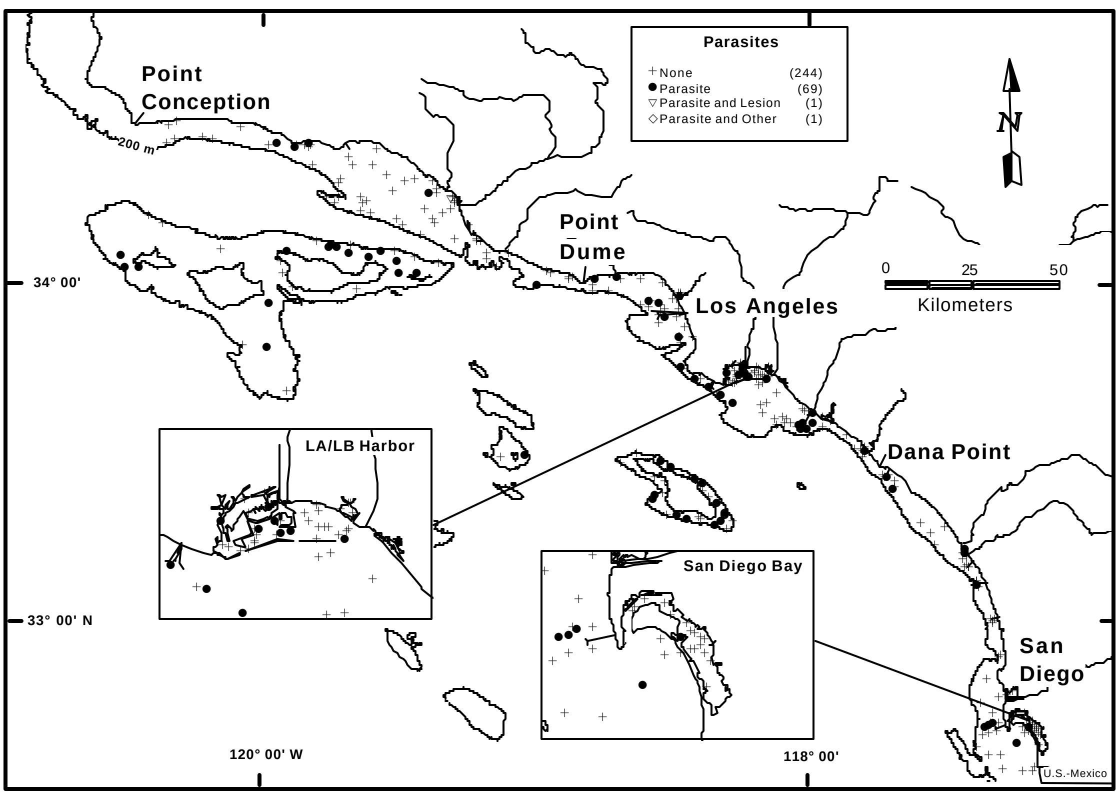


Figure 23. Distribution of external parasites of fish on the southern California shelf at depths of 2-202 m, July-September 2002.

tion (15.5%), and inner shelf “other coastal mainland” (9.7%) subpopulation (Table 30, Figure 22). Tumors were most widespread at the southeast Channel Islands (11.0%), in the middle shelf LPOTW areas (6.9%), and in the mainland region outer shelf zone subpopulation (4.3%). Tumors occurred on the Palos Verdes Shelf, near the heads of Redondo Canyon and Santa Monica canyons, and at Santa Cruz Island (Figure 22).

DISCUSSION

Historical Surveys

Many surveys of soft-bottom fishes have been conducted in southern California since Carlise (1969) conducted the first environmental assessment trawl survey of Santa Monica Bay from 1957-1963, using the same trawl gear used in present-day surveys. As with Carlise (1969), the primary focus of these studies (e.g., CLAEMD 1994a,b; CSDMWWD 1995; Stull 1995; CSDOC 1996; Stull and Tang 1996; CSDLAC 2000) has been the assessment of the effects of wastewater discharge on fish populations. Most are focused on local areas (primarily large POTW areas) rather than the SCB as a whole. Many of the routine monitoring surveys near wastewater outfalls began between 1969 and 1972, and shortly after, the effort was made to put outfall conditions into a Bight-wide perspective by compiling existing data (SCCWRP 1973, Mearns 1974, Mearns *et al.* 1976, Allen and Voglin 1976, Allen 1977, Allen 1982). Then came the need to conduct synoptic surveys at various regional scales to get better temporal coherence and similarity of spatial coverage (Mearns and Green 1974, Allen and Mearns 1977, Word *et al.* 1977, Love *et al.* 1986, Thompson *et al*. 1987, 1993b). The first synoptic regional trawl survey in 1994 (Allen *et al*. 1998) provided a region-wide assessment of demersal fish population conditions for the mainland shelf of southern California and provides perspective to the 1998 data. In addition, Allen and Voglin (1976) compiled information on demersal fish populations from surveys conducted throughout southern California from 1957-1975. In all, information on population attributes were collected from 2,237 samples, generally using the same gear as the present study. The 1994 survey (Allen *et al*. 1998) collected 114 trawl samples from 9-215 m, all on the mainland shelf. The 1998 survey reported here collected samples from 314 stations, of which 197 were from the mainland shelf (depths of 10-200 m).

Population Attributes

Fish population attribute mean values for the SCB were very similar between the three time periods (Table 31): fish abundance was 156-173 individuals/haul; biomass was 4.9-7.1 kg/haul; species richness was 10.1-11.7 species/haul; and diversity was 1.28-1.59 bits/individual/haul. For the SCB mainland shelf (islands and bays excluded), mean fish abundance and biomass was higher in 1957-1975 (generally a cool period) than in either 1994 or 1998 (a warm period). Mean fish abundance in 1994 and 1998 was roughly the same (156 and 157, respectively) but was higher (173) in the earlier period. Mean biomass was highest in the early period, and lowest in 1994. Species richness was slightly higher in 1994 and lowest in 1998. Diversity was highest in 1994 but lowest in the early period. It should be noted that the number of samples used in the analysis was much smaller in 1994 and 1998 than in 1957-1975. However, in the latter two years, the samples were collected synoptically within the same year using a stratified randomized design; whereas in 1957-1975, samples collected over a 29-year period were compiled from surveys of varying designs.

By region, population attribute mean values often showed remarkable similarity (note that 1957-1975 values are given as ranges of values across regions) (Table 31). In the southern region, all mean values for 1994 and 1998 population attributes fell within the range of values for 1957-1975. Overall, fish abundance was

Table 31. Comparison of demersal fish population attributes by region and for the Southern California Bight in 1957-1975, 1994, and 1998 regional survey data.

		Mean/haul[a]			
Southern California Bight Database	No. samples	Abundance (no. of individuals)	Biomass (kg)	No. of Species	Diversity[b] (bits/individual)
Northern Region					
1957-1975[c]	1-74	64	3.5	8.1-12.2	0.91-1.50
1994	45	137	3.6	12.2	1.72
1998[d]	65	136	4.6	9.0	1.45
Central Region					
1957-1975	13-32	139-420	7.6-13.4	10.0-16.1	1.23-1.64
1994	41	159	6.7	10.9	1.45
1998[d]	78	158	7.0	10.2	1.54
Southern Region					
1957-1975	2-13	97-192	3.3-6.2	9.6-12.5	1.06-1.5
1994	28	197	5.7	11.4	1.47
1998[d]	54	174	5.5	11.2	1.66
All Regions (SCB as a whole)					
1957-1975	2237	173	7.1	11.0	1.28
1994	114	157	4.9	11.7	1.59
1998[d]	197	156	5.8	10.1	1.57

[a]The 1994 and 1998 mean values are weighted in accordance with the sampling design.
[b]Historical values are Brillouin diversities; 1994 and 1998 values are Shannon-Wiener diversities.
[c]Historical data are from Allen and Voglin (1976).
[d]Data from Bays/Harbors excluded from analysis.

highest in the south and lowest in the north. Biomass was highest in the central region and lowest in the northern region. Species richness was typically higher in the southern region than in the central region; but in the northern region, species richness was variably higher or lower than in these regions. Diversity differed less between 1994 and 1998 in the central region than in the other two regions.

As in 1994 (Allen and Moore 1996, Allen *et al*. 1998) fish abundance, species richness, and diversity were low in the inner shelf zone relative to the middle shelf and outer shelf zones, and biomass was higher in the outer shelf zone (Tables 14, 16, 18, and 20; Appendices C1, C4, C7, and C10). In 1998, bays and harbors were also surveyed, and these areas had higher values than the inner shelf zone for all attribute values; biomass values in bays/harbors were higher than in any of the other shelf zone subpopulations. These higher values are largely related to the increased likelihood of encountering schooling fishes in these areas than on the open coast.

In 1994, fish abundance, biomass, and diversity were significantly higher at POTW areas than at non-POTW reference areas for the middle shelf zone (Allen and Moore 1996, Allen *et al*. 1998). However, it was clear in that study that the size of the POTW area was much larger than the area where fish population effects were observed in the 1970s, when wastewater effluent had much higher levels of contaminants (Mearns *et al*. 1976). Fish population attributes were often depressed in the immediate vicinity of some outfalls during that period (Mearns *et al*. 1976, Allen 1977, CSDLAC 1988). Thus, the survey design of the 1998 regional survey reduced the size of the area included in the LPOTW area to the area where outfall effects on fish and invertebrate populations had been observed. In comparing outfall effects between the two periods, the 1998 POTW boundaries were applied to the 1994 station map, and 1994 stations were reapportioned into the new LPOTW and non-LPOTW subpopulation boundaries of 1998; the 1994 stations retained their area-weights from that year. Comparing middle shelf zone reference (non-LPOTW) and LPOTW areas, there was little difference in median fish population attributes between reference and POTW areas, and little difference between years in both subpopulations (Figure 24, Table 32). Similarly, there was little difference in the percent of LPOTW area (for a particular population attribute) above the reference median for the same year, except for biomass, which was significantly higher in 1994 than in 1998 (Figure 25, Table 32).

Species Composition

There were some important changes in species composition between 1994 and 1998. The distribution of

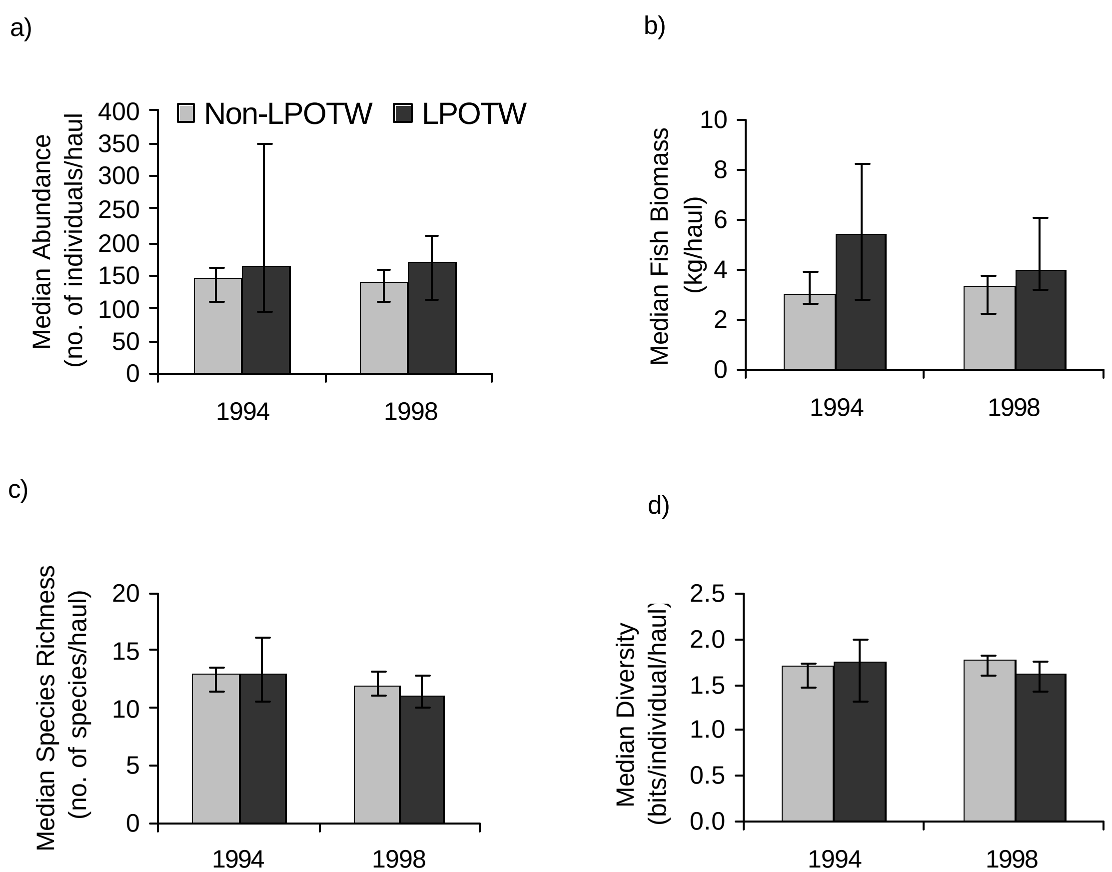


Figure 24. Median (and 95% confidence limits) of fish population attributes at large publicly owned treatment work (LPOTW) and reference (non-Large POTW) subpopulations on the southern California middle shelf in 1994 and 1998: a) abundance; b) biomass; c) species richness; and d) diversity. NOTE: LPOTW boundaries of 1998 were used for both years; non-large POTW areas consist of all mainland middle shelf stations that did not fall within the LPOTW boundaries.

Table 32. Demersal fish abundance, biomass, species richness, and diversity at middle-shelf large publicly owned treatment work (LPOTW) and reference (non-LPOTW) subpopulations in 1994 and 1998. Data from 1994 reanalyzed using 1998 subpopulation boundaries.

					Stratified Values					Percent Above
	No. of		Range			95% CL				Bight
Category	Stations	Total	Min.	Max.	Md	LL	UL	Mn	SD	Median
Abundance (no. of individuals/haul)										
1994 LPOTW	9	2,304	43	726	164	92	351	257	211	53
1998 LPOTW	32	6,997	23	775	169	113	209	219	182	56
1994 non-LPOTW	49	8,452	23	394	146	108	160	162	93	52
1998 non-LPOTW	61	8,987	6	371	141	107	157	160	87	59
Biomass (kg/haul)										
1994 LPOTW	9	53.9	1.5	19.3	5.5	2.8	8.2	8.0	5.3	63
1998 LPOTW	32	208.7	0.8	24.5	4.0	3.2	6.0	6.5	6.0	53
1994 non-LPOTW	49	213.5	0.6	15.2	3.1	2.6	3.9	4.2	3.3	32
1998 non-LPOTW	61	247.8	0.1	26.3	3.4	2.3	3.8	4.2	4.5	38
Number of Species (no. of Species/haul)										
1994 LPOTW	9	37	8	21	13	10	16	14	4	56
1998 LPOTW	32	51	5	26	11	10	13	12	5	44
1994 non-LPOTW	49	60	7	23	13	11	13	13	3	66
1998 non-LPOTW	61	63	3	23	12	11	13	13	4	62
Shannon-Wiener Diversity (bits/individual/haul)										
1994 LPOTW	9		1.00	2.46	1.74	1.29	1.99	1.66	0.44	60
1998 LPOTW	32		0.61	2.43	1.62	1.43	1.74	1.63	0.39	65
1994 non-LPOTW	49		0.67	2.37	1.70	1.46	1.72	1.65	0.42	62
1998 non-LPOTW	61		0.46	2.30	1.75	1.59	1.81	1.74	0.37	71

CL = Confidence limits (LL = Lower Limit; UL = Upper Limit); Min. = Minimum; Max. = Maximum; No. = Number; SD = Standard deviation; Md = Median; Mn = Mean.

species among higher taxa was nearly the same as in 1994 (Allen *et al*. 1998, 2001b), although the number of species collected was 143 in 1998 and 87 in 1994. Sebastidae, Pleuronectidae, and Paralichthyidae were the most diverse families in both surveys. In 1994, six species (Pacific sanddab, Dover sole, plainfin midshipman, California lizardfish, hornyhead turbot, and yellowchin sculpin) occurred in more than 50% of the area. In 1998, only two species (Pacific sanddab, California lizardfish) occurred in 50% or more of the area (Table 22). This, in part, is related to the addition of shallow bays and offshore islands to the survey in 1998; whereas in 1994, the survey was limited to the mainland shelf. Pacific sanddab was the most abundant species and California halibut contributed the most biomass in 1994; in contrast, white croaker was the most abundant species and contributed the most biomass in 1998 (Tables 24 and 26). In 1994, white croaker occurred in 4% of the area, and contributed 3% of the total abundance and 8% of the biomass. In 1998, white croaker occurred in 17% of the area and represented 28% of the total abundance and 26% of the total biomass (Tables 22, 24, 26; Appendix C14). The increased abundance of white croaker in 1998 was largely

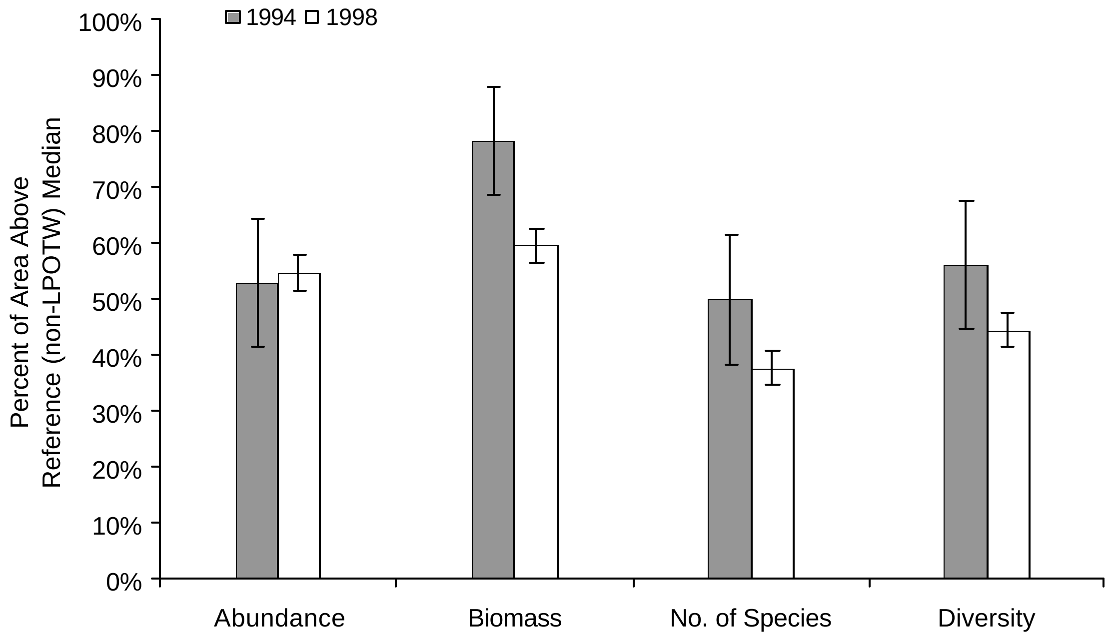


Figure 25. Percent of area (with 95% confidence limits) of large publicly owned treatment work (LPOTW) subpopulations with fish population attributes above the reference (NLPOTW: mainland, middle shelf, non-large POTW) subpopulation medians in 1994 and 1998. NOTE: LPOTW boundaries of 1998 were used for both years; NLPOTW areas consist of all mainland middle shelf stations that did not fall within the LPOTW boundaries.

due to the addition of LA/LB Harbor to the study scope; white croaker is very abundant in this harbor, and in 1979-1980, it was the most abundant species in Los Angeles Harbor in trawl surveys (Allen *et al*. 1983).

El Niño Effects

Changes in Areal Occurrence

In the 1994 survey, six species of demersal fishes (Pacific sanddab, Dover sole, plainfin midshipman, California lizardfish, hornyhead turbot, and yellowchin sculpin) comprised more than 50% of the area in the SCB (Table 33) (Allen *et al*. 1998, 2001b). In 1998, only two species (Pacific sanddab and California lizardfish) occurred in 50% or more of the area of the southern California shelf (Table 22). However, whereas the 1994 survey sampled only the mainland shelf, the 1998 survey also sampled islands and bays, which clearly affected the number of widespread species in the survey.

When only the mainland shelf of the 1998 survey is compared to the 1994 survey (which only consisted of the mainland shelf), this pattern changes (Table 33). Six species occurred in 50% or more of the area of the mainland shelf in both 1994 and 1998. Three species (California lizardfish, hornyhead turbot, and yellowchin sculpin) were this common in both surveys. The three species that decreased in occurrence between 1994 and 1998 were Pacific sanddab, plainfin midshipman, and Dover sole. These all are temperate species with ranges extending north to Alaska (Eschmeyer *et al*. 1983). The three species that increased their occurrence were California tonguefish, longfin sanddab, and bigmouth sole. These are all warm-temperate species that occur north to southern Oregon or Monterey, but are rare north of Point Conception. However, the three species that did not change also do not occur north of central California.

Table 33. Comparison of demersal fish species in occurring in greater than 20% of the area on the mainland shelf of southern California in 1994 and 1998.

		No. of Stations		Percent of Stations		Percent of Area*	
Scientific Name	Common Name	1994	1998[a]	1994	1998[a]	1994	1998[a]
Synodus lucioceps (4)[b]	California lizardfish	58	131	51	71	<u>68.3</u>	<u>76.6</u>
Symphurus atricaudus	California tonguefish	49	111	43	60	45.1	<u>68.8</u>
Pleuronichthys verticalis (5)	hornyhead turbot	60	93	53	50	<u>51.3</u>	<u>56.4</u>
Citharichthys xanthostigma	longfin sanddab	55	101	48	55	48.7	<u>55.5</u>
Icelinus quadriseriatus (6)	yellowchin sculpin	51	75	45	41	<u>50.9</u>	<u>54.3</u>
Hippoglossina stomata	bigmouth sole	56	87	49	47	48.7	<u>51.6</u>
Citharichthys sordidus (1)	Pacific sanddab	75	76	66	41	<u>68.3</u>	48.7
Zaniolepis latipinnis	longspine combfish	44	51	39	28	46.1	45.6
Parophrys vetulus	English sole	50	62	44	34	47.2	42.3
Zalembius rosaceus	pink seapearch	44	54	44	29	43.8	42.2
Citharichthys stigmaeus	speckled sanddab	47	67	41	36	36.2	40.4
Porichthys notatus (3)	plainfin midshipman	57	51	50	28	<u>54.3</u>	38.0
Sebastes saxicola	stripetail rockfish	50	46	44	25	46.9	37.0
Paralichthys californicus	California halibut	23	70	20	38	15.9	32.0
Xystreurys liolepis	fantail sole	27	47	24	25	21.3	29.0
Microstomus pacificus (2)	Dover sole	65	40	57	22	<u>57.4</u>	28.2
Genyonemus lineatus	white croaker	6	50	5	27	4.3	24.5
Porichthys myriaster	specklefin midshipman	13	31	11	17	14.7	24.5
Scorpaena guttata	California scorpionfish	26	39	22	21	19.5	20.3
Total (all stations)		114	185			3,075[c]	3,229[c]

*Percent of area based on area-weighted frequency of occurrences.

[a]Mainland shelf only (10-200 m); stations in island and bay/harbor subpopulations were excluded from the 1998 analysis.

[b]Numbers in parentheses represent rank of species by percent of areal occurrence in 1994 (species occurred in greater than 50% of the area).

[c]Total area in km^2.

Areal occurrences of 50% or greater are underlined

The reduced areal occurrence of the coldwater species and the increased occurrence of warmwater species suggest a response to the 1997-1998 El Niño. The decrease in areal occurrence of the coldwater species was due in part to decreased occurrence in the SCB, and due to a shift in distribution from the middle shelf zone to the outer shelf zone. As the middle shelf zone comprises about 50% of the area of the southern California mainland shelf (Allen 1982), a species shift in distribution from the middle shelf to the outer shelf would also decrease the overall areal distribution of the species. During an El Niño, it is likely that some coldwater species might seek refuge on the outer shelf to avoid the increase in water temperature on the middle shelf. All three coldwater species showed a decrease in areal occurrence in the middle shelf zone in 1998 relative to 1994 (Appendix C14; Allen *et al*. 1998). In contrast, of the three species that became more widespread in

1998, California tonguefish and longfin sanddab expanded their occurrence northward (the former becoming more widespread in the northern region and the latter in the central region); whereas the bigmouth sole simply became more widespread in the central region (Appendix C14; Allen *et al*. 1998). Thus, the coldwater species appeared to have shifted its range deeper to the outer shelf zone (comprises less area), whereas the warmwater species increased its occurrence in the middle shelf zone.

New Species to California

As noted above, two species, blacklip dragonet (Callionymidae) and speckletail flounder (Bothidae), were taken for the first time in California during this survey (Allen and Groce 2001b, Groce *et al*. 2001a). Both are the first representatives of their families in California. Previous ranges for these fishes did not extend north past Bahia Vizcaino, located on the central coast of Baja California. Two blacklip dragonets were taken, the first off Santa Catalina Island at 97 m during the 1998 regional survey, and the second in 1999 at 100 m off San Diego (Groce *et al*. 2001a). The specimen taken off Santa Catalina Island during the 1998 regional survey was collected on July 23, 1998. The prior range of the blacktip dragonet was from Bahia Magdalena, Baja California Sur, Mexico, to Peru. This occurrence represents a range extension of 1,250 km to the north.

The speckletail flounder was collected at 63 m off San Diego during the 1998 regional survey (Allen and Groce 2001b). This fish was collected on August 6, 1998, north of the La Jolla submarine canyon at a depth of 63 m. The previous range for the speckletail flounder was from Bahia Vizcaino, Baja California, Mexico, to Peru. This represents a range extension of 600 km to the north.
Two additional demersal species were collected in 1998 (but not in the regional survey) that were new to California: blackspot wrasse (*Decodon melasma*) (Allen and Groce 2001a) and calico lizardfish (*Synodus lacertinus*) (Groce *et al*. 2001a). Two blackspot wrasse were taken at 60 m off Dana Point in 1998 and one was taken 100 m off San Diego in 1999 (Allen and Groce 2001a). One calico lizardfish was collected at 27 m off Tijuana just south of the U. S.-Mexico international border in 1998 (Groce *et al*. 2001b). The occurrence of these species in southern California was probably related to the 1997-1998 El Niño, when they were most likely transported as larvae to southern California in fall 1997 or spring 1998, from sites along the Baja California coast (Allen and Groce 2001a,b; Groce *et al*. 2001a,b).

Size Distribution

The length-frequency distribution of fish collected in the 1998 survey (Figure 15) was nearly identical to that of the 1994 survey (Allen *et al*. 1998) and of 1972-1973 (Allen 1982). Modal sizes were 6.5 cm in 1972-1973 and 1994 and 7.5 cm in 1998. The length-frequency distributions of these surveys were skewed to the right and strongly truncated to the left at 3.5-4.5 cm. The truncation on the left probably reflected both a net-related sampling bias (due to the size of the cod-end mesh, 1.25 cm) and the size at which many species recruit to the bottom. The skewness to the right was probably due to the increased ability of larger organisms to avoid the net and from the decreased density of larger fish (Allen 1982). Based on information on growth rates of the most abundant species, it can be assumed that most fish collected were juveniles.

Anomalies and Parasites

The prevalence of anomalies in demersal fish from the mainland shelf of southern California was lower in 1998 (0.5%) than in 1994 (1.0%) (Allen *et al*. 1998, 2001b). As in 1994, the prevalence of anomalies in

1998 was similar to background anomaly rates in mid-Atlantic (0.5%) and Gulf Coast (0.7%) estuaries (Fournie *et al*. 1996). In contrast, the prevalence of anomalies on the mainland shelf of the SCB from 1969-1976 was higher (5%) (Mearns and Sherwood 1977).

Fin erosion was not observed in any fish in the 1998 regional survey. Fin erosion was the most frequently observed anomaly in 1972 and 1976 (Mearns and Sherwood 1977). It was found in 33 species of fish on the shelf, with 60% of the species being flatfishes (Pleuronectidae, Paralichthyidae [= Bothidae, in part], and Cynoglossidae) and rockfishes. The disease was very prevalent on the Palos Verdes Shelf but was found at a low frequency in Santa Monica Bay, San Pedro Bay, and Dana Point. Approximately 39% of the Dover sole from the Palos Verdes Shelf had fin erosion in 1972 and 1976. Bight-wide (including the Palos Verdes Shelf), 30% of Dover sole had fin erosion. Fin erosion in Dover sole decreased as sediment contamination levels decreased between the early 1970s and the mid-1980s and was virtually absent on the Palos Verdes Shelf by 1990 (Stull 1995). Only 1 fish of 18,912 fish had fin erosion in 1994 (Allen *et al.* 1998, 2001b). The fin erosion in this specimen off Santa Barbara did not have the dark edges found in fin erosion on the Palos Verdes Shelf in the 1970s.

In the 1998 regional survey, epidermal tumors occurred in 12 of 1,635 (0.7%) Dover sole collected; Dover sole with tumors occurred on the Palos Verdes Shelf and at the southeast Channel Islands. In 1972-1975, epidermal tumors occurred in 126 (1.4%) of 8,733 Dover sole collected from Santa Monica Bay to Point Loma, California (Mearns and Sherwood 1977). Most of the individuals with this anomaly were less than 12 cm in length. The prevalence of epidermal tumors in Dover sole on the Palos Verdes Shelf decreased with increasing distance from the White Point outfall and also with time from 1971-1983 (Cross 1988). Epidermal tumors in Dover sole are not found only at outfall areas. Sherwood and Mearns (1976) found epidermal tumors in Dover sole from Point Arguello, California, to off Cedros Island, Baja California Sur, Mexico. In 1994, epidermal tumors were found in 10 (1%) of 961 Dover sole, occurring from Santa Barbara to Mission Bay (Allen *et al*. 1998, 2001b). This rate of occurrence probably represents the background prevalence for this disease in the SCB. Epidermal tumors are x-cell lesions thought to be caused by an amebic parasite (Dawe *et al.* 1979).

Ambicoloration has been found in a number of southern California flatfish species over the years, including bigmouth sole, California halibut, diamond turbot, Dover sole, English sole, curlfin sole, hornyhead turbot, and California tonguefish (Haaker and Lane 1973, Mearns and Sherwood 1977). In 1994, this anomaly was found in California halibut, California tonguefish, spotted turbot, Dover sole, hornyhead turbot, rex sole, and fantail sole (Allen *et al*. 1998). In the 1998 regional survey, ambicoloration was found mostly in hornyhead turbot, but also in California tonguefish, bigmouth sole, spotted turbot, California halibut, and speckled sanddab (Table 29).

Parasites were the most common anomalous occurrence of fishes in the 1998 survey, and Pacific sanddab was the species most affected (Table 29). The most noticeable external parasite that infests Pacific sanddab is the eye copepod (*Phrixocephalus cincinnatus*). It was the most common external parasite on demersal fish collected from 1969-1976 (Mearns and Sherwood 1977) and in 1994 (Allen *et al*. 1998). Although Mearns and Sherwood (1977) found a lower prevalence of this infestation on the Palos Verdes Shelf in the early 1970s (when that area was highly contaminated), the prevalence was relatively high at this location in fish collected from 1979-1994 (Perkins and Gartman 1997). Although it was the larger and more obvious parasites that were reported in this survey, additional species of parasitic copepods were identified from the fins and bodies of flatfishes and rockfishes (Kalman 2001).

MEGABENTHIC INVERTEBRATE POPULATIONS

INTRODUCTION

The megabenthic (trawl-caught) invertebrate fauna of the soft-bottom habitat of the southern California shelf is diverse, consisting of several hundred species (Moore and Mearns 1978, Allen *et al*. 1998, Stull *et al*. 2001). Because these species are relatively sedentary and respond to changes in the benthic environment, they have been monitored for more than 30 years to assess impacts resulting from human activities. Most information on the megabenthic invertebrate fauna of the southern California shelf has resulted from regular trawl surveys conducted near ocean outfalls to assess effects from wastewater discharge (e.g., Carlisle 1969a,b; Mearns and Greene 1974; CLAEMD 1994a,b; CSDMWWD 1995; CSDOC 1996; Stull 1995; CSDLAC 2000). While local areas have been well-studied for temporal and small-scale spatial variability, most earlier regional assessments compiled trawl data for various times, places, and purposes (Allen and Voglin 1976, Thompson *et al*. 1993a), collected data in reference surveys of limited scope (Word *et al*. 1977, Thompson *et al*. 1987, Thompson *et al*. 1993b), or provided a synoptic assessment of populations in wastewater discharge areas (Mearns and Greene 1974). A synoptic regional assessment of these populations along the southern California coast was not conducted until 1994 (Allen *et al*. 1998, Stull *et al*. 2001). Although this study provided substantial background information for the fauna of the mainland shelf (10-200 m depth), it did not assess invertebrate populations in bays and harbors, nor at islands of the SCB. A second regional survey was conducted in 1998 to provide additional region-wide background information on the status and health of invertebrate populations, as well as to assess invertebrate populations in bays and harbors and at offshore islands, as well as on the mainland shelf.

The objectives of this chapter are 1) to describe the distribution, relative importance (areal coverage, abundance, and biomass) and health of the dominant invertebrate species of the southern California shelf (including bays and islands), and of predetermined geographic, depth, and human influence subpopulations in 1998; 2) to assess population changes since 1994; and 3) to examine historical trends based on earlier studies. This information will provide a context for understanding local population patterns in routine monitoring studies to assess human impact. Other aspects of this fauna are presented in the Assemblages chapter.

RESULTS

Population Attributes

Abundance per Haul

A total of 132,790 invertebrates were collected during the survey (Table 34). The number of invertebrates per haul ranged from 0 to 10,005. The lowest individual value occurred in the mainland region on the inner shelf and the highest in the island region on the middle shelf. The median for the Bight as a whole was 100 individuals per haul, with subpopulation medians ranging from 4 (inner shelf, small POTWs) to 638 (southeast Channel Islands). Invertebrate abundance was higher (more area above the Bight median) at the islands than on the mainland (Table 34, Appendix D1). All regional island medians were above the Bight median. The warm islands had much higher numbers of invertebrates than did the cool islands, with the median number of invertebrates being 619 and 105, respectively. On the mainland, the median number of invertebrates was highest in the north (76), followed by the southern (62) and central (53) regions. By shelf (depth) zone, the outer shelf had the highest median number, followed by the middle shelf, bays/harbors, and lastly,

Table 34. Megabenthic invertebrate abundance by subpopulation at depths of 2-202 m on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Total	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Abundance (no. of individuals/haul)*									
Region									
Mainland	257	64,876	0	4,712	64	320	579	116	39.9
Northern	68	18,526	0	2,137	76	413	643	217	41.7
Central	114	26,147	0	2,765	53	221	404	103	37.5
Southern	75	20,203	0	4,712	62	296	653	246	39.6
Island	57	67,914	21	10,005	145	716	1,409	383	64.3
Cool (NW Channel Islands)	15	3,031	27	1,409	105	265	406	253	51.6
Warm	42	64,883	21	10,005	619	1,547	2,069	796	87.3
SE Channel Islands	16	18,394	21	6,430	638	1,455	1,856	1,038	87.6
Santa Catalina Island	26	46,489	27	10,005	568	1,788	2,527	971	83.8
Shelf Zone									
Bays and Harbors (2-30 m)	60	8,033	4	1,133	40	133	227	598	30.6
Ports	15	4,421	4	1,133	107	284	346	177	59.0
Marinas	18	1,709	11	672	43	93	149	69	18.0
Other Bay	27	1,903	4	507	22	75	123	53	19.0
Inner Shelf (2-30 m)	82	1,414	0	172	7	16	19	6	0.0
Small POTWs	15	121	0	38	4	8	11	5	0.0
River Mouths	31	646	0	172	11	21	31	11	2.0
Other Mainland	32	468	0	62	7	15	18	6	0.0
Island	4	179	27	71	39	46	16	16	0.0
Middle Shelf (31-120 m)	125	99,048	1	10,005	145	620	1,196	248	58.8
Large POTWs	32	25,092	56	4,712	235	784	1,136	394	75.1
Small POTWs	15	1,293	10	538	31	85	127	63	18.7
Mainland non-POTW	46	12,932	1	2,039	95	383	585	201	49.7
Island	32	59,731	21	10,005	145	886	1,606	537	68.2
Outer Shelf (121-202 m)	47	24,295	2	2,137	256	437	512	163	65.5
Mainland	26	16,291	2	2,137	318	648	648	258	78.0
Island	21	8,004	29	1,103	121	265	258	141	54.2
Total (all stations)	314	132,790	0	10,005	100	470	999	158	50.0

* The average area sampled during a trawl tow was 3,014 m^2.
CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number;
SD = Standard deviation.
POTW = Publicly owned treatment work monitoring areas.

the inner shelf; medians were 256, 145, 40, and 7, respectively. On the outer shelf, mainland catches were higher than at islands (Table 34, Appendix D2). On the middle shelf, large POTWs had the highest median abundances and small POTWs had the lowest. In bays and harbors, ports had higher median numbers than did marinas and "other bays." On the inner shelf, invertebrate abundance was highest (39) at islands and lowest at small POTWs. In the inner and middle shelf zones, invertebrate abundance was highest at the islands, but in the outer shelf zone, it was highest on in the central mainland region (Table 35, Appendix D3).

Table 35. Megabenthic invertebrate abundance by region within shelf zone subpopulations on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Total	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values SD	Area-Weighted Values 95% CL	Percent Above Bight Median
Abundance (no. of individuals/haul)*									
Shelf Zone									
Bays and Harbors (2-30 m)	60	8,033	4	1,133	40	133	227	598	30.6
Northern Region	3	83	11	44	20	28	14	16	0.0
Central Region	36	5,571	4	1,133	54	83	107	41	35.0
Southern Region	21	2,379	4	772	27	110	201	88	21.0
Inner Shelf (2-30 m)	82	1,414	0	172	7	16	19	6	0.0
Northern Region	30	370	0	57	5	17	20	10	0.0
Central Region	30	416	0	51	7	10	9	5	0.0
Southern Region	18	449	0	172	8	18	23	15	0.0
NW Channel Islands	3	152	39	71	41	51	14	16	0.0
SE Channel Islands	0	0	0	0	0	0	0	0	0.0
Santa Catalina Island	1	27	27	27	27	27	0	0	0.0
Middle Shelf (31-120 m)	125	99,048	1	10,005	145	620	1,196	248	58.8
Northern Region	17	7,552	1	2,039	97	575	731	395	53.0
Central Region	44	15,500	4	2,765	95	236	355	124	49.0
Southern Region	32	16,265	10	4,712	102	420	772	365	51.0
NW Channel Islands	7	2,213	27	1,409	117	316	457	339	57.0
SE Channel Islands	10	16,206	21	6,430	659	1,714	2,005	1,283	84.0
Santa Catalina Island	15	41,312	52	10,005	1,700	2,754	2,968	1,502	85.0
Outer Shelf (121-202 m)	47	24,295	2	2,137	256	437	512	163	65.5
Northern Region	18	10,521	2	2,137	270	585	636	294	71.0
Central Region	4	4,660	311	1,850	1,052	1,165	568	557	100.0
Southern Region	4	1,110	185	385	188	214	43	31	100.0
NW Channel Islands	5	666	29	397	48	133	138	121	30.0
SE Channel Islands	6	2,188	38	762	431	479	270	263	82.0
Santa Catalina Island	10	5,150	82	1,103	492	515	243	151	89.0
Total (all stations)	314	132,790	0	10,005	100	470	999	158	50.0

* The average area sampled during a trawl tow was 3,014 m^2.
CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number;
SD = Standard deviation.

More than 1,150 invertebrates per haul were caught at 31 stations (Figure 26). Most of these high abundance stations were at Santa Catalina Island, where the highest invertebrate catch of 10,005 individuals occurred. Most (126) stations had invertebrate catches of 60 to 1,150 individuals.

Biomass per Haul

A total of 1,910.0 kg of invertebrates were taken during the survey (Table 36). The biomass of invertebrates per haul ranged from 0 to 151.5 kg. Lowest individual values occurred in all mainland regions at all shelf zones, although not in all human influence subpopulations. The highest individual biomass occurred on the

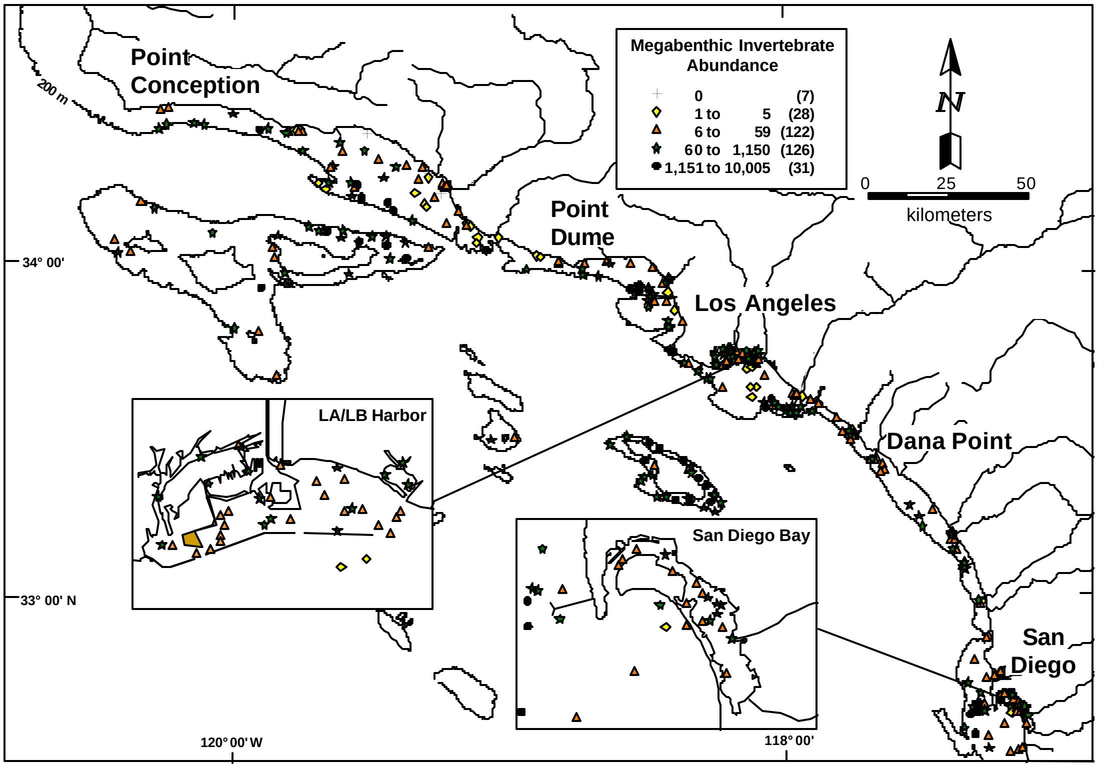


Figure 26. Distribution of megabenthic invertebrate abundance per haul at depths of 2-202 m on the southern California shelf, July-September 1998.

middle shelf at Santa Catalina Island. The overall median for the Bight was 1.9 kg per haul, with subpopulation medians ranging from 0.0 (inner shelf at small POTWs and "other" mainland areas) to 12.3 kg (Santa Catalina Island). Invertebrate biomass was higher (more area above the Bight median) on the island than the mainland region (Table 36, Appendix D4). The median biomass at all islands was above the Bight median. Among these islands, Santa Catalina Island and the southeast Channel Islands had a much higher number of invertebrates than the northwest Channel Islands, with median biomass values of 151.5, 54.1, and 21.1, respectively. Among the mainland regions, the northern and southern regions had the highest median biomass (0.8 kg) and the central regions had the lowest biomass (0.5 kg). Invertebrate biomass differed greatly among the shelf zones and increased with increasing depth. The outer shelf had the highest median biomass, followed by the middle shelf, bays and harbors, and the inner shelf, with medians of 9.3, 2.7, 0.2, and 0.0 kg, respectively. On the outer shelf zone, the mainland biomass was higher than the islands (Table 36, Appendix D5). On the middle shelf, large POTWs had the highest biomass and small POTWs had the lowest. In bays and harbors, marinas had a higher median biomass than ports and "other bays". Overall, the inner shelf biomass values were very low, with the highest median (0.2 kg) at river mouths. The highest mean (2.3 kg) was at the islands. Islands had the highest median biomass in all coastal shelf zones (inner, middle and outer shelf) (Table 37, Appendix D6). Overall, 31 stations had catches exceeding 18.1 kg, with most occurring at Santa Catalina Island (Figure 27). Most (125) stations had biomass values between 1.7 and 18.1 kg.

Species Richness (Number of Species per Haul)

A total of 313 species of invertebrates were collected during the survey (Table 38). The number of species per haul ranged from 0 to 25. No invertebrates were caught in at least one station in the north, central and

Table 36. Megabenthic invertebrate biomass by subpopulation at depths of 2-202 m on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Total	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Biomass (kg/haul)*									
Region									
Mainland	257	980.7	0.0	125.4	0.7	4.0	6.8	1.2	37.3
Northern	68	289.0	0.0	26.7	0.8	5.2	6.8	2.0	47.2
Central	114	273.1	0.0	30.7	0.5	3.0	5.9	1.9	25.1
Southern	75	418.6	0.0	125.4	0.8	3.1	7.5	1.8	37.2
Island	57	929.3	0.1	151.5	3.9	7.5	14.8	2.9	68.5
Cool (NW Channel Islands)	15	67.9	0.1	21.1	2.8	4.1	4.6	2.2	58.4
Warm	42	61.4	0.6	151.5	6.3	13.9	22.9	6.1	82.0
SE Channel Islands	16	225.6	0.6	54.1	6.0	9.8	12.2	5.6	76.6
Santa Catalina Island	26	635.8	0.8	151.5	12.3	24.5	36.6	14.1	93.8
Shelf Zone									
Bays and Harbors (2-30 m)	60	327.2	0.0	125.4	0.2	4.0	15.2	3.4	29.7
Ports	15	146.9	0.0	125.4	0.2	7.9	27.2	10.1	34.5
Marinas	18	45.5	0.0	7.9	1.8	2.6	2.2	1.1	49.2
Other Bay	27	134.8	0.0	49.8	0.1	2.8	8.1	2.5	16.7
Inner Shelf (2-30 m)	82	39.0	0.0	5.3	0.0	0.6	1.2	0.4	8.0
Small POTWs	15	2.0	0.0	1.2	0.0	0.1	0.3	0.1	0.0
River Mouths	31	12.6	0.0	3.0	0.2	0.4	0.6	0.2	2.6
Other Mainland	32	15.6	0.0	4.9	0.0	0.5	1.2	0.4	6.4
Island	4	8.9	0.1	5.3	1.0	2.3	2.1	2.1	37.7
Middle Shelf (31-120 m)	125	801.3	0.0	151.5	2.7	4.9	9.8	1.6	53.1
Large POTWs	32	153.3	0.2	20.2	2.0	4.8	5.3	1.8	52.4
Small POTWs	15	10.0	0.0	2.6	0.1	0.7	0.8	0.4	9.9
Mainland Non-POTW	46	130.6	0.0	16.3	1.0	3.9	5.2	1.8	40.9
Island	32	507.3	0.2	151.5	2.9	6.1	13.4	3.0	64.1
Outer Shelf (121-202 m)	47	742.6	0.0	138.2	9.3	12.2	14.8	3.9	77.0
Mainland	26	329.5	0.0	34.3	10.3	12.1	9.6	3.8	77.1
Island	21	413.9	0.7	138.2	6.3	12.2	17.9	6.3	75.0
Total (all stations)	314	1,910.0	0.0	151.5	1.9	5.3	10.7	1.3	50.0

* The average area sampled during a trawl tow was 3,014 m^2.

CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number;

SD = Standard deviation.

POTW = Publicly owned treatment work monitoring areas.

Table 37. Megabenthic invertebrate biomass by region within shelf zone subpopulations on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Total	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Biomass (kg/haul)*									
Shelf Zone									
Bays and Harbors (2-30 m)	60	327.2	0.0	125.4	0.2	4.0	15.2	3.4	29.7
Northern Region	3	9.8	2.2	5.0	2.4	3.3	1.2	1.4	100.0
Central Region	36	54.4	0.0	7.9	0.2	0.8	1.3	0.4	19.2
Southern Region	21	262.9	0.0	125.4	0.6	11.5	28.0	12.2	44.6
Inner Shelf (2-30 m)	82	39.0	0.0	5.3	0.0	0.6	1.2	0.4	8.0
Northern Region	30	11.6	0.0	4.9	0.0	0.7	1.6	0.8	11.2
Central Region	30	12.3	0.0	3.0	0.0	0.3	0.6	0.3	0.3
Southern Region	18	6.2	0.0	1.6	0.0	0.4	0.5	0.3	0.0
NW Channel Islands	3	8.1	0.1	5.3	1.4	2.7	2.1	2.4	43.3
SE Channel Islands	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Santa Catalina Island	1	0.8	0.8	0.8	0.8	0.0	0.0	0.0	0.0
Middle Shelf (31-120m)	125	801.3	0.0	151.5	2.7	4.9	9.8	1.6	53.1
Northern Region	17	70.6	0.0	16.1	1.9	5.3	6.0	3.2	50.0
Central Region	44	143.7	0.0	17.5	0.6	3.3	5.2	2.6	26.8
Southern Region	32	79.6	0.0	20.2	3.9	2.8	3.0	1.6	49.4
NW Channel Islands	7	20.0	0.2	5.4	2.1	2.9	2.0	1.5	52.1
SE Channel Islands	10	116.6	0.6	54.1	3.1	8.4	12.3	6.6	70.4
Santa Catalina Island	15	370.7	2.6	151.5	11.9	24.7	36.3	18.4	100.0
Outer Shelf (121-202m)	47	742.6	0.0	138.2	9.3	12.2	14.8	3.9	77.0
Northern Region	18	196.9	0.0	26.7	10.3	10.9	8.5	3.9	74.1
Central Region	4	62.7	3.9	30.7	9.3	15.7	10.2	10.0	100.0
Southern Region	4	69.9	1.1	34.3	1.4	15.5	14.2	18.2	52.9
NW Channel Islands	5	39.8	0.7	21.1	3.5	8.0	7.5	6.5	60.7
SE Channel Islands	6	109.0	5.7	37.8	6.7	14.9	10.4	8.9	100.0
Santa Catalina Island	10	264.3	2.6	138.2	17.8	26.4	38.1	23.6	100.0
Total (all stations)	314	1,910.0	0.0	151.5	1.9	5.3	10.7	1.3	50.0

* The average area sampled during a trawl tow was 3,014 m^2.
CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number;
SD = Standard deviation.

southern portion of the mainland region, and at all shelf zones, including POTW and non-POTW areas. The single highest number of species (25) was caught in the northwest Channel Island region on the middle shelf. The median for the Bight as a whole was 11 species per haul, with subpopulation medians ranging from 3 (inner shelf, small POTWs and "other" mainland areas) to 17 (southeast Channel Islands). The number of invertebrate species was higher (more area above the Bight median) on the islands than the mainland regions. All islands had a median number of species equal to or above the Bight median (Table 38, Appendix D7). Among these islands, the southeast Channel Islands had a higher number of species than the northwest Channel Islands and Santa Catalina Islands; median number of species collected was 17, 13 and 11, respec-

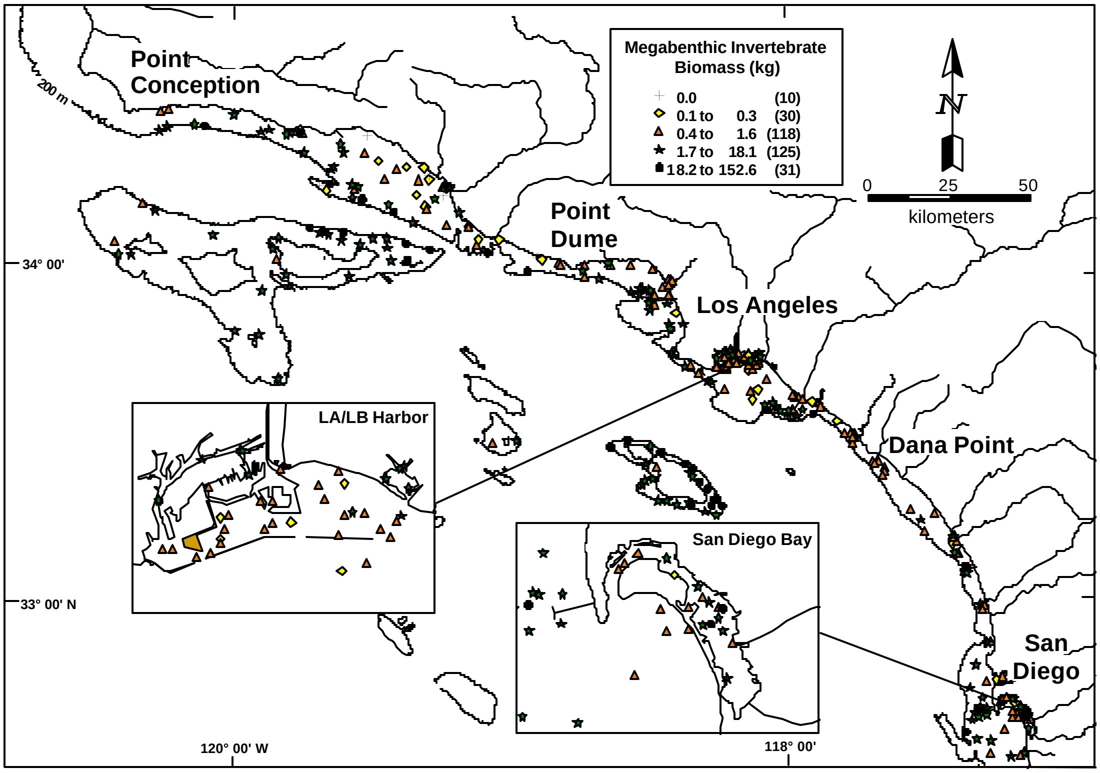


Figure 27. Distribution of megabenthic invertebrate biomass per haul at depths of 2-202 m on the southern California shelf, July-September 1998.

tively. There was little difference among the mainland regions, which had medians of 10, 8, and 7 for the southern, northern, and central regions, respectively. By depth, the middle and outer shelf zones were similar, with median numbers of species of 25 and 23, respectively. Bays and harbors (7 species) and the inner shelf (3 species) had considerably lower median numbers of species. Within the outer shelf zone, the mainland had a higher median number of species than the islands (Table 38, Appendix D8). Within the middle shelf, islands had the highest median, followed by the large POTWs, mainland non-POTW, and small POTWs. For bays and harbors, ports had a higher median than marinas and other bays. Overall, the inner shelf had low species richness values (medians), and the islands had the highest. Comparing regions within shelf zones, the highest medians in the middle and outer shelf zones were at the southeast Channel Islands, and for the inner shelf at the northwest Channel Islands (Table 39, Appendix D9). Overall, 29 stations had more than 17 species, with most of these occurring at the southeast Channel Islands (Figure 28). Most (128) stations had 8 to 17 species.

Diversity per Haul

Invertebrate diversity ranged from 0.0 to 2.51 bits/individual/haul (Table 40). Values of zero occurred at all three mainland regions, and at all shelf zones. The highest diversity occurred in the northern, mainland region. The median for the Bight as a whole was 1.06 bit/individual/haul, with subpopulation medians ranging from 0.69 (outer shelf, mainland) to 1.72 (inner shelf, island). Invertebrate diversity was higher (more area above the Bight median) at the islands than at the mainland: medians were 1.36 and 1.02, respectively (Table 40, Appendix D10). Among the islands, the cool northwest Channel Islands had a greater median diversity than the two warm island regions, southeast Channel Islands and Santa Catalina Island; medians of these were 1.70, 0.72, and 0.70, respectively. Along the mainland, the central region had a higher

Table 38. Number of megabenthic invertebrate species by subpopulation at depths of 2-202 m on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Total	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Number of Species (no. of species/haul)*									
Region									
Mainland	257	260	0	24	8	8	5	1	31.5
Northern	68	126	0	22	8	9	6	2	39.7
Central	114	164	0	23	7	8	5	2	26.7
Southern	75	157	0	24	10	9	4	2	22.1
Island	57	149	3	25	14	14	6	2	58.8
Cool (NW Channel Islands)	15	93	5	25	13	14	6	3	53.2
Warm	42	157	3	23	15	15	6	2	69.2
SE Channel Islands	16	69	5	23	17	16	6	3	72.3
Catalina Islands	26	88	3	17	11	11	4	1	46.2
Shelf Zone									
Bays and Harbors (2-30 m)	60	105	1	21	7	9	5	1	29.1
Ports	15	57	3	21	13	13	5	3	67.8
Marinas	18	50	3	15	10	9	4	2	33.9
Other Bay	27	59	1	18	6	6	3	1	5.3
Inner Shelf (2-30 m)	82	90	0	16	3	4	3	1	5.1
Small POTWs	15	30	0	13	3	3	3	2	1.8
River Mouths	31	43	0	11	4	4	3	1	0.0
Other Mainland	32	52	0	14	3	4	3	1	2.4
Island	4	26	7	16	9	11	4	4	35.6
Middle Shelf (31-120 m)	125	194	1	25	12	12	6	2	50.7
Large POTWs	32	89	4	24	11	12	4	2	50.0
Small POTWs	15	27	1	12	5	5	3	1	2.1
Mainland Non-POTW	46	95	1	20	11	10	5	2	40.4
Island	32	117	6	25	15	15	5	3	63.2
Outer Shelf (121-202 m)	47	120	1	23	11	12	6	2	49.8
Mainland	26	84	1	23	12	12	7	3	54.1
Island	21	76	3	23	11	12	5	3	46.2
Total (all stations)	314	313	0	25	11	11	6	1	50.0

* The average area sampled during a trawl tow was 3,014 m^2.
CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number;
SD = Standard deviation.
POTW = Publicly owned treatment work monitoring areas.

median diversity (1.11) than the Bight, and this was higher than at the southern (1.05) and northern regions (0.70). Among shelf zone areas, bays and harbors had the highest diversity, followed by the outer shelf, middle shelf and inner shelf; medians were 1.13, 1.10, 1.06, and 0.95, respectively. Within bays and harbors, marinas and ports had median diversity values higher than the Bight median (Table 40, Appendix D11). On the outer shelf, islands had a higher median diversity than mainland areas. On the middle shelf, the islands median exceeded the Bight median, whereas the remaining subpopulations were lower. Mainland non-

Table 39. Number of megabenthic invertebrate species by region within shelf zone subpopulations on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Total	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Number of Species (no. of species/haul)*									
Shelf Zone									
Bays and Harbors (2-30 m)	60	105	1	21	7	9	5	1	29.1
Northern Region	3	22	7	15	8	11	4	4	26.8
Central Region	36	75	3	21	8	7	3	1	30.0
Southern Region	21	49	1	18	7	7	5	2	21.7
Inner Shelf (2-30 m)	82	90	0	16	3	4	3	1	5.1
Northern Region	30	46	0	14	2	4	4	2	5.1
Central Region	30	45	0	13	3	4	2	1	0.4
Southern Region	18	36	0	10	3	4	2	1	0.0
NW Channel Islands	3	22	7	16	10	12	4	4	40.0
SE Channel Islands	0	0	0	0	0	0	0	0	0.0
Santa Catalina Island	1	9	9	9	9	9	0	0	0.0
Middle Shelf (31-120 m)	125	194	1	25	12	12	6	2	51.0
Northern Region	17	51	1	18	11	10	6	3	49.7
Central Region	44	84	1	19	11	10	4	2	36.4
Southern Region	32	86	2	24	11	10	3	2	28.3
NW Channel Islands	7	59	7	25	13	15	6	4	57.1
SE Channel Islands	10	60	6	22	17	16	5	3	71.3
Santa Catalina Island	15	67	7	17	13	13	3	2	60.0
Outer Shelf (121-202 m)	47	120	1	23	11	12	6	2	49.8
Northern Region	18	67	1	22	12	12	7	3	51.9
Central Region	4	34	5	23	10	15	7	7	47.5
Southern Region	4	30	5	12	11	9	4	5	50.0
NW Channel Islands	5	40	5	15	11	11	3	3	40.0
SE Channel Islands	6	40	5	23	14	16	7	7	68.3
Santa Catalina Island	10	43	3	15	8	9	4	3	30.0
Total (all stations)	314	313	0	25	11	11	6	1	50.0

* The average area sampled during a trawl tow was 3,014 m^2.
CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number;
SD = Standard deviation.

LPOTWs had the next highest median, followed by small POTWs, and then large POTWs. Islands were also the only group in the inner shelf with a diversity median that exceeded the Bight median. Comparing regions within the shelf zones, the highest diversity medians occurred at islands in the inner, middle, and outer shelf zones; in the northern region, the highest median was in bays and harbors (Table 41, Appendix D12). Invertebrate diversities greater or equal to 1.87 occurred at 31 stations distributed throughout the SCB; however, most were concentrated around the Northwest Channel Islands, Los Angeles Harbor and San Diego Bay (Figure 29). Most (125) stations had diversity values ranging from 1.08 to 1.87.

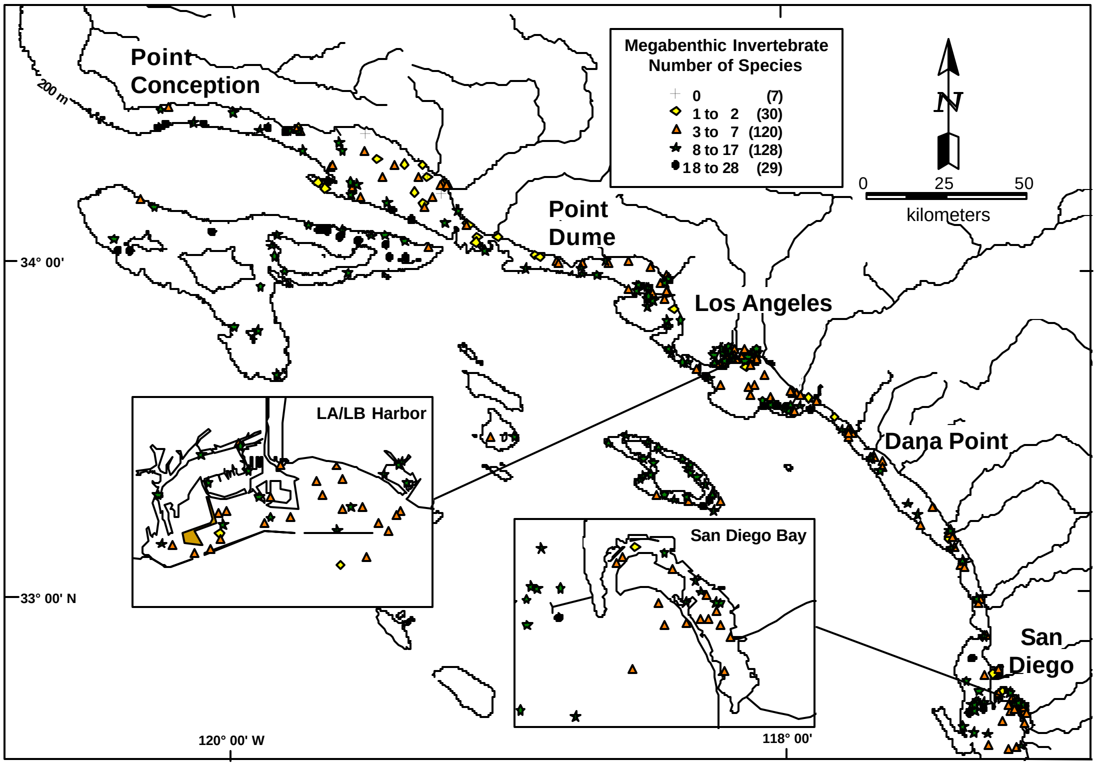


Figure 28. Distribution of numbers of megabenthic invertebrate species per haul at depths of 2-202 m on the southern California shelf, July-September 1998.

Species Composition

Taxonomic Composition

At least 313 species of invertebrates, representing 9 phyla, 21 classes, and 132 families, were collected during the trawl survey (Appendix D13; alphabetical lists of species by scientific and common name are given in Glossary G4 and G5). Of the 313 species, there were 81 mollusks, 78 arthropods, 52 echinoderms, 24 cnidarians, 19 poriferans, 8 chordates, 5 annelids, 4 brachiopods, and 2 ectoprocts. The most diverse classes were Malacostraca, with 74 species, Gastropoda with 64 species, and Anthozoa with 21 species. The most diverse families were Majidae (spider crabs), Asteriidae (sea stars), and Paguridae (right-handed hermit crabs), with 13, 8, and 7 species, respectively. Three species (hinged shrimp, *Pantomus affinis*; Colombian longbeak shrimp, *Plesionika trispinus*; and Pacific arrow crab, *Stenorhynchus debilis*) were taken for the first time in California.

Species Areal Occurrence

Of the 313 species, relatively few occurred over a large proportion of the mainland shelf of the SCB. The equitability curve for areal occurrence was hyperbolic, with a sharp change in slope at 18 species and 12% of the area (Figure 30, Appendix D14). Species ranking to the left of species 18 (California market squid, *Loligo opalescens*) sharply increased in areal occurrence and those to the left decreased in occurrence very gradually. Individually, 14 species (4% of all species) occurred in over 20% and 3 in over 50% of the total area (Table 42). The 6 most widely distributed species were the white sea urchin, California sand star

Table 40. Megabenthic invertebrate diversity by subpopulation at depths of 2-202 m on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Shannon-Wiener Diversity (bits/individual/haul)								
Region								
Mainland	257	0.00	2.51	1.02	1.00	0.61	0.13	45.9
Northern	68	0.00	2.51	0.70	0.85	0.69	0.22	34.7
Central	114	0.00	2.15	1.11	1.10	0.48	0.15	52.3
Southern	75	0.00	2.42	1.05	1.13	0.56	0.26	47.5
Island	57	0.15	2.43	1.36	1.31	0.67	0.27	56.7
Cool (NW Channel Islands)	15	0.38	2.43	1.70	1.54	0.62	0.36	68.3
Warm	42	0.15	2.25	0.72	0.89	0.55	0.22	34.5
SE Channel Islands	16	0.15	1.95	0.72	0.91	0.55	0.29	37.0
Santa Catalina Island	26	0.16	2.25	0.70	0.85	0.56	0.21	25.3
Shelf Zone								
Bays and Harbors (2-30 m)	60	0.00	2.42	1.13	1.16	0.47	0.12	53.5
Ports	15	0.69	1.97	1.16	1.27	0.40	0.20	56.5
Marinas	18	0.32	2.08	1.41	1.30	0.53	0.24	64.3
Other Bay	27	0.00	2.42	0.95	1.04	0.44	0.16	44.3
Inner Shelf (2-30 m)	82	0.00	2.36	0.95	0.96	0.57	0.18	46.9
Small POTWs	15	0.00	1.80	0.80	0.84	0.66	0.33	42.7
River Mouths	31	0.00	1.95	1.00	0.90	0.59	0.21	44.2
Other Mainland	32	0.00	1.13	0.88	0.93	0.54	0.19	45.3
Island	4	0.87	2.36	1.72	1.74	0.56	0.56	68.2
Middle Shelf (31-120 m)	125	0.00	2.43	1.06	1.17	0.68	0.20	49.3
Large POTWs	32	0.09	2.15	0.73	0.99	0.74	0.25	45.1
Small POTWs	15	0.00	1.57	0.85	0.84	0.44	0.22	33.5
Mainland Non-POTW	46	0.00	2.34	1.04	1.05	0.61	0.21	45.2
Island	32	0.15	2.43	1.52	1.32	0.72	0.36	54.4
Outer Shelf (121-202 m)	47	0.00	2.51	1.10	1.09	0.62	0.23	52.2
Mainland	26	0.00	2.51	0.69	0.90	0.69	0.27	38.2
Island	21	0.29	1.78	1.31	1.25	0.50	0.31	61.4
Total (all stations)	314	0.00	2.51	1.06	1.12	0.65	0.14	50.0

* The average area sampled during a trawl tow was 3,014 m^2.
CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number;
SD = Standard deviation.
POTW = Publicly owned treatment work monitoring areas.

(*Astropecten verrilli*), ridgeback rock shrimp (*Sicyonia ingentis*), gray sand star (*Luidia foliolata*), New Zealand paperbubble (*Philine auriformis*), and California sea slug.

Fourteen species occurred in more than 50% of the area in at least one subpopulation (Table 43, Appendix D-14). A mean of 4 species occurred in more than half the area of each subpopulation in the Mainland and island regions, and a mean of 3 species occurred in more than half the area of each shelf zone. In the mainland

Table 41. Megabenthic invertebrate diversity by region within shelf zone subpopulations on the southern California shelf, July-September 1998.

Subpopulation	No. of Stations	Range Min.	Range Max.	Area-Weighted Values Median	Mean	SD	95% CL	Percent Above Bight Median
Shannon-Wiener Diversity (bits/individual/haul)								
Shelf Zone								
Bays and Harbors (2-30 m)	60	0.00	2.42	1.13	1.16	0.47	0.12	53.5
Northern Region	3	1.56	1.89	1.72	1.77	0.15	0.17	100.0
Central Region	36	0.32	2.08	1.10	1.03	0.31	0.09	53.0
Southern Region	21	0.00	2.42	0.92	1.07	0.64	0.31	46.0
Inner Shelf (2-30 m)	82	0.00	2.36	0.95	0.96	0.57	0.18	46.9
Northern Region	30	0.00	2.13	0.69	0.87	0.70	0.35	43.3
Central Region	30	0.00	1.08	0.69	0.95	0.44	0.24	41.0
Southern Region	18	0.00	1.95	1.04	1.02	0.25	0.15	38.4
NW Channel Islands	3	0.87	2.36	1.36	1.69	0.62	0.70	60.3
SE Channel Islands	0	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Santa Catalina Island	1	1.94	1.94	1.94	1.94	0.00	0.00	100.0
Middle Shelf (31-120 m)	125	0.00	2.43	1.06	1.17	0.68	0.20	49.3
Northern Region	17	0.00	2.09	0.72	0.80	0.67	0.36	24.0
Central Region	44	0.00	2.15	1.27	1.17	0.48	0.21	53.4
Southern Region	32	0.12	2.35	1.06	1.22	0.62	0.38	49.2
NW Channel Islands	7	0.46	2.43	1.63	1.60	0.62	0.46	70.7
SE Channel Islands	10	0.15	1.95	0.69	0.81	0.57	0.35	20.6
Santa Catalina Island	15	0.16	2.25	0.63	0.81	0.61	0.31	17.8
Outer Shelf (121-202 m)	47	0.00	2.51	1.10	1.09	0.62	0.23	52.2
Northern Region	18	0.00	2.51	0.67	0.91	0.75	0.34	33.7
Central Region	4	0.07	1.31	1.30	1.00	0.53	0.52	54.9
Southern Region	4	0.39	1.20	0.42	0.60	0.22	0.22	3.9
NW Channel Islands	5	0.38	1.78	1.38	1.33	0.55	0.48	59.7
SE Channel Islands	6	0.90	1.46	1.31	1.30	0.15	0.11	83.1
Santa Catalina Island	10	0.29	1.36	0.71	0.81	0.36	0.22	25.8
Total (all stations)	314	0.00	2.51	1.06	1.12	0.65	0.14	50.0

* The average area sampled during a trawl tow was 3,014 m^2.
CL = Confidence limits (± value); Min. = Minimum; Max. = Maximum; No. = Number;
SD = Standard deviation.

and island regions, the southeast Channel Island area had the highest number (8) of these species, followed by the Santa Catalina Island area (6). The lowest number (2) was found in north and central mainland regions. Among the 4 shelf zones, the middle shelf had the highest number of species occurring in 50% or more of the area (4) and the inner shelf had the least (0). Geographically, the ridgeback rock shrimp was the most common species in the northern and southern regions, whereas the California sea star was the most common species in the central region. The white sea urchin was the most common species occurring at all the islands. Bathymetrically, the tuberculate pear crab (*Pyromaia tuberculata*) was the most commonly occurring species in the bays and harbors; the California sand star was the most common on the middle and inner shelf; and the fragile sea urchin (*Allocentrotus fragilis*) was most common on the outer shelf. No species

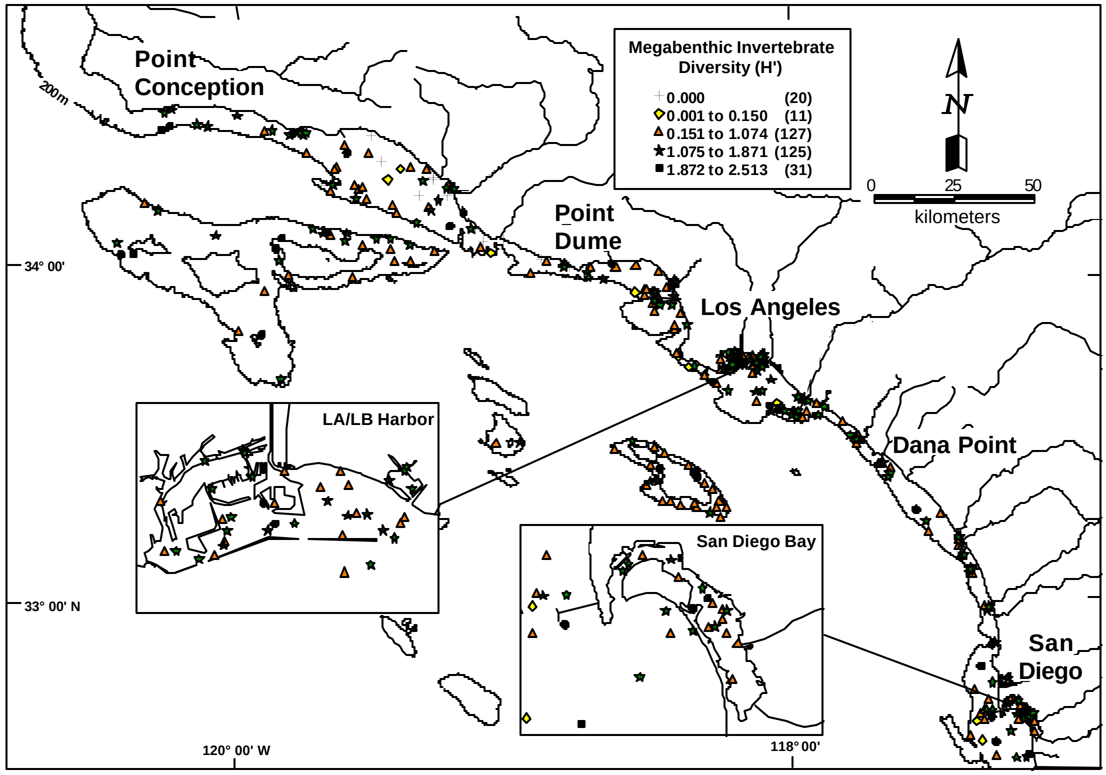


Figure 29. Distribution of megabenthic invertebrate diversity (Shannon-Wiener) per haul at depths of 2-202 m on the southern California shelf, July-September 1998.

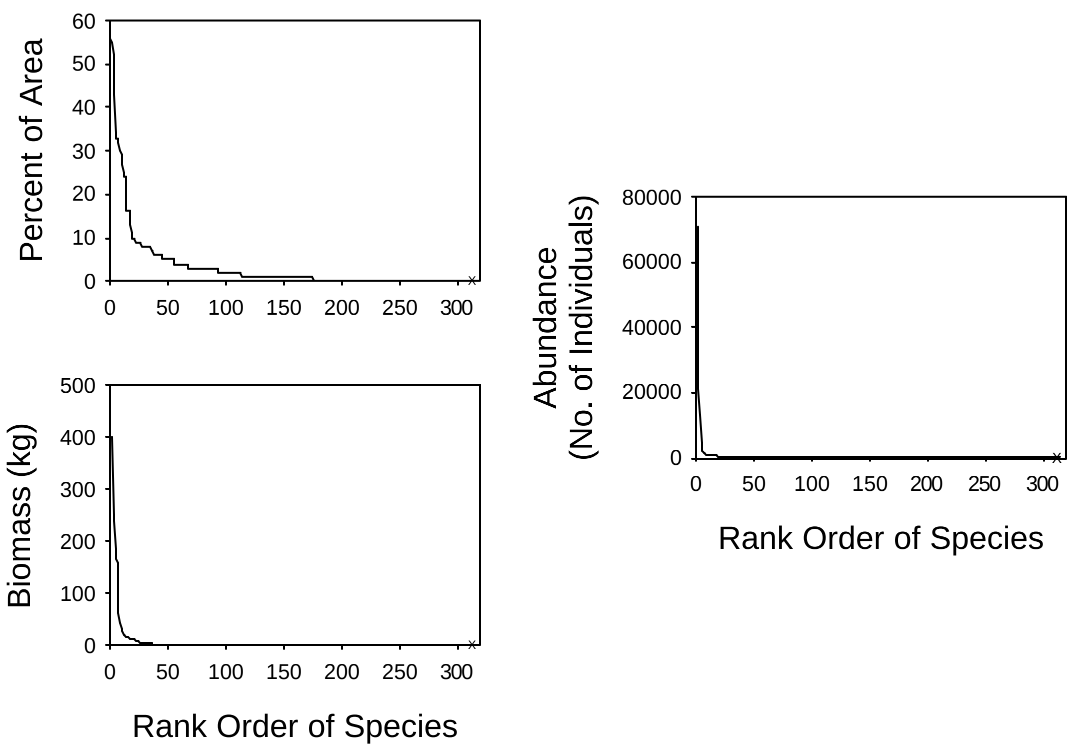


Figure 30. Equitability curves of megabenthic invertebrate occurrence, abundance, and biomass by species at depths of 2-202 m on the southern California shelf, July-September 1998. x = 313rd species.

Table 42. Megabenthic invertebrate species occurring in 20% or more of the area of the southern California shelf at depths of 2-202 m, July-September 1998.

Scientific Name	Common Name	No. of Stations	Percent of Stations	Percent of Area*
Lytechinus pictus	white sea urchin	103	32.8	55.9
Astropecten verrilli	California sand star	145	46.2	55.4
Sicyonia ingentis	ridgeback rock shrimp	122	38.9	51.8
Luidia foliolata	gray sand star	64	20.4	43.0
Philine auriformis	New Zealand paperbubble	91	29.0	34.4
Pleurobranchaea californica	California sea slug	48	15.3	33.4
Hamatoscalpellum californicum	California blade barnacle	54	17.2	32.5
Parastichopus californicus	California sea cucumber	85	27.1	31.5
Thesea sp B	yellow sea twig	56	17.8	30.5
Acanthoptilum sp	trailtip sea pen, unid.	58	18.5	29.1
Mediaster aequalis	red sea star	31	9.9	26.8
Ophiura luetkenii	brokenspine brittlestar	38	12.1	25.3
Octopus rubescens	red octopus	45	14.3	23.8
Ophiothrix spiculata	Pacific spiny brittlestar	47	15.0	23.6

Total stations = 314

Total area = 5,548 km^2

* Based on area-weighted frequency of occurrences.

occurred in more than 50% of the area in all subpopulations. Six species occurred in more than half of the area in a single subpopulation in the mainland and island regions. Of these, the New Zealand paperbubble, the California sea cucumber (*Parastichopus californicus*), and the orange sand star (*Astropecten ornatissimus*) occurred at Santa Catalina Island; the trailtip sea pen (*Acanthoptilum* sp) and the seapen spindlesnail (*Neosimnia barbarensis*) occurred at the southeast Channel Island area. Two species occurred in more than half the area of only a single subpopulation of the shelf zones. The tuberculate pear crab was common in the bays and harbors and the fragile sea urchin was common on the outer shelf.

Species Abundance

The equitability curve of species abundance approximated a smooth, tight hyperbola but was more concave than that for areal occurrence (Figure 30), indicating that relatively fewer species dominated the overall abundance than were dominant in areal occurrence. A sharp change in slope occurred at 5 species and 1.5% (Table 44), with abundance sharply increasing in species ranked to the left of species 5 (California sand star), and decreasing much more gradually to the right. The 24 most abundant species (8% of all species) accounted for 95% of abundance in the survey (Table 44). The white sea urchin was the most abundant species accounting for 53% of the total invertebrate abundance (70,757 individuals were caught). The next most abundant was the ridgeback rock shrimp accounting for 16% (21,221 individuals), and the California lamp shell (*Laqueus californianus*) accounting for 10% (13,014 individuals) of the total abundance.

Combinations of 26 species comprised the top 80% of the abundance in each subpopulation (Table 45, Appendix D15), with a mean of 4 species per subpopulation in the mainland and island regions. A mean of 8 species per subpopulation comprised 80% of the abundance for the shelf zones. On the mainland and island

Table 43. Megabenthic invertebrate species comprising 50% or more of the area by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	Percent of Area											
	Region											
	Mainland			Island			Shelf Zone					
Species*	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
white sea urchin	-	-	56	75	90	65	-	-	79	-	56
California sand star	63	69	56	-	65	50	-	-	67	-	55
ridgeback rock shrimp	64	50	67	-	61	65	-	-	65	63	52
gray sand star	-	-	-	68	67	-	-	-	55	-	-
New Zealand paperbubble	-	-	-	-	-	54	-	-	-	-	-
California sea slug	-	-	-	57	50	-	-	-	-	-	-
California blade barnacle	-	-	-	52	-	-	-	-	-	-	-
California sea cucumber	-	-	-	-	-	62	-	-	-	-	-
trailtip sea pen, unid.	-	-	-	-	63	-	-	-	-	-	-
red sea star	-	-	-	67	70	-	-	-	-	-	-
fragile sea urchin	-	-	-	-	-	-	-	-	-	64	-
tuberculate pear crab	-	-	-	-	-	-	59	-	-	-	-
seapen spindlesnail	-	-	-	-	65	-	-	-	-	-	-
orange sand star	-	-	-	-	-	50	-	-	-	-	-

* See Glossary G5 for scientific names of invertebrate species.

"-" Species not occurring in at least 50% of the area or absent.

N = Northern; C = Central; S = Southern; NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; CAT = Santa Catalina Island; B&H = Bays and Harbors; IS = Inner Shelf; MS = Middle Shelf; OS = Outer Shelf.

Total area (km^2) by subpopulation; N = 1,478; C = 1,214; S = 752; NWI = 1,365; SEI = 535; Cat = 205; SCB = 5,548.

shelf regions, 7 and 6 species comprised 80% of the abundance on the central mainland shelf and northwest Channel Island regions, respectively. More species (13) comprised 80% of the abundance on the inner shelf. Fewer species (2) comprised this abundance on the middle shelf. The white sea urchin was the most abundant species in all regions except the northern mainland region and by depth was most abundant in the middle shelf zone. The ridgeback rock shrimp was the most abundant in the northern region and on the outer shelf. The tuberculate pear crab was the most abundant in the bays and harbors, and the blackspotted bay shrimp (*Crangon nigromaculata*) was most abundant on the inner shelf.

Species Biomass

The equitability curve of species biomass approximated a smooth hyperbola, similar to that for species abundance (Figure 30); relatively few species dominated the overall biomass. A sharp change in slope occurred at 9 species and 1.6% (Table 46), with biomass sharply increasing in species ranked to the left of species 9 (the sponge, Porifera sp. SD2), and decreasing very gradually to the right. Thirty-six species (12% of all species) accounted for the top 95% of biomass in the survey. California sea cucumber had the largest biomass (400.0 kg; 20.9%), followed by the fragile sea urchin with 251.1 kg (13.1%), and the California lamp shell with 238.5 kg (12.5%).

Table 44. Megabenthic invertebrate species comprising 95% or more of the total invertebrate abundance of the southern California shelf at depths of 2-202 m, July-September 1998.

Scientific Name	Common Name	Abundance	Percent	Cumulative Percent
Lytechinus pictus	white sea urchin	70,757	53.3	53.3
Sicyonia ingentis	ridgeback rock shrimp	21,221	16.0	69.3
Laqueus californianus	California lamp shell	13,014	9.8	79.1
Allocentrotus fragilis	fragile sea urchin	4,690	3.5	82.6
Astropecten verrilli	California sand star	1,961	1.5	84.1
Pyromaia tuberculata	tuberculate pear crab	1,795	1.4	85.4
Philine auriformis	New Zealand paperbubble	1,190	0.9	86.3
Ophiothrix spiculata	Pacific spiny brittlestar	1,151	0.9	87.2
Pantomus affinis	hinged shrimp	1,111	0.8	88.0
Musculista senhousia	mat mussel	1,032	0.8	88.8
Parastichopus californicus	California sea cucumber	949	0.7	89.5
Crangon nigromaculata	blackspotted bay shrimp	943	0.7	90.2
Acanthoptilum sp	trailtip sea pen, unid.	853	0.6	90.9
Astropecten ornatissimus	orange sand star	787	0.6	91.5
Hamatoscalpellum californicum	California blade barnacle	757	0.6	92.0
Bulla gouldiana	California bubble	716	0.5	92.6
Neocrangon zacae	moustache bay shrimp	593	0.4	93.0
Microcosmus squamiger	scaly tunicate	502	0.4	93.4
Farfantepenaeus californiensis	yellowleg shrimp	458	0.3	93.7
Ophiopholis bakeri	roughspine brittlestar	399	0.3	94.0
Mytilus galloprovincialis	Mediterranean mussel	360	0.3	94.3
Ophiura luetkenii	brokenspine brittlestar	356	0.3	94.6
Luidia foliolata	gray sand star	355	0.3	94.8
Spatangus californicus	California heart urchin	300	0.2	95.1

Total abundance = 132,790 invertebrates

Combinations of 32 species comprised the top 80% of the biomass in each subpopulation (Table 47, Appendix D16), with a mean of 7 species per subpopulation for the mainland and island regions, and a mean of 6 species per subpopulation for the shelf zones. More species (14) comprised 80% of the biomass in the northwest Channel Island regions than any other region. Only 3 species comprised 80% of the biomass around Santa Catalina Island. By shelf zone, nine species comprised 80% of the biomass on the inner shelf, whereas 7, 4, and 4 comprised this biomass in the bays and harbors and middle and outer shelves, respectively. Geographically, the California sea cucumber was the biomass dominant for the total Bight and in the central mainland region. The fragile sea urchin was the second in biomass dominance and was the most dominant at the southeast Channel Islands and on the outer shelf. The California lamp shell was the biomass dominant at Santa Catalina Island and on the middle shelf. The ridgeback rock shrimp dominated in the northern mainland region. A species of sponge (Porifera sp SD 4) was dominant in the southern region and in bays and harbors. The gigantic sea anemone (*Metridium farcimen*) was the biomass dominant at the northwest Channel Islands as was the sheep crab (*Loxorhynchus grandis*) on the inner shelf.

Table 45. Megabenthic invertebrate species comprising 80% or more of the invertebrate abundance by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	Percent of Catch Abundance										
	Region										
	Mainland			Island			Shelf Zone				
Species*	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
white sea urchin	7	44	72	46	78	59	-	-	70	4	53
ridgeback rock shrimp	70	15	6	14	6	-	-	-	-	51	16
California lampshell	-	-	-	-	-	28	-	-	12	3	10
fragile sea urchin	5	-	-	3	-	-	-	-	-	19	4
California sand star	-	4	-	-	-	-	-	12	-	-	-
tuberculate pear crab	-	7	-	-	-	-	21	7	-	-	-
New Zealand paperbubble	-	3	-	-	-	-	7	3	-	-	-
Pacific spiny brittlestar	-	-	-	-	-	-	-	2	-	-	-
hinged shrimp	-	4	-	-	-	-	-	-	-	5	-
mat mussel	-	-	5	-	-	-	13	-	-	-	-
blackspotted bay shrimp	-	3	-	-	-	-	9	15	-	-	-
California bubble	-	-	-	-	-	-	9	-	-	-	-
scaly tunicate	-	-	-	-	-	-	6	-	-	-	-
yellowleg shrimp	-	-	-	-	-	-	4	10	-	-	-
roughspine brittlestar	-	-	-	13	-	-	-	-	-	-	-
Mediterranean mussel	-	-	-	-	-	-	4	-	-	-	-
yellow-green sea squirt	-	-	-	-	-	-	3	-	-	-	-
warty tunicate	-	-	-	-	-	-	3	-	-	-	-
red sea star	-	-	-	3	-	-	-	-	-	-	-
Pacific sand dollar	-	-	-	-	-	-	-	12	-	-	-
bat star	-	-	-	3	-	-	-	4	-	-	-
spiny sand star	-	-	-	-	-	-	-	5	-	-	-
yellow rock crab	-	-	-	-	-	-	-	4	-	-	-
Xantus swimming crab	-	-	-	-	-	-	-	2	-	-	-
sandflat elbow crab	-	-	-	-	-	-	-	2	-	-	-
offshore sand dollar	-	-	-	-	-	-	-	1	-	-	-

* See Glossary G5 for scientific names of invertebrate species.
"-" = Species not comprising the top 80% of the invertebrate abundance or absent.
N = Northern; C = Central; S = Southern; NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; CAT = Santa Catalina Island; B&H = Bays and Harbors; IS = Inner Shelf; MS = Middle Shelf; OS = Outer Shelf; SCB = Southern California Bight.
Total catch abundance (no. of individuals) by subpopulation: N = 18,526; C = 26,147; S = 20,203; NWI = 3,031; SEI = 18,394; CAT = 46,489; B&H = 8,033; IS = 1,414; MS = 99,048; OS = 24,295; SCB = 132,790.

Species Distributions

The distributions and habitat preferences of 10 species with high occurrence, abundance, and/or biomass are described below. The numbers following each species name are the abundance rank and the biomass rank respectively.

Table 46. Megabenthic invertebrate species comprising 95% or more of the total invertebrate biomass of the southern California shelf at depths of 2-202 m, July-September 1998.

Scientific Name	Common Name	Biomass (kg)	Percent	Cumulative Percent
Parastichopus californicus	California sea cucumber	400.0	20.9	20.9
Allocentrotus fragilis	fragile sea urchin	251.1	13.1	34.1
Laqueus californianus	California lamp shell	238.5	12.5	46.6
Sicyonia ingentis	ridgeback rock shrimp	183.8	9.6	56.2
Lytechinus pictus	white sea urchin	167.4	8.8	65.0
Porifera sp SD 4	"sponge"	157.0	8.2	73.2
Gorgonocephalus eucnemis	basket star	62.4	3.3	76.4
Metridium farcimen	gigantic anemone	42.1	2.2	78.7
Porifera sp SD 2	"sponge"	30.2	1.6	80.2
Porifera sp SD 10	"sponge"	28.0	1.5	81.7
Zoobotryon verticillatum	spaghetti moss-animal	21.5	1.1	82.8
Lopholithodes foraminatus	brown box crab	19.3	1.0	83.8
Loxorhynchus grandis	sheep crab	18.1	0.9	84.8
Luidia foliolata	gray sand star	18.1	0.9	85.7
Parastichopus parvimensis	warty sea cucumber	17.6	0.9	86.7
Spatangus californicus	California heart urchin	14.1	0.7	87.4
Porifera sp SD 6	"sponge"	14.0	0.7	88.1
Panulirus interruptus	California spiny lobster	11.8	0.6	88.7
Paralithodes californiensis	California king crab	11.8	0.6	89.4
Paguristes turgidus	slenderclaw hermit	11.8	0.6	90.0
Farfantepenaeus californiensis	yellowleg shrimp	11.5	0.6	90.6
Stylasterias forreri	fish-eating star	9.5	0.5	91.1
Pisaster brevispinus	shortspined sea star	8.2	0.4	91.5
Asterina miniata	bat star	7.7	0.4	91.9
Mytilus galloprovincialis	Mediterranean mussel	6.9	0.4	92.3
Porifera sp SD 5	"sponge"	6.4	0.3	92.6
Muricea californica	golden gorgonian	5.8	0.3	92.9
Microcosmus squamiger	scaly tunicate	5.6	0.3	93.2
Astropecten ornatissimus	orange sand star	4.9	0.3	93.5
Pleurobranchaea californica	California sea slug	4.7	0.2	93.7
Staurocalyptus solidus	"glass sponge"	4.7	0.2	93.9
Ciona intestinalis	yellow-green sea squirt	4.5	0.2	94.2
Astropecten verrilli	California sand star	4.5	0.2	94.4
Aplysia californica	purple sea hare	4.0	0.2	94.6
Loxorhynchus crispatus	moss crab	3.5	0.2	94.8
Poecillastra tenuilaminaris	plate sponge	3.0	0.2	95.0

Total biomass = 1,910.0 kg

Table 47. Megabenthic invertebrate species comprising 80% or more of the invertebrate biomass by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	Percent of Catch Biomass										
	Region										
	Mainland			Island			Shelf Zone				
Species*	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
California sea cucumber	17	28	14	-	12	30	-	-	24	27	21
fragile sea urchin	18	10	-	11	23	16	-	-	-	33	13
California lamp shell	-	-	-	-	-	38	-	-	28	-	12
ridgeback rock shrimp	37	13	-	4	8	-	-	-	8	16	10
white sea urchin	-	12	8	6	11	-	-	-	21	-	9
"sponge" [a]	-	-	38	-	-	-	48	-	-	-	8
basket star	-	-	-	7	22	-	-	-	-	-	3
gigantic anemone	-	-	4	12	-	-	-	-	-	4	2
"sponge" [b]	-	-	7	-	-	-	9	-	-	-	2
"sponge" [c]	-	-	7	-	-	-	9	-	-	-	-
spaghetti moss animal	-	6	-	-	-	-	7	-	-	-	-
brown box crab	-	-	-	-	8	-	-	-	-	-	-
sheep crab	-	-	-	-	-	-	-	26	-	-	-
gray sand star	5	-	-	-	-	-	-	-	-	-	-
California heart urchin	4	-	-	-	-	-	-	-	-	-	-
"sponge" [d]	-	-	3	-	-	-	4	-	-	-	-
California spiny lobster	-	-	-	-	-	-	3	5	-	-	-
slenderclaw hermit	-	-	-	3	-	-	-	-	-	-	-
California king crab	-	3	-	2	-	-	-	-	-	-	-
yellowleg shrimp	-	4	-	-	-	-	2	10	-	-	-
fish-eating star	-	-	-	6	-	-	-	-	-	-	-
shortspined sea star	-	2	-	-	-	-	-	7	-	-	-
bat star	-	-	-	10	-	-	-	11	-	-	-
Mediterranean mussel	-	3	-	-	-	-	-	-	-	-	-
golden gorgonian	-	-	-	-	-	-	-	11	-	-	-
California sea slug	-	-	-	2	-	-	-	-	-	-	-
"glass sponge" [e]	-	-	-	7	-	-	-	-	-	-	-
purple sea hare	-	-	-	-	-	-	-	3	-	-	-
plate sponge	-	-	-	4	-	-	-	-	-	-	-
cloud sponge	-	-	-	4	-	-	-	-	-	-	-
red sea urchin	-	-	-	2	-	-	-	6	-	-	-
black sea hare	-	-	-	-	-	-	-	3	-	-	-

* See Glossary G5 for scientific names of invertebrate species.

[a] "sponge" = Porifera sp SD 4
[b] "sponge" = Porifera sp SD 2
[c] "sponge" = Porifera sp SD 10
[d] "sponge" = Porifera sp SD 6
[e] "glass sponge" = *Staurocalyptus solidus*

"-" = Species not comprising at least 80% of invertebrate biomass or absent.

White Sea Urchin (*Lytechinus pictus*) (1,5). The white sea urchin is a predominantly middle shelf species that occurred in 55.9% of the area and was most common at the island and southern mainland regions (Tables 42, 43). It was the most abundant species caught (70,757 individuals) and accounted for 53.3% of the total Bight invertebrate abundance (Table 44). It ranked fifth among all species for its biomass contribution, which was 8.8% (Table 46). The white sea urchin was the numerical dominant in the central and southern mainland regions, all island regions, and the middle shelf zone (Table 45). Catches greater than 5,850 individuals were taken from two sites, one located at the northwest Channel Islands and the other located off Santa Catalina Island (Appendix D17). Biomass of the white sea urchin was less than 1.8 kg in most (287) of the stations, but a maximum biomass of 17.0 kg was taken from one site located off Point Loma near the City of San Diego wastewater outfall.

California Sand Star (*Astropecten verrilli*) (5, 33). The California sand star is a predominantly middle shelf species that occurred in 55.4% of the area and was most common on the mainland regions and at the warm islands (Tables 42, 43). It accounted for 1.5% of the total Bight invertebrate abundance and 0.2% of the biomass (Tables 44, 46). This species was not a numerical or biomass dominant in any area (Tables 45, 47). The largest numbers (over 173 individuals) were taken from two sites both located near the Hyperion Treatment Plant outfall in Santa Monica Bay (Appendix D18). The maximum biomass of the California sand star was only 1.2 kg and was also found at one site near the Hyperion Treatment Plant outfall. Biomass values for the California sand star were mainly low (< 0.1 kg) to absent.

Ridgeback Rock Shrimp (*Sicyonia ingentis*) (2,4). The ridgeback rock shrimp is a middle and outer shelf species that occurred in 51.8% of the area and was most common at the mainland regions and the warm islands (Tables 42, 43). It was the second most abundant invertebrate caught (21,221 individuals) and accounted for 16.0% of the total Bight invertebrate abundance and 9.6% of the biomass (Tables 44, 46). This species was a numerical dominant in the northern mainland and outer shelf zone, and ranked second in abundance at the central and southern mainland regions, as well as at the northwest Channel Islands (Table 45). The ridgeback rock shrimp was also a biomass dominant in the northern mainland region and ranked second in biomass at the central mainland region (Table 46). Both abundance and biomass increased from south to north. The largest numbers (over 1,909 individuals) were taken from two different sites, one located near Mugu Submarine Canyon and the other located off Naples Point west of Santa Barbara (Appendix D19). The largest amount of biomass (21.2 kg) was taken from one site near Mugu Submarine Canyon.

California Lamp Shell (*Laqueus californianus*) (3,3). The California lamp shell (Phylum Brachiopoda) occurred in 1% of the area and was most common at Santa Catalina Island (Appendix D14). It accounted for 9.8% of the total SCB invertebrate abundance and 12.5% of the biomass (Tables 44, 46). This species was not a numerical dominant in any area, but was the second most abundant at Santa Catalina Island and on the middle shelf (Table 45). However, it was a biomass dominant at Santa Catalina and on the middle shelf (Table 47). The greatest abundance (6,600) was taken from one site located on the southeast side of Santa Catalina Island; this was also the site of maximum biomass, 147.4 kg (Appendix D20). The second largest abundance (over 3,419 individuals) was also taken from Santa Catalina Island.

California Sea Cucumber (*Parastichopus californicus*) (11,1). The California sea cucumber, a middle and outer shelf species, occurred in 31.5% of the area and was most common at Santa Catalina Island (Table 42, 43). It accounted for 0.7% of the total Bight invertebrate abundance and 20.9% of the biomass (Tables 44, 46). This species was not a numerical dominant in any of the subpopulations (Table 45); however, it contributed the most biomass taken in the survey, including the central mainland region (Table 47; Appendix

D16). Further, the California sea cucumber was second in biomass dominance in the middle and outer shelf zones. The highest abundance (over 101 individuals) was taken from one location at the northwest Channel Islands (Appendix D21). California sea cucumber was absent over the majority of the stations. However, 122 kg was taken at one station located on the northwest side of Santa Catalina Island.

Fragile Sea Urchin (*Allocentrotus fragilis*) (4,2). The fragile sea urchin, a middle and outer shelf species, occurred in 16% of the area and in all regions (Appendix D14). It accounted for 3.5% of the total Bight invertebrate abundance and 13.1% of the biomass (Tables 44, 46). This species was not a numerical dominant in any subpopulation, but ranked second in abundance on the outer shelf zone (Table 45). In terms of biomass, the fragile sea urchin ranked second and was the most dominant in the southeast Channel Island region and the outer shelf zone (Table 47). The largest catch of the fragile sea urchin (over 462 individuals) was taken from two sites, one located off the mainland shelf west of Point Dume and the other located on the southeast side of Santa Catalina Island (Appendix D22). Maximum biomass (21.7 kg) occurred at the southeast end of Santa Catalina Island where the highest abundance was also recorded.

Gray Sand Star (*Luidia foliolata*) (23, 15). The gray sand star occurred mostly in the middle and outer shelf zones, occupied 43% of the area, and accounted for 0.3 and 0.9% of the abundance and biomass, respectively (Appendix D14; Tables 44, 46). The largest catch (over 46 individuals) was taken from two sites along the 200m isobath south of Point Conception; these two sites were also the location of maximum biomass (Appendix D23). The gray sand star was absent at a majority of the stations (250).

New Zealand Paperbubble (*Philine auriformis*) (7,221). The New Zealand paperbubble (a gastropod) is predominantly a middle shelf species. It occurred in 34.4% of the area, mostly around Santa Catalina Island (Tables 42, 43; Appendix D14). The New Zealand paperbubble accounted for 0.9% of the total Bight invertebrate abundance but was not a significant contributor of biomass in any subpopulation (Tables 44, 46; Appendix D16). While it was absent at the majority of stations (223), 146 individuals were taken at one station located inside LA/LB Harbor. In addition to this site, four other sites yielded at least 74 individuals; three of these were located inside LA/LB Harbor (Appendix D24). Biomass was not significant at any station, being less than 0.1 kg at all (91) stations where it occurred.

California Sea Slug (*Pleurobranchaea californica*) (32, 31).
The California sea slug, a middle and outer shelf species, occurred in 15.3% of the area and was most common at the northwest and southeast Channel Islands (Tables 42, 43; Appendix D14). It comprised 0.1% of the total abundance and 0.2% of the biomass (Appendix D15; Table 44). This species was not a significant contributor of abundance or biomass in any subpopulation (Tables 45, 47). The largest catch of 34 individuals was taken at one station located south of Point Conception, otherwise this species was absent at a majority (266) of the stations (Appendix D25). Maximum biomass (1.3 kg) was taken from one station located off the northwest Channel Islands.

Tuberculate Pear Crab (*Pyromaia tuberculata*) (6, 49). The tuberculate pear crab, a bays and harbors and inner shelf species, occurred at 9.0% of the area (Appendix D14). It accounted for 1.4% of the abundance, but made an insignificant biomass contribution (Table 44; Appendix D-16). This species was a numerical dominant in the bays and harbors and ranked third in abundance in the central mainland region (Table 45). The highest abundance (898 individuals) occurred at one site located inside LA/LB Harbor (Appendix D26). This site was also the location of greatest biomass (1.0 kg). The tuberculate pear crab was absent at a majority of the stations sampled (247).

California Sea Cucumber Size (Length) Distribution

The size structure of California sea cucumber varied significantly by shelf zone and somewhat by region. Mean size increased as a function of depth (Figure 31). The modal size (using 5-cm size classes) was 17.5 cm on the inner and middle shelf, and 27.5 cm on the outer shelf. The size range varied from 7.5-27.5 cm on the inner shelf, 7.5-32.5 cm on the middle shelf, and 17.5-32.5 cm on the outer shelf. The smallest individuals collected (7.5 cm size class) were not found on the outer shelf. Only 6 individuals were present on the inner shelf, making comparisons between other shelf zones problematic. However, the comparison between the middle shelf and outer shelf zones, where densities were much higher, clearly shows a greater abundance of larger individuals in the latter habitat. This pattern is generally holds for coastal regions along the southern California mainland (Figure 32). [Regions described here differ somewhat from those of the present report and are defined in Figure 32].

DISCUSSION

Many trawl studies have been conducted in southern California during the past 40 years. Most are focused on local areas rather than the SCB as a whole. However, two studies, Thompson *et al.* (1993a) and the 1994 regional survey (Allen *et al.* 1998, Stull *et al.* 2001), provide population attribute data for the SCB as a whole and provide perspective to the 1998 data. Thompson *et al.* (1993a) summarized information on demersal (megabenthic) invertebrates from 1,203 trawl samples taken in southern California from 1971 to 1985 over a depth range of 10-915 m. Of these, 658 were collected over the mainland shelf (10-137 m). The 1994 survey collected 114 trawl samples from 9-215 m, all on the mainland shelf. The 1998 survey collected samples from 314 stations, of which 197 were from the mainland shelf (depths of 10-202 m).

Population Attributes

Invertebrate population attributes in 1998 were generally lower than in 1957-1975 (Thompson *et al.* 1993a) and 1994 (Allen and Moore 1996, Allen *et al.* 1998) (Table 48). For the SCB mainland shelf (islands and bays excluded), mean invertebrate abundance and biomass were highest in 1957-1975, whereas numbers of species and diversity were highest in 1994 (a region-wide diversity estimate for 1957-1975 is not available); the 1998 mean was about half of those in 1957-1975 and 1994. In 1998, fish abundance was 48-52% that of earlier periods, biomass was 51-55%, and numbers of species was 60-62%. Diversity was more similar, with that of 1998 being about 91% of 1994. It should be noted that the number of samples used in the analysis was much smaller in 1994 and 1998 than in 1957-1975. However, in the latter two years the samples were collected synoptically within the same year using a stratified randomized design, whereas in 1957-1975, samples collected over a 29 year period were compiled from surveys of varying designs.

By region, values were almost always much lower in 1998 than in 1994; the only exception was diversity in the southern region which was higher in 1998 (Table 48). In 1998, fish abundance was lower relative to 1994 in the north (40%) and highest in the central region (70%). Biomass was lowest in the central region (48%) but highest in the north (77%), and numbers of species showed a similar decrease in all regions (those of 1998 being 60-62% of 1994). Diversity values in 1998 were about 80-83% of those in 1994 for the central and northern regions but were 140% of the 1994 value.

As in 1994 (Allen and Moore 1996, Allen *et al.* 1998) invertebrate abundance, biomass, and species richness were very low on the inner shelf, relative to the middle and outer shelf zones (Tables 34, 36, and 38;

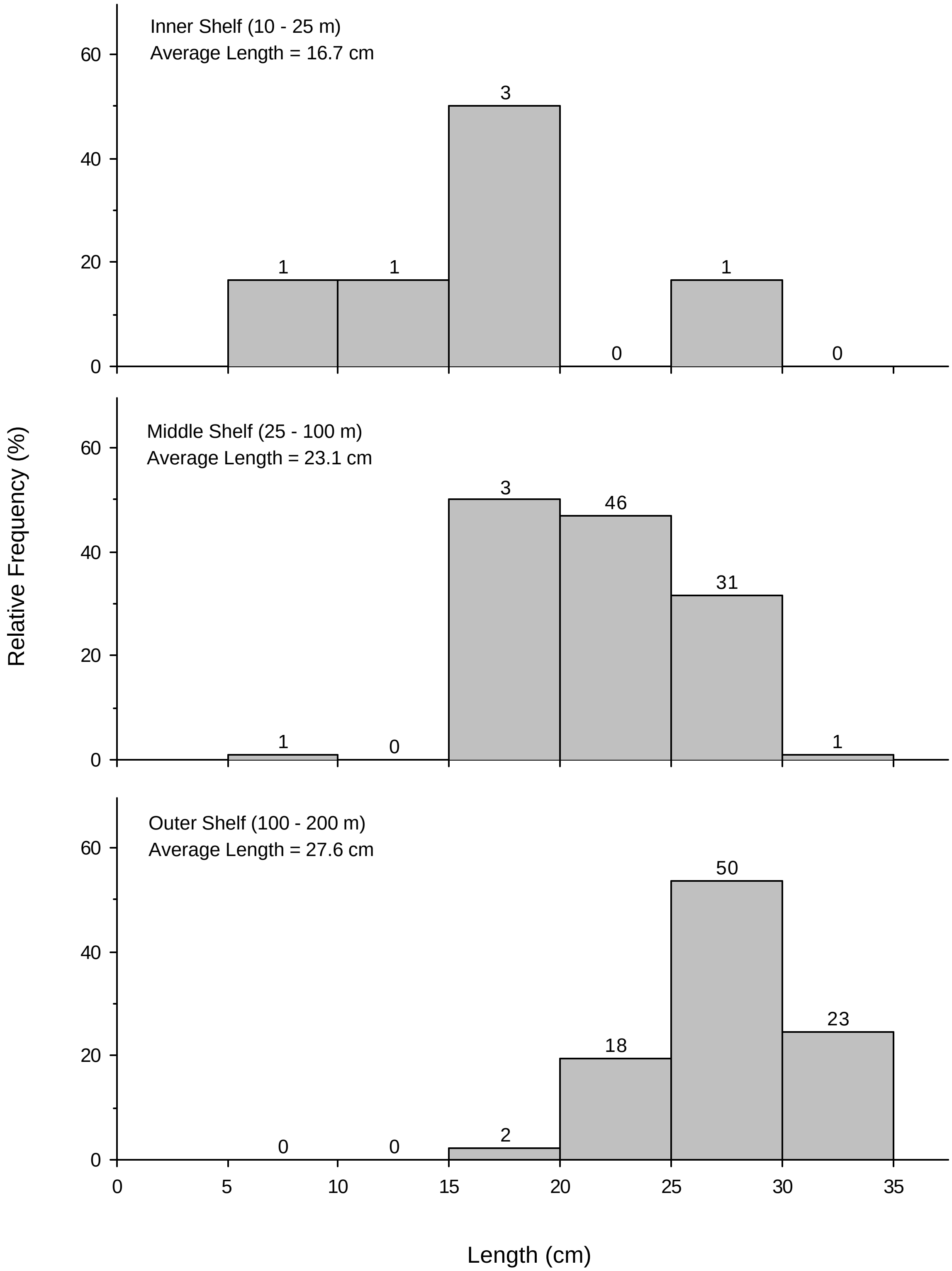


Figure 31. Length-frequency distribution of California sea cucumber (*Parastichopus californicus)* from selected sites on the southern California shelf at depths of 2-202 m, July-September 1998. The number of individuals in each 5-cm size class is shown on the top of each bar.

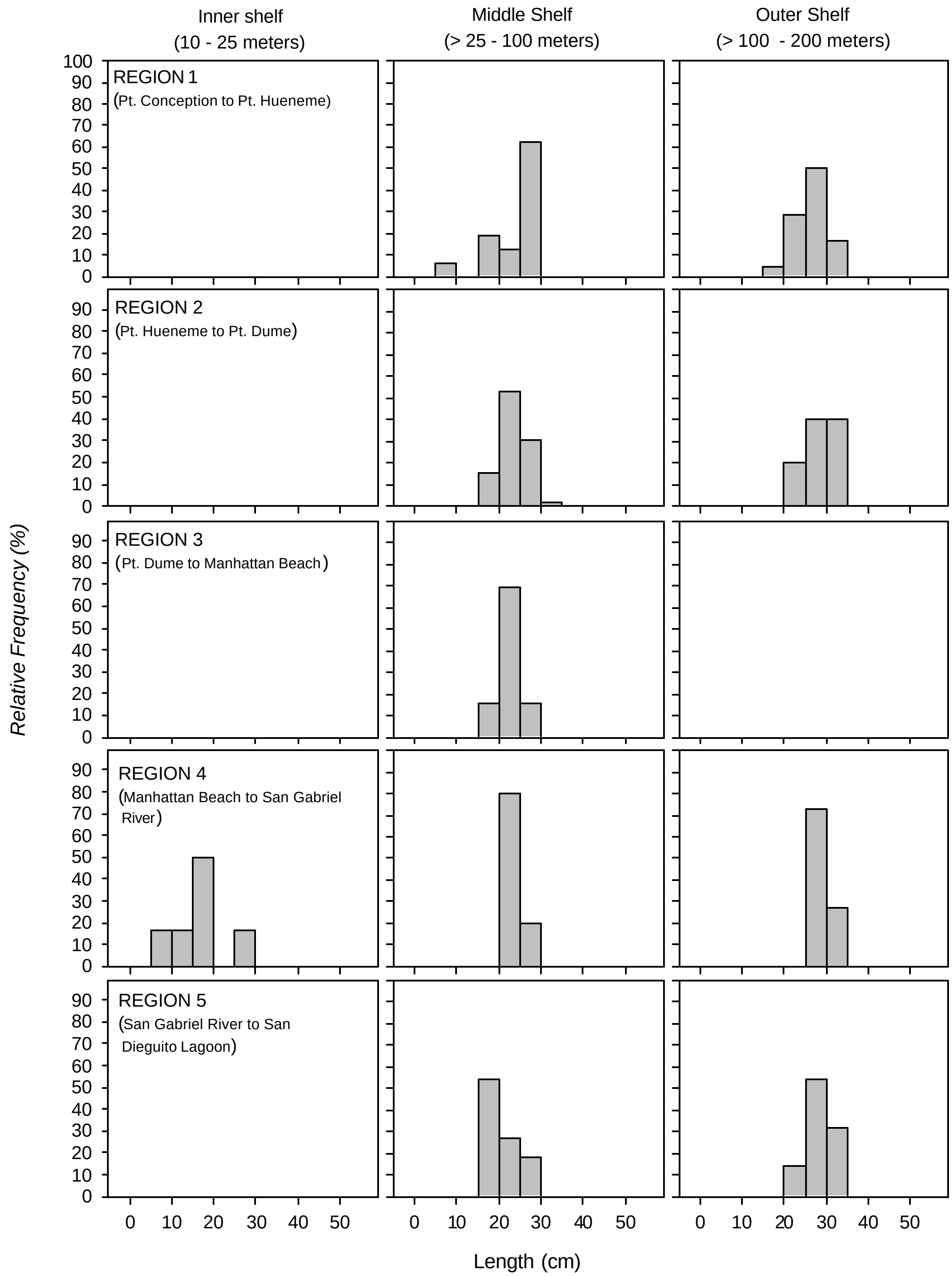


Figure 32. Length-frequency distributions of California sea cucumber (*Parastichopus californicus)* by region and shelf zone on the southern California mainland shelf, July-September 1998.

Table 48. Comparison of megabenthic invertebrate population attributes on the mainland shelf of Southern California in 1957-1975, 1994, and 1998 regional survey data.

Southern California Bight Database	No. of Samples	Mean/Haul[a] Abundance of no. individuals	Biomass (kg)	No. of species	Diversity (bits/individual)
Northern Region					
1994	45	805	7.4	12.5	1.03
1998[c]	65	318	5.7	7.7	0.85
Central Region					
1994	41	384	7.0	12.8	1.36
1998[c]	78	267	3.4	7.7	1.09
Southern Region					
1994	28	530	6.2	12.8	0.81
1998[c]	54	336	3.5	7.9	1.13
All Regions (SCB as a whole)					
1957-1975[b]	658	577	6.6	13.1	--
1994	114	631	7.0	12.6	1.09
1998[c]	197	302	3.6	7.8	0.99

[a]1994 and 1998 means are weighted in accordance with the sampling design.

[b]Historical data are from Thompson *et al*. (1993a).

[c]Data from Bays/Harbors excluded from 1998 analysis.

Appendices D1, D4, and D7). As in this study and the 1994 study, Thompson *et al.* (1987) found a distinct increase in invertebrate biomass with depth, but that study found fewer individuals on the middle shelf and more species on the inner shelf. Allen *et al.* (1998) suggested that the low population attributes in the inner shelf zone might be related to a more variable environment (e.g., of temperature, salinity, turbulence, and food availability). The higher daytime light levels in this zone may also select for more cryptic invertebrate species and facilitate net avoidance by fish.

Comparing middle shelf reference (non-LPOTW) and LPOTW areas, there was little difference in median invertebrate population attributes between reference and POTW areas or between years in both subpopulations (Figure 33, Table 49). However, all attributes differed significantly in percent area of LPOTW above the reference median for the same year (Figure 34). More area of the LPOTW subpopulations had higher invertebrate abundance in 1998 than in 1994, whereas for species richness and diversity, the percent area above the reference median was higher in 1994 than in 1998. These results are based on a reapportionment of 1994 stations into the more restrictive LPOTW areas of 1998.

Species Composition

There were some important changes in species composition between 1994 and 1998. Although the distribution of species among higher taxa was nearly the same as in 1994 (Allen *et al.* 1998, Stull *et al.* 2001), Asteriidae (sea stars) replaced Crangonidae (bay shrimps) in 1998 as one of the three most diverse families.

California sand star and ridgeback rock shrimp were the most widespread invertebrate species in 1994, occurring in more than 50% of the area. In 1998, both of these species also occurred in more than half the area but white sea urchin was the most widespread species (Table 42). White sea urchin was clearly the most abundant species and California sea cucumber was the biomass dominant in both years (see Tables 44 and 46 for 1998).

El Niño Effects

Changes in Areal Occurrence

In both the 1994 and 1998 surveys, two species (California sand star and ridgeback rock shrimp) comprised more than 50% of the area of the mainland shelf of southern California (Table 50) (Allen *et al.* 1998, Stull *et al.* 2001). Three species (New Zealand paperbubble; yellow sea twig, *Thesea* sp. B; and California blade barnacle, *Hamatoscalpellum californicum*) showed dramatic increases in areal occurrence from 1994 to 1998. In contrast, California sea slug, brokenspine brittlestar (*Ophiura luetkenii*), gray sand star, and spiny brittlestar (*Ophiothrix spiculata*) had large decreases in areal occurrence during this period. California blade barnacle is a warm-temperate species (Austin 1985). New Zealand papperbubble is an introduced

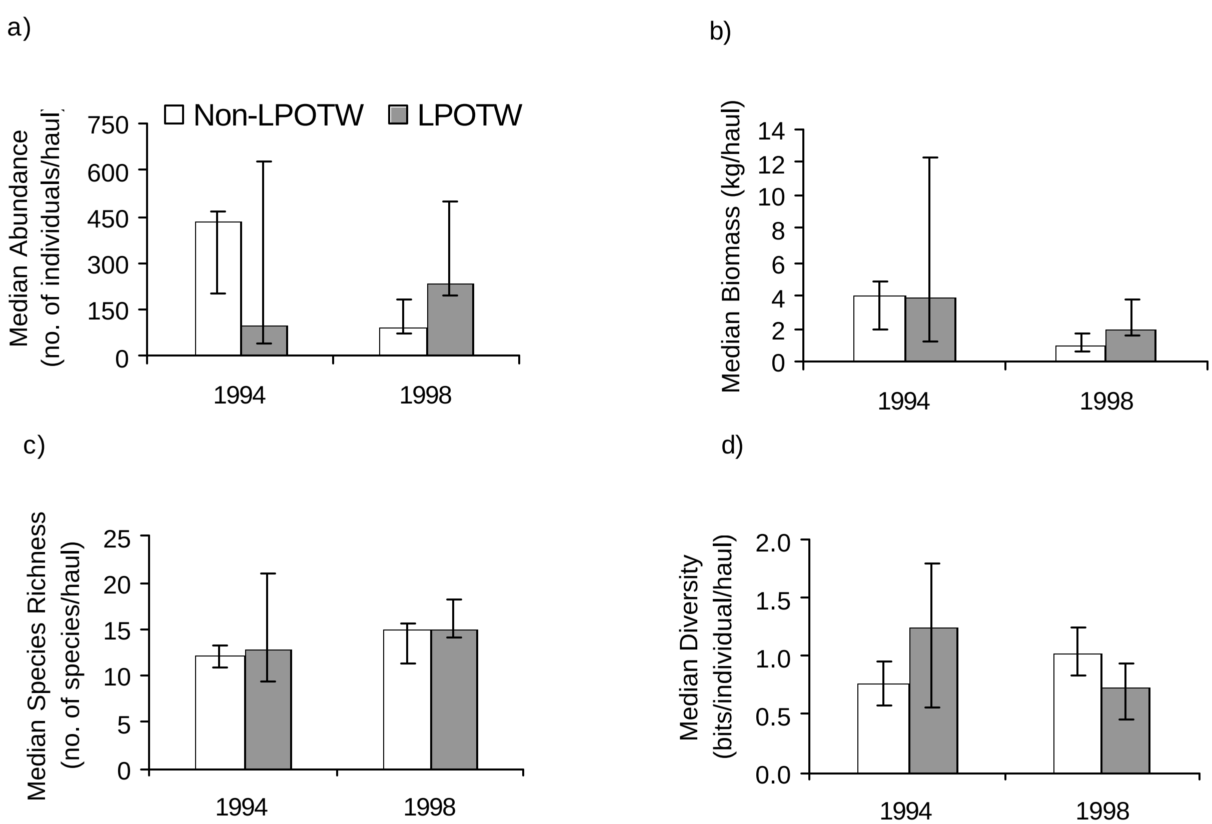


Figure 33. Median (and 95% confidence limits) megabenthic invertebrate population attributes at large publicly owned treatment work (LPOTW) subpopulations and reference (NLPOTW: mainland, middle shelf, non-large POTW) subpopulations in 1994 and 1998: a) abundance; b) biomass; c) species richness; and d) diversity. NOTE: LPOTW boundaries of 1998 were used for both years; non-large POTW areas consist of all mainland middle shelf stations that did not fall within the LPOTW boundaries.

Table 49. Megabenthic invertebrate abundance, biomass, species richness, and diversity at middle-shelf large publicly owned treatment work (LPOTW) and reference (non-LPOTW) subpopulations in 1994 and 1998. Data from 1994 reanalyzed using 1998 subpopulation boundaries.

					Stratified Values					Percent Above
	No. of		Range			95% CL				Bight
Category	Stations	Total	Min.	Max.	Md	LL	UL	Mn	SD	Median
Abundance (no. of individuals/haul)										
1994 LPOTW	9	5,745	16	2,831	97	54	536	637	950	50
1998 LPOTW	32	25,091	56	4,712	235	41	265	784	1,136	75
1994 non-LPOTW	49	44,446	16	11,616	439	200	468	903	1,948	68
1998 non-LPOTW	61	14,225	1	2,039	95	77	179	379	582	49
Biomass (kg/haul)										
1994 LPOTW	9	73.3	0.0	29.0	3.9	1.3	12.3	8.7	9.2	59
1998 LPOTW	32	153.3	0.2	20.2	2.0	1.6	3.8	4.8	5.3	52
1994 non-LPOTW	49	374.8	0.0	31.8	3.8	2.0	4.9	6.7	7.1	65
1998 non-LPOTW	61	140.6	0.0	16.3	1.0	0.6	1.8	3.8	5.2	41
Species Richness (no. of species/haul)										
1994 LPOTW	9	68	5	35	13	9	21	16	8	67
1998 LPOTW	32	89	6	34	15	14	18	17	6	50
1994 non-LPOTW	49	155	6	40	12	11	13	13	6	52
1998 non-LPOTW	61	100	1	28	15	11	16	13	6	66
Shannon-Wiener Diversity (bits/individual/haul)										
1994 LPOTW	9	0.45	0.23	2.34	1.26	0.56	1.80	1.26	0.69	58
1998 LPOTW	32	1.30	0.09	2.15	0.73	0.45	0.93	0.99	0.74	45
1994 non-LPOTW	49	0.30	0.03	2.42	0.77	0.59	0.96	0.99	0.62	41
1998 non-LPOTW	61	0.63	0.00	2.34	1.02	0.84	1.26	1.05	0.61	44

CL = Confidence limits (LL = Lower Limit; UL = Upper Limit); Min. = Minimum; Max. = Maximum; No. = Number; SD = Standard deviation; Md = Median; Mn = Mean.
POTW = Publicly owned treatment work monitoring areas.

species, and was not found in the 1994 survey (Allen *et al.* 1998). Yellow sea twig and California blade barnacle greatly increased its areal occurrence on the middle shelf in 1998, and the former disappeared from the inner shelf (Appendix D14; Allen *et al.* 1998). Those that decreased in occurrence generally did so across all shelf zones, with the gray sand star disappearing from the inner shelf in 1998. Most of these have ranges that extend well into the temperate zone. Most of these species have ranges extending from cooler temperate waters to warm temperate or tropical waters. As only the 1994 and 1998 surveys provide data for comparing areal occurrence of species, it is not known whether these responses are related to El Niño or to interannual variation in populations

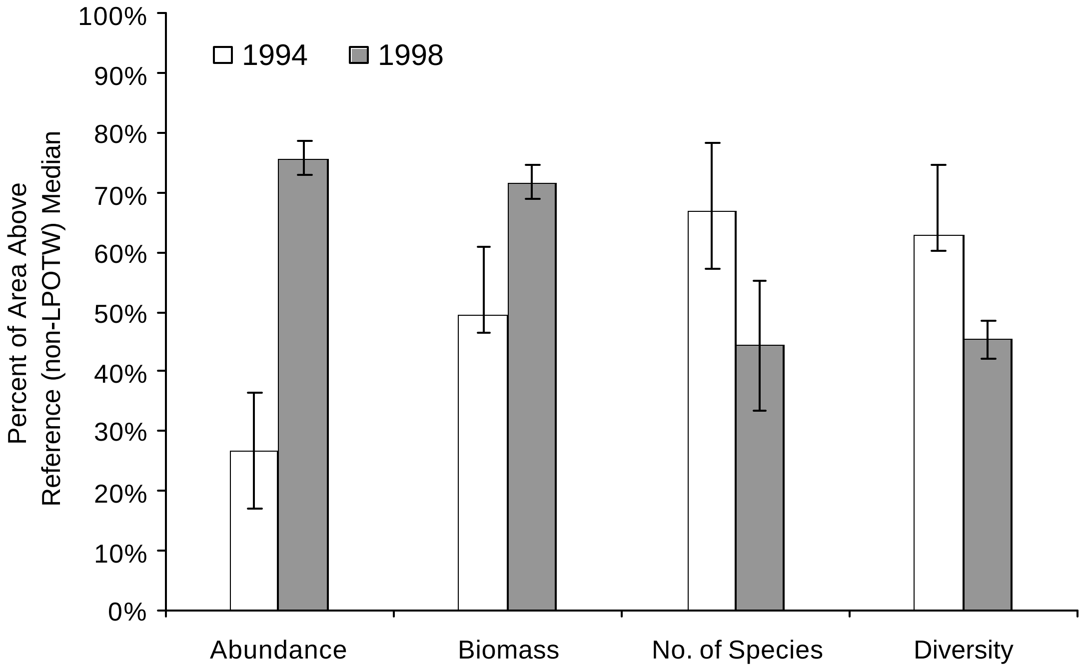


Figure 34. Percent of area (with 95% confidence limits) within the large publicly owned treatment plant subpopulation (LPOTW) of megabenthic invertebrate population attributes above the reference (NLPOTW: mainland, middle shelf, non-large POTW) subpopulation medians in 1994 and 1998. NOTE: LPOTW boundaries of 1998 were used for both years; non-large POTW areas consist of all mainland middle shelf stations that did not fall within the LPOTW boundaries.

New Species to California

As noted above, three species new to California were collected during the 1998 survey (Montagne and Cadien 2001). These were the hinged shrimp and Colombian longbeak shrimp (both Pandalidae) and Pacific arrow crab (Majidae). The hinged shrimp was collected at station 2116 off Point Dume, California at a depth of 191 m on 19 August 1998, extending its range north from Santa Inez Bay, Baja California, Mexico. The Colombia longbeak shrimp was collected at station 2119 off Newport Beach at a depth of 194 m on 7 August 1998. However, this specimen was taken as early as February 1998 off Palos Verdes Peninsula, California. Prior to 1998, this species was not collected north of Santa Maria, Sinaloa, Mexico. The Pacific arrow crab was collected in this survey at two stations (2077 and 2087) off Santa Catalina Island at depths of 50 and 69 m, on 22 and 24 of July, 1998. However, a collection off Huntington Beach in another survey on 11 August 1999, extended its range even further north from its previous northern record at Bahia Magdalena, Baja California Sur, Mexico.

Size Distribution of California Sea Cucumber

During the course of the 1998 survey, size information on California sea cucumbers on the southern California shelf was collected as part of an assessment of effects of commercial fisheries on sea cucumber populations (Schroeter and Reed 2001). The information collected in this survey showed that the size structure of

Table 50. Comparison of megabenthic invertebrate species occurring in greater than 20% of the area on the mainland shelf of southern California in 1994 and 1998.

		No. of Stations		Percent of Stations		Percent of Area*	
Scientific Name	Common Name	1994	1998[a]	1994	1998[a]	1994	1998[a]
Astropecten verrilli (1)[b]	California sand star	80	118	70	64	<u>72.0</u>	<u>67.7</u>
Sicyonia ingentis (2)	ridgeback rock shrimp	67	88	59	48	<u>61.0</u>	<u>62.9</u>
Lytechinus pictus	white sea urchin	55	65	48	35	48.0	45.3
Parastichopus californicus	California sea cucumber	53	56	46	30	46.0	38.2
Thesea sp B	yellow sea twig	29	45	25	24	18.9	34.7
Philine auriformis	New Zealand paper bubble	0	54	0	29	0.0	32.0
Luidia foliolata (3)	gray sand star	55	38	48	21	49.0	31.6
Hamatoscalpellum californicum	California blade barnacle	21	44	18	24	16.8	26.7
Ophiura luetkenii	brokenspine brittlestar	44	23	39	12	39.0	23.5
Pleurobranchaea californica	California sea slug	44	28	39	15	46.0	23.5
Luidia armata	mosaic sand star	19	36	19	19	19.0	22.4
Ophiothrix spiculata	Pacific spiny brittlestar	33	28	29	15	31.0	21.6
Acanthoptilum sp	trailtip sea pen, unid.	25	30	22	16	24.0	21.2
Total (all stations)		114	185			3,075[c]	3,229[c]

* Percent of area based on area-weighted frequency of occurrences.
[a]Mainland shelf only (10 - 200 m); stations in island and bay/harbor subpopulations were excluded from the 1998 analysis.
[b]Numbers in parentheses represent rank of species occurring in greater than 50% of the area in 1994.
[c]Total area in km^2.
Areal occurrences of 50% or greater are underlined.

California sea cucumber populations varied with depth, with mean size as well as the proportion of larger individuals increasing with depth. This pattern was similar across all regions along the mainland shelf of southern California. The smallest sea cucumbers in this survey were on the inner shelf in the Palos Verdes Shelf/LA-LB Harbor area. In another study near Santa Barbara (Schroeter and Reed 2001), sizes increased in shallow water during June, suggesting that larger California sea cucumber moves into the inner shelf during the spring to spawn.

ASSEMBLAGES AND BIOINTEGRITY

INTRODUCTION

The demersal fish and invertebrate fauna of southern California have been the focus of environmental assessment studies for more than 30 years. Most studies were local in nature and assessed the effects of wastewater discharge on fish and invertebrate populations (e.g., Carlisle 1969a,b; CSDLAC 1990; CLAEMD 1994a,b; CSDMWWD 1995; CSDOC 1996). While these studies focused on populations, some used cluster analysis to describe species and site assemblages near outfalls (e.g., CSDOC 1996); others (Allen 1985) used this method to define soft-bottom assemblages relative to hard-bottom assemblages. Some early studies described demersal fish communities for southern California using recurrent group analysis (based on species co-occurrence) (SCCWRP 1973, Mearns 1974, Allen 1982). Thompson *et al.* (1993a) used cluster analysis to describe site and species assemblages based upon species-abundance data accumulated from 1971-1985 from the southern California mainland shelf, slope, and basins as well as from highly contaminated sites and different (warm and cool) oceanic regimes. These studies focused on the central part of the SCB and identified depth-related species groups for the southern California shelf. However, their data were collected from different places in different years and did not provide a description of the assemblages in the SCB for a single time period.

The first description of demersal fish and invertebrate assemblages for the mainland shelf as a whole was based on data collected in the 1994 regional survey (Allen and Moore 1997a, 1997b; Allen *et al.* 1998, 1999a,b). Recurrent group analysis was used to describe species groups and cluster analysis was used to describe species and site clusters. Both analyses identified depth as the primary factor around which the communities were organized. Only site clusters (which provide assemblage information for all sites) provided a basis for assessing publicly owned treatment work (POTW) effects, and no effects were observed in the assemblages. Although the 1994 survey provided a baseline description of fish and invertebrate communities for the mainland shelf, assemblages in bays/harbors and islands were not sampled. In addition, assemblages were described for fish and invertebrates separately; they were not described for fish and invertebrates combined. Because no suitable indices were available for assessing the biointegrity of these assemblages, the extent of altered assemblages in the SCB could not be determined.

The objectives of this study were 1) to describe assemblages of demersal fishes, megabenthic invertebrates, and combined fishes and invertebrates for the southern California shelf to determine whether bay and island assemblages differ from depth-related shelf assemblages, and 2) to assess the areal extent of assemblages with disrupted biointegrity. Assemblages were defined by several methods.

Recurrent group analysis was used to describe species groups based on presence/absence data and species co-occurrence, cladistic analysis to describe site and species clades based on presence/absence and abundance data, and cluster analysis was used to describe species and site clusters based on species abundances The areal extent of altered communities was determined using recently developed biointegrity indices (Allen *et al.* 2001a). A model of the functional organization of the fish communities (Allen 1982) was used to examine effects of regime changes and the 1998 El Niño event.

RESULTS

Fish Assemblages

Fish Recurrent Groups

Recurrent group analysis at the 0.50 level of affinity identified 10 recurrent groups of fishes consisting of 2-6 species per group with 4 associate species (Figure 35). In all, the groups and associates included 33 (23%) of the 143 species collected in the survey. The groups generally differed in depth distribution, with each occurring in one or two of the four predetermined shelf zones (Figure 36). Groups were found at 1-60 stations, with 6 groups occurring at more than 10 stations (Figure 37).

Group 1 (San Diego Bay Group). Group 1 consisted of two species, round stingray and spotted sand bass (*Paralabrax maculatofasciatus*) (Figure 35). The group occurred at 11 stations in San Diego Bay at depths of 4-15 m (Figures 36 and 37). Group 1 did not have affinities with other recurrent groups.

Group 2 (Harbor/Inner-Shelf Schoolers Group). Group 2 consisted of two schooling sciaenid species, white croaker and queenfish (Figure 35). This group occurred most frequently and was found at 60 stations ranging in depth from 5-89 m, but primarily at depths of 5-30 m (Figures 36 and 37). It was found primarily in LA/LB Harbor and near the Santa Clara and Ventura river mouths, as well as at a number of coastal inner shelf sites. It was not found in San Diego Bay or on the islands. California halibut was an associate of this group (Figure 35).

Group 3 (Catalina Shallow-Reef Group). Group 3 consisted of two rocky bottom gobies, bluebanded goby (*Lythrypnus dalli*) and zebra goby (*Lythrypnus zebra*) (Figure 35). This group occurred at one site (Station 2088) at Santa Catalina Island at 42 m (Figure 36, Appendix C14). It was not associated with any of the other groups.

Group 4 (Mainland Middle-Shelf Group). Group 4 consisted of 6 species: California lizardfish, longfin sanddab, California tonguefish, yellowchin sculpin, bigmouth sole, and hornyhead turbot (Figure 35). The group occurred at 39 sites ranging in depth from 23-89 m (Figures 36 and 37). It occurred throughout the mainland middle shelf zone but was not found at the islands (Figure 37). California halibut, California scorpionfish (*Scorpaena guttata*), and Groups 6 and 7 were associates of this group (Figure 35).

Group 5 (Catalina Shelf-break Group). Group 5 consisted of 2 species, slender snipefish (*Macroramphosus gracilis*) and pit-head sculpin (*Icelinus cavifrons*) (Figure 35). It occurred at 2 sites at 88-97 m at Santa Catalina Island (Figures 36 and 37; Appendix C14). It was not associated with any other group.

Group 6 (Middle Shelf/Outer Shelf Group). Group 6 consisted of two species, longspine combfish (*Zaniolepis latipinnis*) and pink seaperch (*Zalembius rosaceus*) (Figure 35). The group occurred at 48 sites ranging from 29-184 m, but was more frequent in the middle shelf zone from 29-135 m (Figures 36 and 37). It occurred widely in the mainland and island regions within the middle shelf and outer shelf zones (Figure 36). It was associated with Groups 4 and 7 (Figure 35).

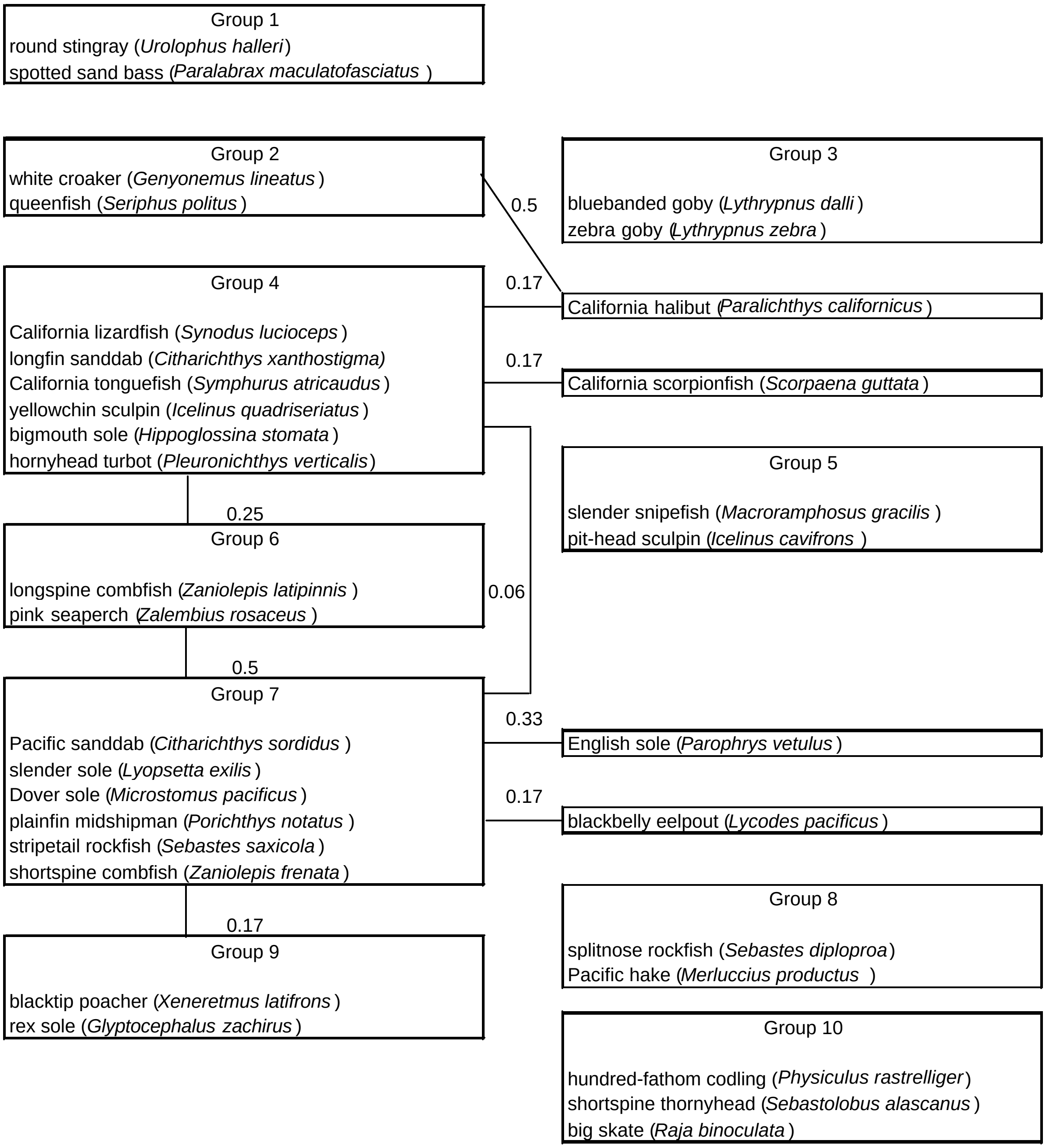


Figure 35. Recurrent groups of demersal fishes on the southern California shelf at depths of 2-202 m, July-September 1998. Index of affinity (I.A.) = 0.50. Species within a group are listed in order of abundance. Lines show relationships between groups and associates, with values indicating proportion of possible pairs with I.A. = 0.50.

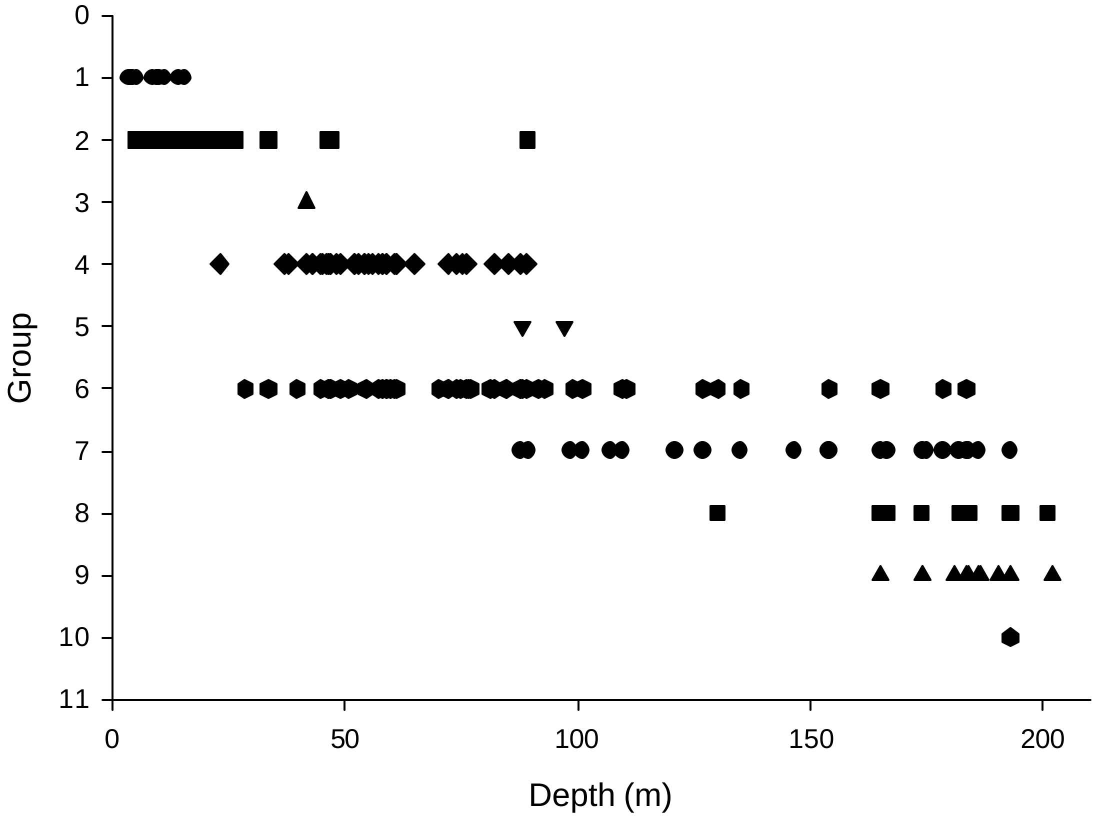


Figure 36. Bathymetric distribution of demersal fish recurrent groups on the southern California shelf, July-September 1998.

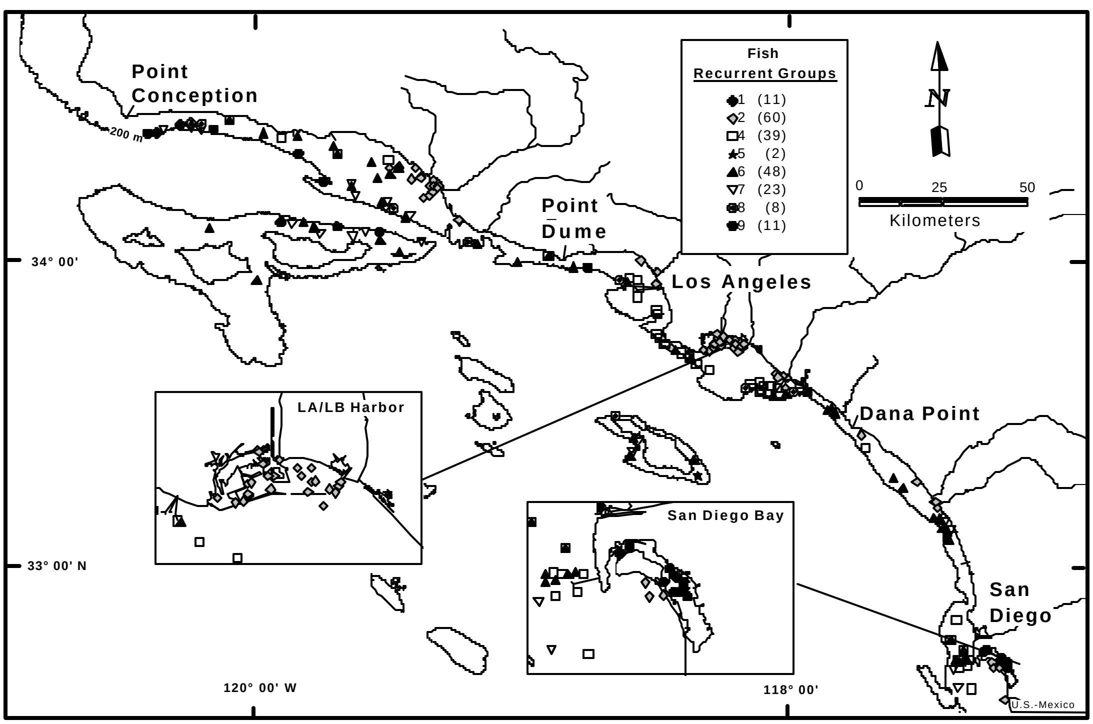


Figure 37. Distribution of demersal fish recurrent groups on the southern California shelf at depths of 2-202 m, July-September 1998.

Group 7 (Outer Shelf Group). Group 7 consists of 6 species: Pacific sanddab, slender sole, Dover sole, plainfin midshipman, stripetail rockfish, and shortspine combfish (*Zaniolepis frenata*) (Figure 35). The group occurred at 23 sites ranging in depth from 88-193 m (Figures 36 and 37). It occurred widely on the mainland and at the islands (Figure 37). It was associated with Groups 6 and 9, and with English sole and blackbelly eelpout (*Lycodes pacificus*) (Figure 35).

Group 8. (Outer Shelf Water-column Group). Group 8 consists of two species, splitnose rockfish (*Sebastes diploproa*) and Pacific hake (*Merluccius productus*) (Figure 35). It occurred at 8 sites ranging in depth from 130-201 m, mostly deeper than 160 m (Figures 36 and 37). It occurred in the mainland and island regions but not at the northwest Channel Islands or the southern mainland region (Figure 37). It was not associated with another group.

Group 9. (Outer Shelf Benthic Group). Group 9 consists of 2 species, blacktip poacher (*Xeneretmus latifrons*) and rex sole (Figure 35). It occurred at 11 sites ranging in depth from 165-202 m (Figures 36 and 37). It was found in the mainland and island regions but was not found in the southern mainland region or at Santa Catalina Island (Figure 37, Appendix C14). It was associated with Group 7 (Figure 35).

Group 10. (Mesobenthal Group). Group 10 consists of 3 species, hundred-fathom codling (*Physiculus rastrelliger*), shortspine thornyhead (*Sebastolobus alascanus*), and big skate (*Raja binoculata*) (Figure 35). It occurred at 1 site at 193 m in the central mainland region near Newport Submarine Canyon (Figure 36, Appendix C14). It was not associated with another group.

Fish Species Clades

The most parsimonious reconstruction of the trawled fish data from the 313 sampling events (trawls) and 141 characters or fish species is represented by the cladogram with a primary clade, several secondary clades, and many tertiary clades (Figure 38).[1] The analysis resulted in many, very similar, equally parsimonious reconstructions (tree length of 1734 steps) of the data (cladograms). The cladogram possessed a consistency index of 0.1805 with a relatively high retention index (indicator of branch support) of 0.4719.

Both fit statistics have a maximal value of 1.0. The novel utilization of parsimony analysis for an "R-mode" approach or PAA as coined herein proved very informative regarding the associations and distributions of the various species analyzed. The root of the cladogram (Figure 38) is composed of the California butterfly ray and diamond stingray which are found adjacent to a San Diego Bay clade composed of round stingray, spotted sand bass, and black croaker (*Cheilotrema saturnum*). The next large and elongate section of the tree is composed of many species found in deeper waters than bays and harbors with an interesting association of seven species of rockfishes: chilipepper (*Sebastes goodei*), shortbelly rockfish (*Sebastes jordani*), and then a closely associated group composed of greenblotched rockfish (*Sebastes rosenblatti*), pink rockfish (*Sebastes eos*), greenstriped rockfish (*Sebastes elongatus*), halfbanded rockfish (*Sebastes semicinctus*), and greenspotted rockfish (*Sebastes chlorostictus*). Fol-

[1]See pdf file at www.sccwrp.org.

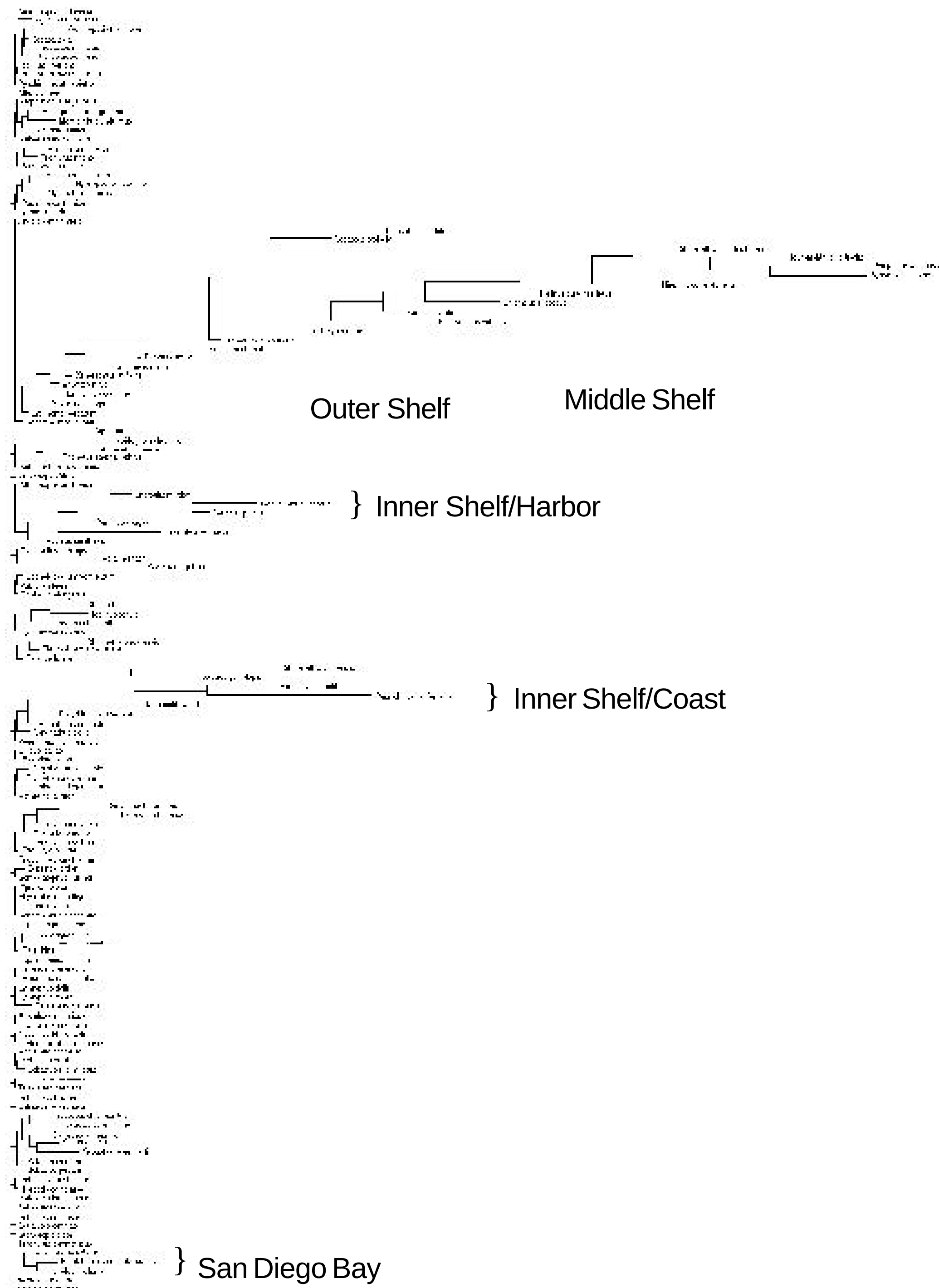


Figure 38. Species cladogram for demersal fish assemblages on the southern California shelf at depths of 2-202 m, July-September 1998.

lowing this, more striking clades are evident with longer branch lengths, indicating species associations with wider distributions being found at more stations. Although there are too many clades to detail here, a small clade composed of shiner perch, white seaperch, and black perch (*Embiotoca jacksoni*) is an inshore group.

Secondary clades include a bay/harbor and inner shelf clade with somewhat elongated branch lengths consisting distally of queenfish and white croaker, associated with northern anchovy and Pacific sardine, and with Pacific pompano (*Peprilus simillimus*), and specklefin midshipman (*Porichthys myriaster*) in the more basal locations (Figure 38). A coastal inner shelf clade was composed of California halibut, barred sand bass, spotted turbot, speckled sanddab, fantail sole, thornback (*Platyrhinoidis triseriata*), and shovelnose guitarfish (*Rhinobatos productus*). Barcheek pipefish (*Syngnathus exilis*) and kelp pipefish (*Syngnathus californiensis*) are closely aligned to this group.

An elongate outer shelf/middle shelf clade is the primary clade (Figure 38). It consists of 22 species, with outer shelf species occurring near the base and middle shelf species occurring near the distal end. Intermediate species occurred in the middle shelf and outer shelf zones. The species nearest the base was bearded eelpout (*Lyconema barbatum*) and the pair at the distal end was California lizardfish and California tonguefish.

Fish Site and Species Clusters

Selection of Species. The trawl survey sampled 314 stations and collected 62,266 fish representing 143 species. Based upon the screening criteria, 308 stations representing 61,853 fish and 73 species were included in the cluster analysis. The cluster analysis delineated eight major site clusters (station clusters), denoting habitats, and seven major species clusters, denoting species assemblages or communities (Figure 39[2], Appendix E1). Each site and species cluster was unique, based on the relative proportion of different species clusters within a site cluster and the relative proportion of each species cluster in different site clusters (Figures 39 and 40).

Site Clusters. The site clusters varied by region, depth, and subpopulation (Table 51, Figures 39 and 41), as well as to a lesser extent by sediment type (Figure 42). Each site cluster had one or two dominant species clusters (Figures 39 and 40).

Site Cluster 1 included 19 stations, all in the outer shelf zone at depths of 130-202 m (Table 51; Figures 39, 41, and 43). This site group represents an outer shelf habitat characterized by 11 mainland and 8 island region outer shelf sites. By subregion, this cluster included 7 northern mainland, 4 central main-

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[2] Figure 39 is a summary of the two-way table depicting the dendrograms associated with the cluster analysis. It depicts relationships (dissimilarity) among the clusters, with circles indicating the significance of the relationship between site and species clusters, the larger the circle the stronger the relationship. The upper two-way table (columns sum to 100%) shows the relative percent contribution of species clusters in delineating each site cluster while the lower table (rows sum to 100%) shows the proportional distribution of each species cluster across all site clusters. The upper table shows relationships between site and species cluster groups while the lower table depicts the actual proportions of each species cluster within each site cluster. For example, the lower table shows that about 64% of the individuals occurring in site cluster 1 are found within species cluster G and about 33% are from species cluster E. Individuals from other species clusters are essentially absent from site cluster 1. This relationship is also depicted in the upper table by a large black circle under site cluster 1 next to species cluster G and a medium-small black circle next to species cluster E.

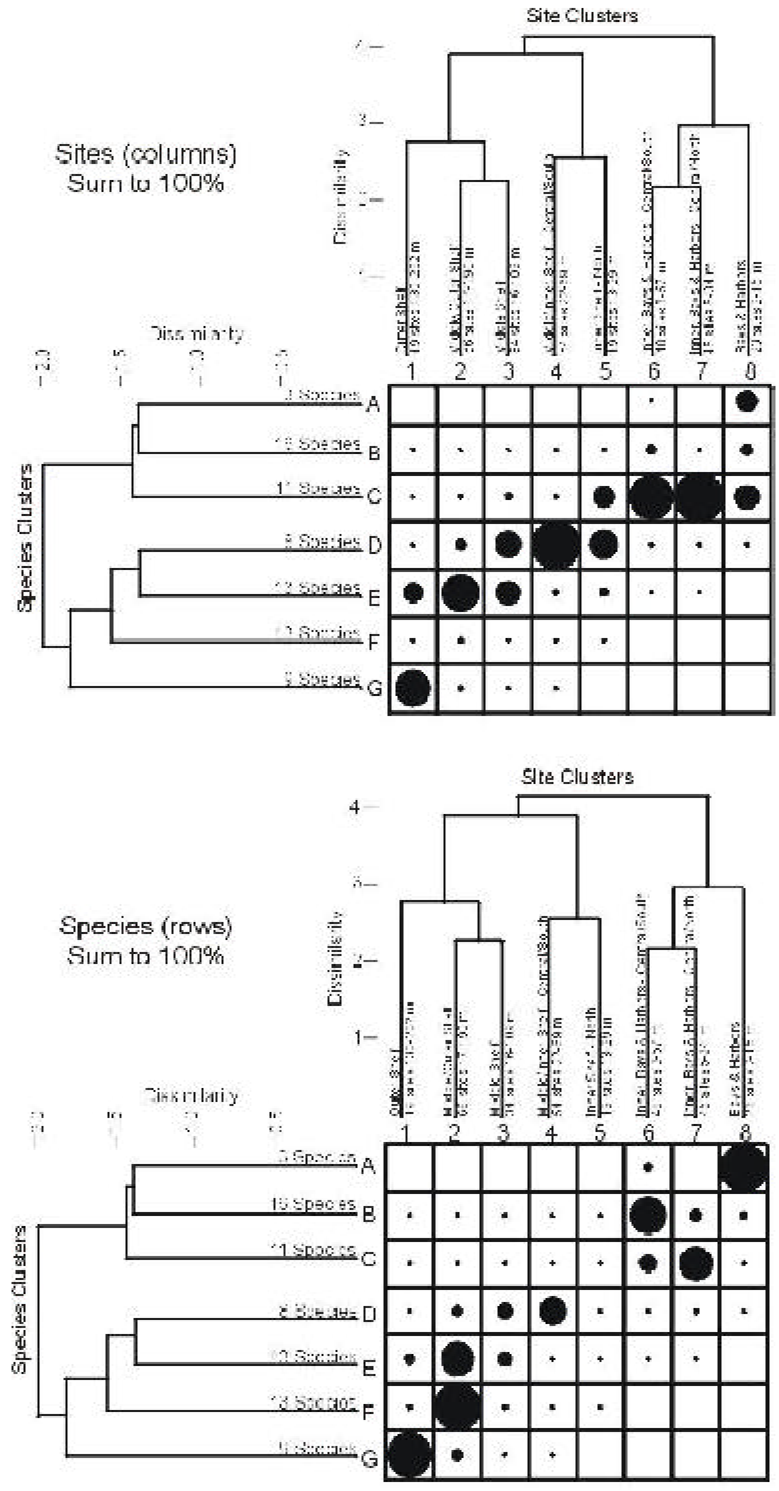


Figure 39. Summary of demersal fish cluster analysis and relationships among site and species clusters on the southern California shelf at depths of 2-202 m, July-September 1998.

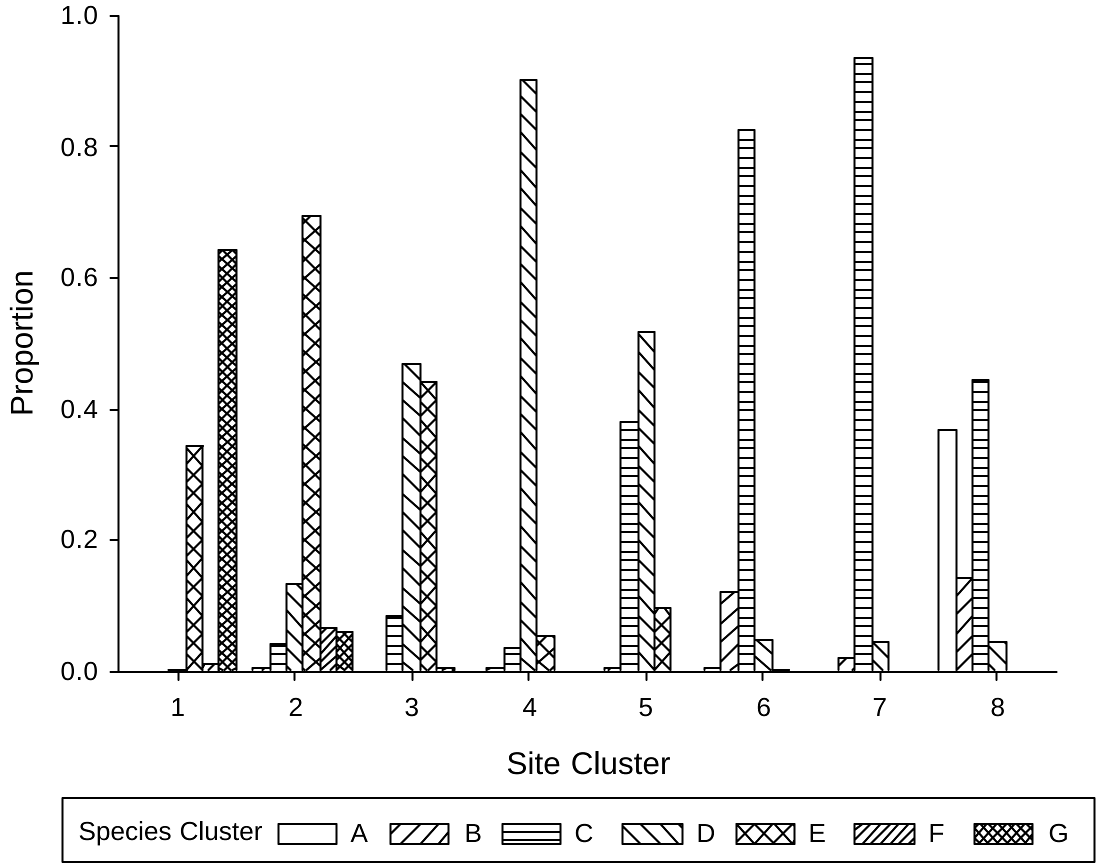


Figure 40. Proportion of demersal fish species clusters in each fish site cluster on the southern California shelf at depths of 2-202 m, July-September 1998.

land, 4 Santa Catalina Island, 1 northwestern Channel Islands, and 3 southeastern Channel Islands sites (Table 51). Thus, there appears to be no strong latitudinal gradient associated with this outer shelf fish site cluster, and the island region sites appear to be no different than the mainland region sites. Six species from Species Cluster G and six from Species Cluster E occurred in more than 50% of the stations within Site Cluster 1 (Table 52, Appendices E2 and E3). The six species from Species Cluster G included rex sole (79%), blackbelly eelpout (74%), slender sole (100%), blacktip poacher (63%), Pacific hake (53%), and splitnose rockfish (53%). With the exception of slender sole, which occurred in 44% of the stations in Site Cluster 2, these six species occurred rarely in Site Cluster 2 and were essentially not found in any other site cluster. Thus, these six species characterize the soft-bottom outer shelf habitat. The six species from Species Cluster E included English sole (53%), plainfin midshipman (79%), Dover sole (95%), Pacific sanddab (89%), shortspine combfish (84%), and stripetail rockfish (68%). These six species were commonly found in Site Clusters 2 and 3 and represent more broadly distributed species.

Site Cluster 2, the largest site cluster, included 66 stations ranging in depth from 17-190 m. Site Cluster 2 represents a generalized outer shelf/middle shelf habitat (Table 51; Figures 39, 41, and 43). All subregions were well represented including 16 northern region, 5 central region, 7 southern region, 17 Santa Catalina Island, 11 northwestern Channel Islands, and 10 southeastern Channel Islands sites (Table 51). With over half of the sites from islands, this could be characterized as an 'island' cluster; however, there

Table 51. Frequency of occurrence (number of stations) of demersal fish site clusters by region and subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	SITE CLUSTER								
	1	2	3	4	5	6	7	8	
	Outer Shelf	Outer / Middle Shelf	Middle Shelf	Middle / Inner Shelf C/S	Inner Shelf N	Inner Shelf B&H C/S	Inner Shelf B&H N/C	B&H C/S	Grand Total
Depth Range (m)	130-202	17-190	16-109	22-69	13-29	3-57	5-34	2-15	
Subpopulation									
Region									
Mainland	11	28	31	52	16	45	45	23	251
Northern	7	16	9	4	13	4	12	-	65
Central	4	5	10	30	2	24	30	6	111
Southern	-	7	12	18	1	17	3	17	75
Island	8	38	3	2	3	3	0	0	57
Cool (NW Channel Islands)	1	11	-	-	3	-	-	-	15
Warm									
SE Channel Islands	3	10	3	-	-	-	-	-	16
Santa Catalina Island	4	17	-	2	-	3	-	-	26
Shelf Zone									
Bays and Harbors (2-30 m)	-	-	1	-	-	12	22	23	58
Ports	-	-	-	-	-	2	8	4	14
Marinas	-	-	-	-	-	8	3	6	17
Other Bay	-	-	-	-	-	2	11	13	26
Inner Shelf (2-30 m)	-	2	-	7	19	32	21	-	81
Small POTWs	-	-	-	2	5	4	4	-	15
River Mouths	-	-	-	-	1	19	10	-	30
Other Mainland	-	2	-	5	10	8	7	-	32
Island	-	-	-	-	3	1	-	-	4
Middle Shelf (31-120 m)	-	39	33	47	-	4	2	-	125
Small POTWs	-	-	-	-	-	-	-	-	0
Large POTWs	-	4	11	15	-	1	1	-	32
Mainland non-LPOTW	-	10	19	29	-	1	1	-	60
Island	-	25	3	2	-	2	-	-	32
Outer Shelf (121-202 m)	19	25	-	-	-	-	-	-	44
Mainland	11	12	-	-	-	-	-	-	23
Island	8	13	-	-	-	-	-	-	21
Total (all stations)	19	66	34	54	19	48	45	23	308

C = Central; N = Northern; S = Southern; B&H = Bays/Harbors; POTW = Publicly owned treatment work monitoring area.

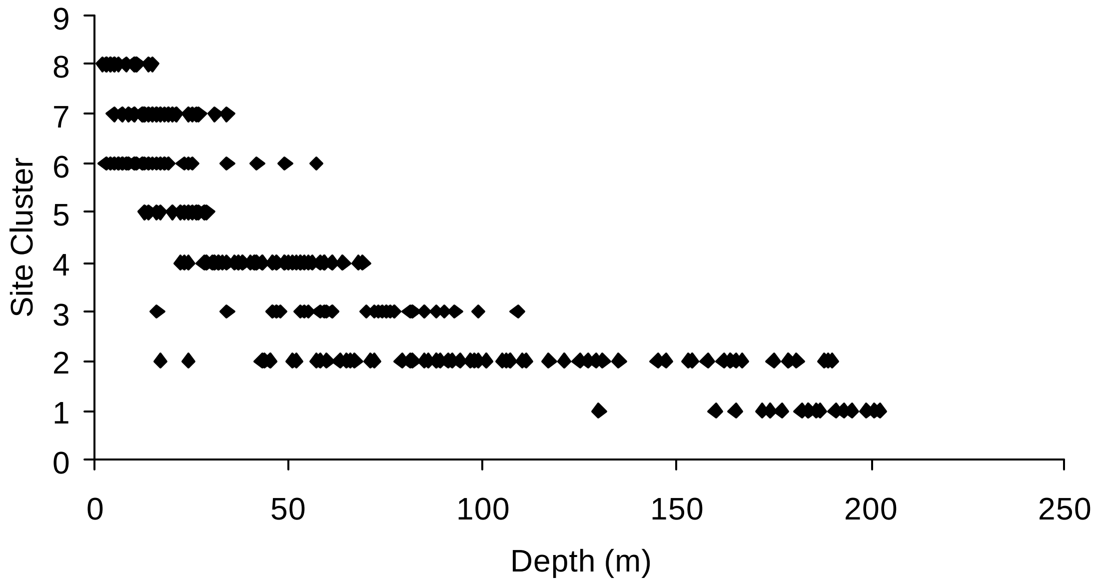


Figure 41. Bathymetric distribution of demersal fish site clusters on the southern California shelf at depths of 2-202 m, July-September 1998.

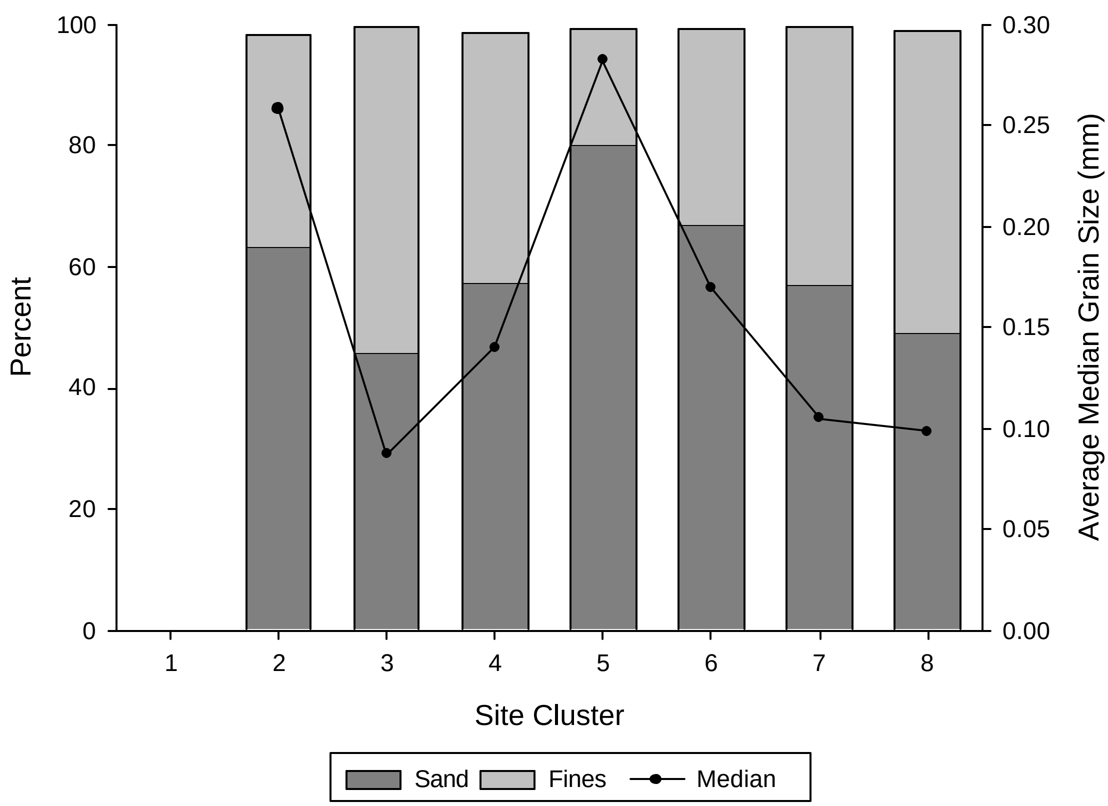


Figure 42. Average percent of sand, percent of fines, and median grain size (mm) for each demersal fish site cluster on the southern California shelf at depths of 2-202 m, July-September 1998.

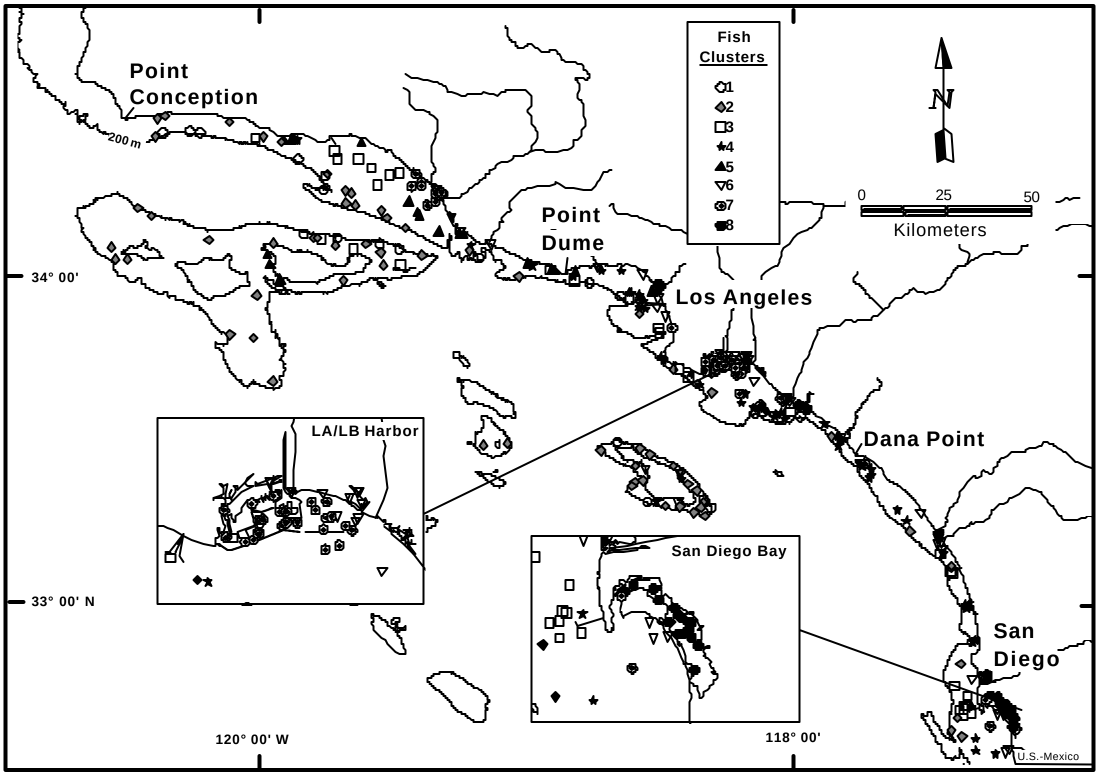


Figure 43. Distribution of demersal fish site clusters on the southern California shelf at depths of 2-202 m, July- September 1998.

appears to be no major difference between the mainland and island region clusters, and no strong latitudinal gradient within the cluster. By depth category, this site cluster included 25 outer shelf, 39 middle shelf, and 2 inner shelf sites. Species distributions in this site cluster did not strongly distinguish between outer shelf zone and middle shelf zone. The 25 outer shelf sites were equally distributed by region with 12 from the mainland region and 13 from the island region, suggesting no major habitat difference between island and mainland sites for the deeper stations. The 39 middle shelf sites included 4 large POTW stations, 10 mainland non-POTW stations, and 25 island stations.

There was no distinct POTW subgrouping within this cluster. The two inner shelf stations were non-POTW mainland stations. Six species from Species Cluster E occurred in 50% or more of the sites including pink seaperch (56%), plainfin midshipman (79%), Dover sole (71%), Pacific sanddab (94%), shortspine combfish (59%), and stripetail rockfish (59%); and one species (bigmouth sole, 52%) from Species Cluster D (Table 52, Appendices E2 and E3). Thus, Site Cluster 2 shares some similarities with Site Cluster 1 but essentially lacks the six outer shelf species from Species Cluster G that largely delineated Site Cluster 1.

Site Cluster 3 characterizes a middle shelf habitat entailing 34 sites ranging in depth from 16-109 m (Table 51; Figures 39, 41, and 43). All mainland subregions were well represented including 9 northern stations, 10 central stations, 12 southern stations, and 1 bay/harbor station located in outer LA/LB Harbor (Station 2599) (Table 51, Figure 43). By depth category, there were 33 middle shelf sites and 1 bay/harbor site. The 33 middle shelf sites represented 11 large POTW, 19 non-POTW, and 3 island sites.

Table 52. Frequency of occurrence (percent of stations) of demersal fish species occurring at 50% or more of the stations in at least one site cluster on the southern California shelf at depths of 2-202 m, July-September 1998.

			SITE CLUSTER							
			1	2	3	4	5	6	7	8
			Outer Shelf	Outer / Middle Shelf	Middle Shelf	Middle / Inner Shelf C/S	Inner Shelf N	Inner Shelf B&H C/S	Inner Shelf B&H N/C	B&H C/S
		Number of Stations	19	66	34	54	19	48	45	23
		Depth Range (m)	130-202	17-190	16-109	22-69	13-29	3-57	5-34	2-15
Species Cluster	Common Name	Scientific Name								
A	spotted sand bass	*Paralabrax maculatofasciatus*	-	-	-	-	-	2	-	74
	round stingray	*Urolophus halleri*	-	-	-	-	-	8	-	57
C	California halibut	*Paralichthys californicus*	-	5	29	44	37	71	51	78
	barred sand bass	*Paralabrax nebulifer*	-	-	3	9	11	46	33	87
	speckled sanddab	*Citharichthys stigmaeus*	-	20	15	35	100	35	20	-
	white croaker	*Genyonemus lineatus*	-	2	29	9	5	65	89	13
	queenfish	*Seriphus politus*	-	3	9	-	-	44	78	4
D	yellowchin sculpin	*Icelinus quadriseriatus*	-	36	97	56	5	2	-	-
	hornyhead turbot	*Pleuronichthys verticalis*	5	26	76	70	42	23	24	-
	bigmouth sole	*Hippoglossina stomata*	16	52	82	80	5	10	2	-
	longfin sanddab	*Citharichthys xanthostigma*	-	26	74	100	16	15	7	-
	California lizardfish	*Synodus lucioceps*	5	30	91	93	68	44	60	17
	California tonguefish	*Symphurus atricaudus*	-	21	85	81	53	23	64	13
E	longspine combfish	*Zaniolepis latipinnis*	16	41	79	17	-	-	-	-
	pink seaperch	*Zalembius rosaceus*	42	56	74	26	-	-	-	-
	English sole	*Parophrys vetulus*	53	42	56	20	26	6	11	-
	plainfin midshipman	*Porichthys notatus*	79	64	65	7	-	2	2	-
	Dover sole	*Microstomus pacificus*	95	71	35	-	-	-	-	-
	Pacific sanddab	*Citharichthys sordidus*	89	94	68	37	11	0	2	-
	shortspine combfish	*Zaniolepis frenata*	84	59	9	-	-	-	-	-
	stripetail rockfish	*Sebastes saxicola*	68	59	50	2	-	-	-	-
G	rex sole	*Glyptocephalus zachirus*	79	3	-	-	-	-	-	-
	blackbelly eelpout	*Lycodes pacificus*	74	14	-	2	-	-	-	-
	slender sole	*Lyopsetta exilis*	100	44	6	-	-	-	-	-
	blacktip poacher	*Xeneretmus latifrons*	63	9	-	-	-	-	-	-
	Pacific hake	*Merluccius productus*	53	5	-	-	-	-	-	-
	splitnose rockfish	*Sebastes diploproa*	53	3	-	-	-	-	-	-

C = Central; S = Southern; N = Northern; B&H = Bays/Harbors.
See Appendix E3 for a complete list of species and their occurrences in site clusters.

Thus, there appears to be no major distinction between POTW and non-POTW sites. Six species from Species Cluster D and six species from Species Cluster E occurred in more than 50% of the stations within this site cluster (Table 52, Appendices E2 and E3). The six species from Species Cluster D characterize a middle shelf assemblage and include the yellowchin sculpin (97%), hornyhead turbot (76%), bigmouth sole (82%), longfin sanddab (74%), California lizardfish (91%), and California tonguefish (85%). The six species from Species Cluster E characterize an assemblage with a broader depth distribution and more typical of middle/outer shelf species and included the longspine combfish (79%), pink seaperch (74%), English sole (56%), plainfin midshipman (65%), Pacific sanddab (68%), and stripetail rockfish (50%). The six species common to Species Cluster D also had a high prevalence in Site Cluster 4; but what separated Site Cluster 3 from 4 was the paucity in Site Cluster 4 of the rather abundant and more broadly distributed six species from Species Cluster E.

Site Cluster 4 included 54 sites ranging in depth from 22-69 m, characterizing a middle shelf/inner shelf habitat from the central and southern mainland regions (Table 51; Figures 39, 41, and 43). All mainland regions were represented, but only 4 sites were in the northern region, 30 sites in the central region, 18 sites in the southern region, and two sites at Santa Catalina Island (Table 51, Figure 43). By depth category, 47 sites were characterized in the middle shelf zone and 7 sites in the inner shelf zone. The 7 inner shelf sites included 5 mainland non-POTW sites and 2 small POTW sites. The 47 middle-shelf zone sites included 15 large POTW, 29 non-POTW, 1 small POTW, and 2 island sites (suggesting little difference between POTW and non-POTW sites). Six species within Species Cluster D, which also characterized Site Cluster 3, were found to occur within 50% or more of the sites for this site cluster (Table 52, Appendices E2 and E3). These six species included yellowchin sculpin (56%), hornyhead turbot (70%), bigmouth sole (82%), longfin sanddab (100%), California lizardfish (93%), and California tonguefish (81%). Species from Species Cluster E that helped to characterize Site Clusters 1, 2, and 3 were poorly represented in Site Cluster 4, contributing to the uniqueness of this site cluster.

Site Cluster 5 included 19 inner shelf sites ranging in depth from 13-29 m, characterizing a northern region inner shelf habitat (Table 51; Figures 39, 41, and 43). This site cluster tended to have low abundance and diversity. By region, this site cluster was found primarily in the northern region (13 sites), but was also found at 2 central region, 1 southern region, and 3 northwest Channel Islands sites. By depth category or potential habitat types, these inner shelf sites included 3 northwest Channel Islands, 10 mainland, 1 river mouth, and 5 small POTW sites (Table 51). This also indicates little difference between POTW and non-POTW sites. The speckled sanddab of Species Cluster C was found at all stations within this cluster and tended to characterize the cluster. Two other species from Species Cluster D occurred in 50% or more of the stations: California lizardfish (68%) and California tonguefish (53%) (Table 52, Appendices E2 and E3).

Site Cluster 6 contained 48 sites characterizing a generalized shallow-water habitat ranging in depth from 3-57 m with tendency towards the central and southern regions (Table 51; Figures 39, 40, and 43). By region, this site cluster included 4 northern mainland, 24 central mainland, 17 southern mainland, and 3 Santa Catalina Island sites, indicating a central and southern region dominance (Table 51). This site cluster encompassed a range of depths including 4 sites from the middle shelf zone, 32 sites from the inner shelf zone, and 12 sites from bays and harbors. By depth (or potential habitat type), the middle shelf sites included 1 large POTW, 1 non-POTW, and 2 Santa Catalina Island sites; the inner shelf sites included 1 Santa Catalina Island, 8 mainland, 19 river mouth, and 4 small POTW sites; and the bay/harbor sites included 8 marina, 2 ”other bay,” and 2 port sites. This site cluster encompasses a diverse range of depths and potential habitat types with a tendency towards river mouth sites. However, river mouths do not appear to represent a unique habitat type. This site cluster was largely characterized by two species from Species Cluster C: California halibut and white croaker, which occurred at 71% and 65% of the sites within this cluster, respectively (Table 52, Appendices E2 and E3). It is important to note that white croaker is the most abundant demersal fish in LA/LB Harbor and its presence there contributed to the inclusion of the bay/harbor depth category into this site cluster. However, white croaker are more typically found on the inner shelf of the open coast and in this study were rare in San Diego Bay, Marina del Rey, Channel Islands Harbor, and Ventura Harbor (Appendix C18). Thus, the uniqueness of the LA/LB Harbor to support a very large white croaker population is attributable not only to its status as a protected embayment but also to the fact that the construction of the breakwater encompassed a large area of the open coast.

Site Cluster 7 contained 45 stations characterizing an inner shelf, bay/harbor habitat ranging in depth from 5-34 m (Table 51; Figures 39, 41, and 43). By region, this site cluster included 12 northern region, 30 central region, and 3 southern region sites, indicating a central and northern region tendency (Table 51). By depth, 2 sites were from the middle shelf zone, 21 from the inner shelf zone, and 22 from the bays and harbors. The 2 sites from the middle shelf zone included 1 large POTW and 1 non-POTW site; the inner shelf sites included 7 mainland, 10 river mouth, and 4 small POTW sites. This suggests that river mouths and small POTWs are not distinct from the 7 mainland sites. The bay/harbor depth category included 3 marina, 11 "other bay," and 8 port sites. This would indicate that these marina and port sites are not notably different from "other bay" sites. Similarly, Site Cluster 6 was largely determined by California halibut and white croaker, which occurred at 51% and 89% of the stations, respectively. The presence of queenfish (78%) from Species Cluster C and two species from Species Cluster D (California tonguefish, 64%; and California lizardfish, 60%) helped to delineate this site cluster from Site Cluster 6 (Table 52, Appendices E2 and E3).

Site Cluster 8 contained 23 sites characterizing a bay/harbor habitat tending towards the central and southern regions, and ranging in depth from 5-34 m (Table 51; Figures 39, 41, and 43). By region, no sites were represented for the northern region; however 6 central mainland and 17 southern mainland region sites were included in this site cluster. Within the bay/harbor subpopulation, 8 sites were marinas, 13 sites were "other bay" areas, and 4 sites were ports (Table 51). There does not appear to be a strong distinction between these potential habitats in the bays and harbors. This site cluster was largely determined by two species from Species Cluster C, California halibut and barred sand bass, which occurred at 78% and 87% of the sites within this site cluster, respectively; and two species from Species Cluster A, spotted sand bass and round stingray, which occurred at 74% and 57% of the stations within this site cluster, respectively (Table 52, Appendices E2 and E3). It is of interest to note that white croaker were only found in 3 (13%) of the sites within the bay/harbor cluster group, indicating that white croaker are not typically representative of bay/harbor habitats.

Species Clusters. Seven major species groups were delineated by the analysis (Figure 39). The species clusters occupied successively deeper depth zones. The relationship of the site clusters with water depth results from the depth distribution patterns of fish species found in the species clusters. All site clusters included representatives of two or more species groups (Figure 40). Species Cluster G was the dominant cluster in Site Cluster 1; Species Cluster E in Site Cluster 2; Species Cluster D in Site Clusters 3, 4, and 5; and Species Cluster C in Site Clusters 6, 7, and 8.

Species Cluster A included only 3 species (black croaker, spotted sand bass, and round stingray), which were essentially only found in the shallow waters of bays and harbors, Site Cluster 8 (Table 52; Appendices E1, E2, and E3). While these species are found in the shallow waters of the open coast, black croaker and round stingrays are most common in the surf zone, an area generally not trawlable; and spotted sand bass are often found in association with hard bottom habitats, also an area that is not trawlable.

Species Cluster B included 16 species that characterize an inner shelf and bay/harbor assemblage (Table 52; Appendices E1, E2, and E3); however, none occurred at 50% or more of the stations for any site clusters. These 16 species included 3 species of drums (Sciaenidae): spotfin croaker (*Roncador stearnsii*), California corbina (*Menticirrhus undulatus*) and yellowfin croaker (*Umbrina roncador*). Spotfin croaker and yellowfin croaker only occurred within Site Cluster 6 and California corbina mostly occurred in Site

Cluster 6 with a few found in Site Cluster 7. Four species of surfperch (Embiotocidae) — black perch, white seaperch, shiner perch, and walleye surfperch (*Hyperprosopon argenteum*)—characterized this cluster and were generally restricted to Site Clusters 6 and 7. A few were found in Site Clusters 2, 4, 5, and 8. This cluster also included 3 species of Rajiformes (skates and rays) including the bat ray (*Myliobatis californica*)(Site Cluster 6, 7, and 8), shovelnose guitarfish (Site Clusters 6 and 8), and thornback (only Site Cluster 6). Miscellaneous species within this cluster included the deepbody anchovy (Site Groups 6 and 7), slough anchovy (*Anchoa delicatissima*; Site Groups 6 and 8), kelp bass (*Paralabrax clathratus*; only Site Group 6), cutlassfish (*Trichiurus lepturus* [=Pacific cutlassfish, *Trichiurus nitens*]); Site Groups 3 and 6), diamond turbot (Site Groups 6, 7, and 8), and barcheek pipefish (Site Groups 1 and 6). With the exception of the cutlassfish, this species cluster included common species that typify the shallow waters of the inner shelf and bays and harbors. Some of these species (e.g., the surfperches and kelp bass) are more generally associated with hard-bottom features or pier pilings and breakwaters, while others (e.g., deepbody anchovy, slough anchovy) are typically found in schools off the bottom. The cutlassfish is a southern species that is generally rare along the southern California coast but is more common during El Niño events, as was present during this survey.

Species Cluster C was similar to Species Cluster B in that the species within these two clusters characterize an inner shelf and bay/harbor fauna (i.e., fishes of shallow water) (Table 52; Appendices E1, E2, and E3). However, the taxa comprising Species Cluster C tended to delineate Site Cluster 7 while those of Species Cluster B delineated Site Cluster 6. The species comprising Species Cluster C were diverse and represented many different types of fish. While none of the species in Species Cluster B occurred at more than 50% of the sites within a site cluster, there were 5 species in Species Cluster C that occurred with a frequency greater than 50%. The California halibut occurred in all site clusters (except Site Cluster 1) and was most prevalent within Site Clusters 6 (71%), 7 (51%), and 8 (78%). This tends to show the importance of shallow-water habitats for this important commercial and sport fish. The barred sand bass occurred in Site Clusters 3 to 8 but was most prevalent within Site Cluster 8 (87%). California halibut and barred sand bass were two of the four species most important for delineating Site Cluster 8. The speckled sanddab occurred in Site Clusters 2 to 7, but this species helps to delineate Site Cluster 5, where it was found at all sites (100%). White croaker were found within all site clusters (except Site Cluster 1), but were most prevalent within Site Clusters 6 (65%) and 7 (89%). Queenfish were less widely distributed and were most prevalent within Site Cluster 7 (78%). Other species within this cluster included the spotted turbot, fantail sole, Pacific pompano, Pacific sardine, northern anchovy, and specklefin midshipman.

Species Cluster D contained 8 abundant species having wide distributions, as indicated by each species being present in at least 5 of the 8 site clusters (Table 52; Appendices E1, E2, and E3). This species cluster characterizes a middle shelf assemblage; however, because some of these species occur in shallow waters, this assemblage could also be characterized as the ubiquitous Bight fauna of the middle shelf and inner shelf zones. The California lizardfish was the most widely distributed species, being found in all site clusters. Three species occurred with a prevalence greater than 50% for two site clusters: yellowchin sculpin (Site Cluster 3 at 97% and Site Cluster 4 at 56%), hornyhead turbot (Site Cluster 3 at 76% and Site Cluster 4 at 70%), and longfin sanddab (Site Cluster 3 at 74% and Site Cluster 4 at 100%). Bigmouth sole occurred within all site clusters except Site Cluster 8 and was most prevalent at Site Clusters 3, 4, and 5, occurring with a prevalence of 52, 82, and 80%, respectively. The California lizardfish and California tonguefish were widely distributed but most prevalent in Site Clusters 3, 4, 5, and 7, where their prevalence ranged from 53-93% of stations within each of these site clusters. The

California scorpionfish and California skate occurred with low frequency but were widely distributed, being found within 6 of the site groups.

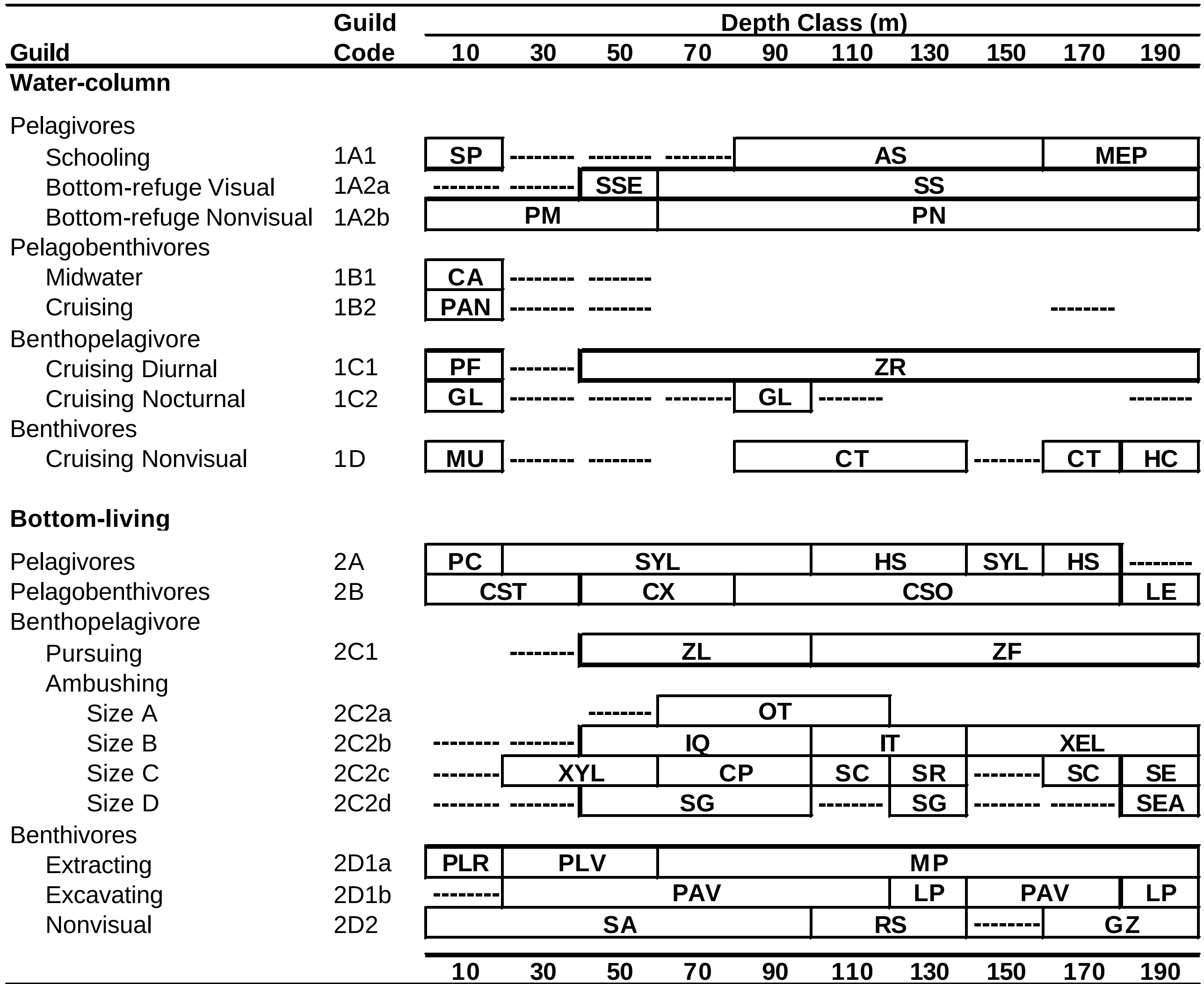
Species Cluster E contained 13 species, largely characterizing a middle shelf and outer shelf assemblage; and 8 of the species occurred at more than 50% of the stations within Site Clusters 1-3 (Table 52; Appendices E1, E2, and E3). These species tend to be the ubiquitous species of the middle shelf/outer shelf depth category. Species Cluster E largely delineated Site Cluster 2. Longspine combfish was most prevalent within Site Cluster 3, occurring at 79% of the sites. Four species were found occurring within two site clusters with prevalence greater than 50%: pink seaperch (Site Clusters 2 and 3: 56 and 74%, respectively), English sole (Site Clusters 1 and 3: 53 and 56%, respectively), Dover sole (Site Clusters 1 and 2: 95 and 71%, respectively), and shortspine combfish (Site Clusters 1 and 2: 84 and 59%, respectively). Three species had 50% or greater prevalence for Site Clusters 1, 2, and 3: plainfin midshipman (79, 64, and 65%, respectively), Pacific sanddab (89, 94, and 68%, respectively), and stripetail rockfish (68, 59, and 50%, respectively). The remaining species within this cluster occurred less frequently and included lumptail searobin (*Prionotus stephanophrys*), gulf sanddab, Pacific argentine (*Argentina sialis*), bay goby, and greenblotched rockfish.

Species Cluster F contained 13 species characterizing a middle/outer shelf assemblage that had low abundance, occurred infrequently, and were generally restricted to Site Clusters 1, 2, and 3 (Table 52; Appendices E1, E2, and E3). None of these species in species Cluster F occurred in 50% or more of the stations within these site clusters. Included in this species cluster were six species of rockfish (copper rockfish, *Sebastes caurinus*; vermilion rockfish, *Sebastes miniatus*; halfbanded rockfish; pink rockfish; greenstriped rockfish; and greenspotted rockfish), two poachers (pygmy poacher, *Odontopyxis trispinosa*; bluespotted poacher, *Xeneretmus triacanthus*), two sculpins (roughback sculpin, *Chitonotus pugetensis*; spotfin sculpin, *Icelinus tenuis*), curlfin sole, blackeye goby (*Coryphopterus nicholsii*), and spotted cusk-eel (*Chilara taylori*).

Species Cluster G contained 9 species that characterized an outer shelf assemblage restricted to the deepest water depths (Table 52; Appendices E1, E2, and E3). With the exception of a few individuals, these species were only found at stations within Site Clusters 1 and 2. Six of the nine species occurred at more than 50% of the stations within Site Cluster 1: rex sole (79%), blackbelly eelpout (74%), slender sole (100%), blacktip poacher (63%), Pacific hake (53%), and splitnose rockfish (53%). Three other species associated with deeper water but occurring less frequently included bluebarred prickleback (*Plectobranchus evides*), bearded eelpout, and spotted ratfish (*Hydrolagus colliei*).

Fish Functional Organization

Overview of Community Organization. Fishes collected in this survey represented at least 18 foraging guilds (Figures 5, 6; based on Allen 1982) (Figure 44). More bottom-living guilds were widespread across the depth range (0-200 m) of the shelf than water-column guilds. However, only three guilds that occurred with a frequency of 20% or more within the 20-m depth classes also occurred across the entire shelf. These were bottom-refuge nonvisual pelagivores (midshipmen guild), bottom-living pelagobenthivores (sanddab guild), and bottom-living extracting benthivores (turbot guild). Two guilds (e.g., midwater pelagobenthivores, shiner perch guild; cruising pelagobenthivores, sand bass guild) had limited (shallow) depth distributions in this survey. The highest number of guilds (16) occurred at 90 m, followed by 14 guilds each at 110 and 130 m. The least number of guilds (6) were found at 30 m,



AS = *Argentina sialis*
CA = *Cymatogaster aggregata*
CP = *Chitonotus pugetensis*
CSO = *Citharichthys sordidus*
CST = *Citharichthys stigmaeus*
CT = *Chilara taylori*
CX = *Citharichthys xanthostigma*
GL = *Genyonemus lineatus*
GZ = *Glyptocephalus zachirus*
HS = *Hipposlossina stomata*
IQ = *Icelinus quadriseriatus*
IT = *Icelinus tenuis*
LE = *Lyopsetta exilis*
LP = *Lycodes pacificus*
MEP = *Merluccius productu*s
MP = *Microstomus pacificus*
MU =*Menticirrhus undulatus*
OT = *Odontopyxis trispinosa*
PAN = *Paralabrax nebulifer*
PAV = *Parophrys vetulus*
PC= *Paralichthys californicus*
PF = *Phanerodon furcatus*
PLR = *Pleuronichthys ritteri*
PLV = *Pleuronichthys verticalis*
PM = *Porichthys myriaster*
PN = *Porichthys notatus*
RS = *Raja stellulata*
SA = *Symphurus atricaudus*
SC = *Sebastes chlorostictus*
SE = *Sebastes eos*
SEA = *Sebastolobus alascanus*
SG = *Scorpaena guttata*
SP = *Seriphus politus*
SR = *Sebastes rosenblatti*
SS = *Sebastes saxicola*
SSE = *Sebastes semicinctus*
SYL = *Synodus lucioceps*
XEL = *Xeneretmus latifrons*
XYL = *Xystreurys liolepis*
ZF = *Zaniolepis frenata*
ZL = *Zaniolepis latipinnis*
ZR = *Zalembius rosaceus*

Boxes indicate where guild occurred in 20% or more of stations in depth class.
Dotted lines define areas where guild occurred in less than 20% of stations in depth class.
Dominant species in guild is identified by abbreviations.

See Glossary G2 for common names of fish species.

Figure 44. Functional organization of demersal fish communities on the southern California shelf in July-September 1998 (see Allen 1982).

followed by 9 guilds at 150 m. The highest number of water-column guilds (7) occurred at 10 m and the least number (1) occurred at 30 m. The highest number of bottom-living guilds (10) occurred at 70 and 90 m, whereas the least number (4) occurred at 10 m.

Dominant Species in Guilds by Depth. Dominant members of the guilds by depth generally were characteristic of shelf zones, although some guilds were represented by more species. Eight water-column and 10 bottom-living guilds were represented.

Water column guilds included pelagivores, pelagobenthivores, benthopelagivores, and benthivores, with most of these having subdivisions. Of the schooling pelagivores, queenfish was the dominant on the inner shelf to 20 m (Figure 44). However, there was a hiatus in the occurrence of this guild from 20 to 80 m. Below that depth, Pacific argentine was dominant on the deeper middle shelf and shallow outer shelf, with Pacific hake dominant between 160 and 200 m. The bottom-refuge visual pelagivores were poorly represented from 2 to 40 m; however, halfbanded rockfish (typical of sand-rock areas) was dominant on the middle shelf from 40-60 m and stripetail rockfish on the middle and outer shelf from 60 to 200 m. Among the bottom refuge nonvisual pelagivores, specklefin midshipman was dominant from 2 to 60 m and plainfin midshipman from 60 to 200 m. The midwater pelagobenthivores were represented by shiner perch, which only occurred commonly on the inner shelf from 2 to 20 m. Cruising pelagobenthivores were represented by barred sand bass, which was also restricted largely to the inner shelf from 2 to 20 m.

Of the cruising diurnal benthopelagivores, white seaperch was dominant on the inner shelf from 2 to 20 m and pink seaperch on the middle and outer shelf from 40 to 200 m (Figure 44). The guild was not common from 20 to 40 m in this survey. White croaker was the dominant member of the cruising nocturnal benthopelagivore guild, and was common on the inner shelf at 2-20 m and on the middle shelf at 80-100 m; it occurred uncommonly at other depths between 20 and 120 m. Of the cruising nonvisual benthivores, California corbina was dominant on the inner shelf (2-20 m); spotted cusk-eel on the middle and outer shelf at 80 to 130 m and 160 to 180 m; and spotted ratfish on the outer shelf at 180 to 200 m. This guild was rare or absent at other depths in this survey.

Bottom-living guilds also included pelagivores, pelagobenthivores, benthopelagivores, and benthivores, with most of these having subdivisions. Of the bottom-living pelagivores, California halibut was the guild dominant on the inner shelf (2-20 m), California lizardfish on the middle shelf from 20 to 100 m (and unusually at 140 to 160 m), and bigmouth sole from the remaining middle shelf and outer shelf area (100-140 m, 160-180 m) (Figure 44). Of the bottom-living pelagobenthivores (sanddab-guild), the speckled sanddab was dominant on the inner shelf (2-40 m), longfin sanddab on the middle shelf from 40 to 80 m (but only in the southern and central mainland regions), Pacific sanddab on the middle and outer shelf from 80 to 180 m, and the slender sole on the outer shelf from 180 to 200 m.

Bottom-living pursuing benthopelagivores were common only from 40 to 200 m, with the longspine combfish dominant on the middle shelf (40 to 100 m) and shortspine combfish on the outer shelf (100-200 m) (Figure 44). Pygmy poacher was the only representative of the Size A ambushing benthopelagivores, being most common on the middle shelf from 40 to 120 m. Size B ambushing benthopelagivores were poorly represented from 2 to 40 m; however, yellowchin sculpin was dominant on the middle shelf from 40 to 100 m, spotfin sculpin on the middle shelf/outer shelf from 100 to 140 m, and blacktip poacher on the outer shelf from 140 to 200 m. Size C ambushing benthopelagivores were poorly represented on the inner shelf below

20 m. However, fantail sole was dominant on the deeper inner shelf and shallow middle shelf (20 to 60 m), and roughback sculpin on the middle shelf from 60 to 100 m. Deeper than 100 m, greenblotched rockfish (the expected outer shelf species; Figure 6), was dominant only at 120 to 140 m. Greenspotted rockfish, a similar species typical of sand-rock areas, was dominant at 100-120 m and at 160-180 m, with shortspine thornyhead being dominant from 180 to 200 m. Size D Ambushing benthopelagivores were poorly represented shallower than 40 m, but at greater depths, California scorpionfish was dominant on the middle shelf from 40 to 100 m, and at 120 to 140 m; greenblotched rockfish, the expected outer shelf dominant (Figure 6) was absent, but shortspine thornyhead was dominant from 180 to 200 m.

Bottom-living benthivore guilds were generally common at all depths. Of the extracting benthivores, spotted turbot was dominant on the inner shelf from 2 to 20 m, hornyhead turbot on the inner shelf and middle shelf from 20 to 60 m, and Dover sole on the middle and outer shelf from 60 to 200 m (Figure 44). Excavating benthivores were not common on the inner shelf (2-20 m) but were dominated by the English sole on the middle shelf from 20 to 120 m, and unexpectedly on the mainland outer shelf from 140 to 180 m. Blackbelly eelpout (the expected outer shelf dominant; Figure 6), was dominant at 120 to 140 m and 180 to 200 m; it was generally more abundant at the islands than the English sole. Of the nonvisual benthivores, California tonguefish was dominant on the inner and middle shelf (2-100 m), but rex sole (the expected outer shelf dominant; Figure 6), was dominant only from 160 to 200 m. Starry skate (*Raja stellulata*; all small juveniles) were unexpected dominant members of this guild at 100 to 140 m.

The 1998 survey showed many unexpected alterations of expected depth displacement patterns of dominant guild members (Figure 6; Allen 1982). Historical changes in the organization of the fish community are discussed in more detail in the discussion section of this chapter below.

Invertebrate Assemblages

Invertebrate Recurrent Groups

Recurrent group analysis at the 0.50 level of affinity identified 22 recurrent groups of invertebrates consisting of 2-4 species per group with one associate species (Figures 45 and 46). In all, the groups and associates included 47 (15%) of the 313 species collected in the survey. Recurrent groups were found at 1-42 stations; 17 of the 22 groups occurred at only 1 site (Figure 46), with 5 occurring at 5-42 sites (Figure 45). These five major groups generally differed in depth distribution, with each occurring in one or two of the four predetermined shelf zones (Figure 47). The five major groups will be discussed in detail.

Group 2 (San Diego Bay Oyster Group). Group 2 consisted of two species of mollusks, an unidentified oyster (*Ostrea* sp) and onyx slippersnail (*Crepidula onyx*) (Figure 45). The group was found at 4 sites ranging in depth from 4-11 m in San Diego Bay (Figures 47 and 48). Group 2 did not have affinities with other recurrent groups.

Group 11 (San Diego Middle Shelf Group). Group 11 consisted of two species, digger hermit (*Paguristes bakeri*) and California frogsnail (*Crossata californica*) (Figure 45). This group occurred at 6 sites at depths of 47-85 m in the middle shelf zone off the La Jolla and Point Loma areas of San Diego (Figures 47 and 48). Group 11 did not have affinities with other groups.

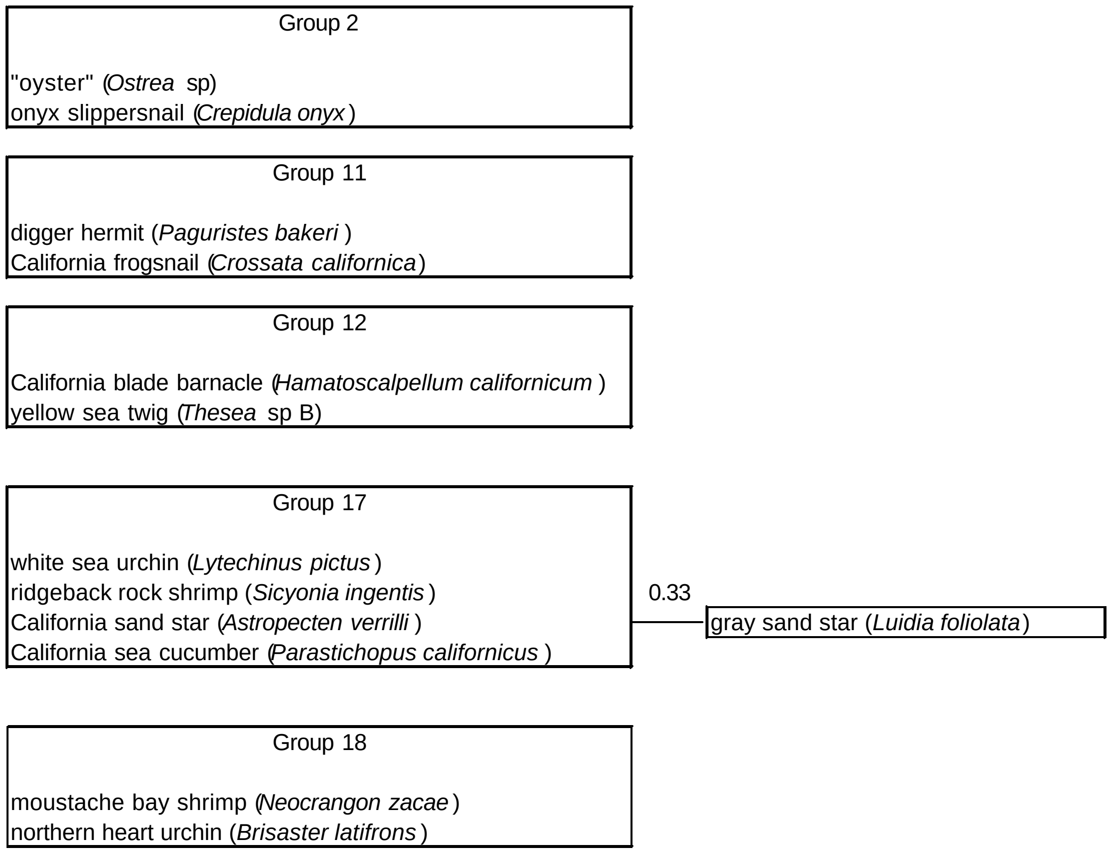


Figure 45. Recurrent groups of megabenthic invertebrates found at multiple sites on the southern California shelf at depths of 2-202 m, July-September 1998. Index of affinity (I.A.) = 0.50. Species within a group are listed in order of abundance. Lines show relationships between groups and associates, with values indicating the proportion of possible pairs with I.A. = 0.50.

Group 12 (Middle Shelf Group). Group 12 consisted of two species, California blade barnacle and yellow sea twig (Figure 45). This group was found at 31 sites at depths of 34-125 m in the middle shelf zone from the northwest Channel Islands to off Point Loma (Figures 47 and 48). Although a wide-ranging group, it appeared to be most common in POTW areas (Figure 48). Group 12 did not have affinities with other groups.

Group 17 (Middle Shelf/Outer Shelf Group). Group 17 consisted of four species, white sea urchin, ridgeback rock shrimp, California sand star, and California sea cucumber (Figure 45). The group occurred at 42 sites ranging in depth from 43-174 m on the middle shelf and outer shelf zones, ranging from the western Santa Barbara Channel to San Diego (Figures 47 and 48). The gray sand star was an associate of this group (Figure 45).

Group 18 (Outer Shelf Group). Group 18 consisted of two species, moustache bay shrimp (*Neocrangon zacae*) and northern heart urchin (*Brisaster latifrons*) (Figure 45). The group occurred at 12 sites from 160-202 m in the outer shelf zone, ranging from Point Conception and the northwest Channel Islands to the southern San Pedro Shelf (Figures 47 and 48). Group 18 did not have affinities with any other group.

Group 1

Monterey sea-lemon (*Archidoris montereyensis*)
giant rock scallop (*Crassadoma gigantea*)
white slippersnail (*Crepidula perforans*)

Group 3

salted yellow doris (*Doriopsilla albopunctata*)
"sponge" (Porifera sp SD 8)

Group 4

"dirona" (*Dirona* sp)
Catalina forreria (*Austrotrophon catalinensis*)
sharpnose crab (*Scyra acutifrons*)

Group 5

brooding anemone (*Epiactis prolifera*)
California drillia (*Crassispira semiinflata*)

Group 6

northern squat lobster (*Munida quadrispina*)
"sponge" (*Plocamia karykina*)

Group 7

"gorgonian" (*Alcyonaria* sp SD 1)
slender coastal shrimp (*Heptacarpus tenuissimus*)

Group 8

sea spider (*Anoplodactylus erectus*)
"sponge" (Porifera sp SD 3)

Group 9

Loebbeck spindlesnail (Neosimnia loebbeckeana)
"left-handed hermit" (*Paguristes* sp A)

Group 10

ribbed lamp shell (*Terebratalia transversa*)
spiny scallop (*Chlamys hastata*)

Group 13

"nestling sea cucumber" (*Cucumaria* sp)
smooth western nassa (*Nassarius insculptus*)

Group 14

Vidler spindlesnail (*Neosimnia aequalis*)
California sidegill slug (*Berthella californica*)

Group 15

Hudson spiny doris (*Acanthodoris hudsoni*)
eggcase limpet (*Addisonia brophyi*)

Group 16

"right-handed hermit" (*Enallopaguropsis guatemoci*)
scaly sea cucumber (*Psolus squamatus*)
"trophon" (*Scabrotrophon grovesi*)

Group 19

"cup coral" (*Caryophyllia alaskensis*)
cloud sponge (*Aphrocallistes vastus*)
"cookie star" (*Ceramaster* sp)
longhorn decorator crab (*Chorilia longipes*)
spiny sea star (*Poraniopsis inflata*)
"sponge" (*Sphincturella* sp A)

Group 20

gray shrimp (*Neocrangon communis*)
helmet puncturella (*Puncturella galeata*)

Group 21

white lamp shell (*Terebratulina crossei*)
"gorgonian" (*Parastenella doederleini*)

Group 22

sea dandelion (*Dromalia alexandri*)
Colombian longbeak shrimp (*Plesionika trispinus*)
brownspot octopus (*Octopus veligero*)

Figure 46. Recurrent groups of megabenthic invertebrates found at single sites on the southern California shelf at depths of 2-202 m, July-September 1998. Index of affinity (I.A.) = 0.50. Species within a group are listed in order of abundance.

Single-Site Groups. Of the 17 single-site groups (Figure 46), some may represent natural associations and some associations may be analytical artifacts. Given this, the groups can be classified into general categories according to the shelf zone of their occurrences. None of them occurred in the inner shelf zone.

Two single-site groups occurred in bays and harbors. Group 1 was found at 3 m (Station 2129) in Channel Islands Harbor. Group 3 was found at 11 m (Station 2231) in San Diego Bay.

Eleven single-site groups occurred in the middle shelf zone. Three groups occurred in LPOTW areas: Group 4 at 43 m on the southern San Pedro Shelf (Station 2211); Group 5 at 47 m on the San Diego Shelf (Station 2413); and Group 9 at 57 m on the Santa Monica Bay Shelf (station 2194). Two additional groups occurred

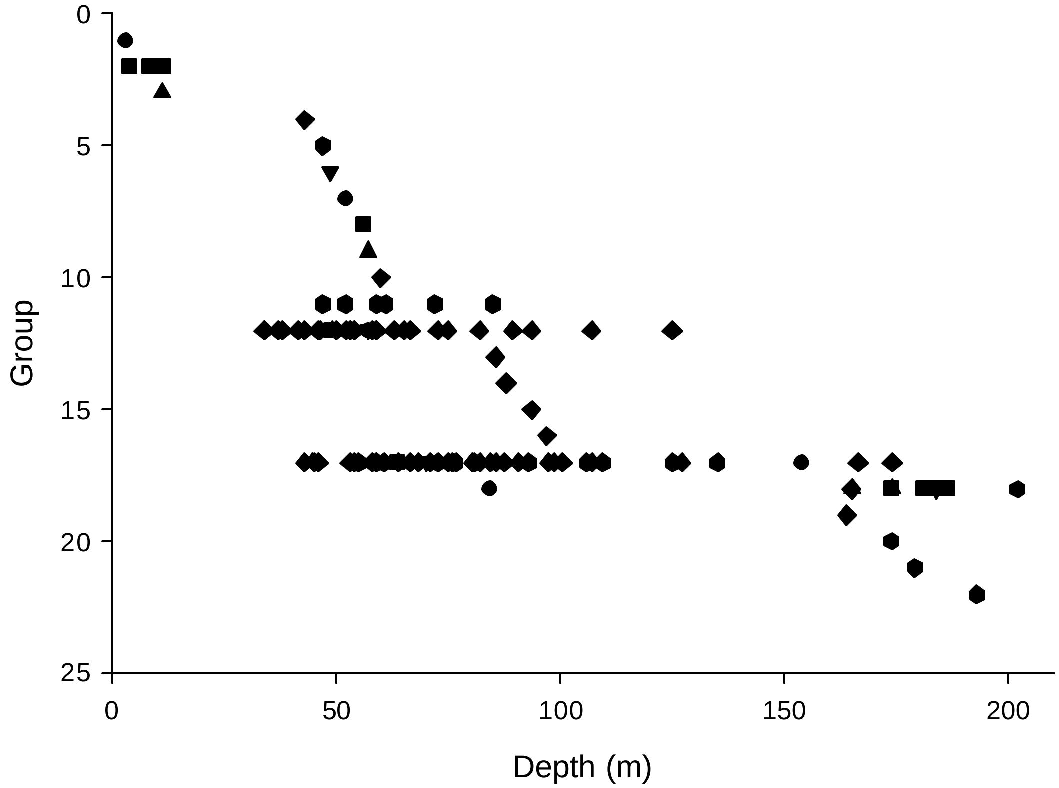


Figure 47. Bathymetric distribution of megabenthic invertebrate recurrent groups on the southern California shelf at depths 2-202 m, July-September 1998.

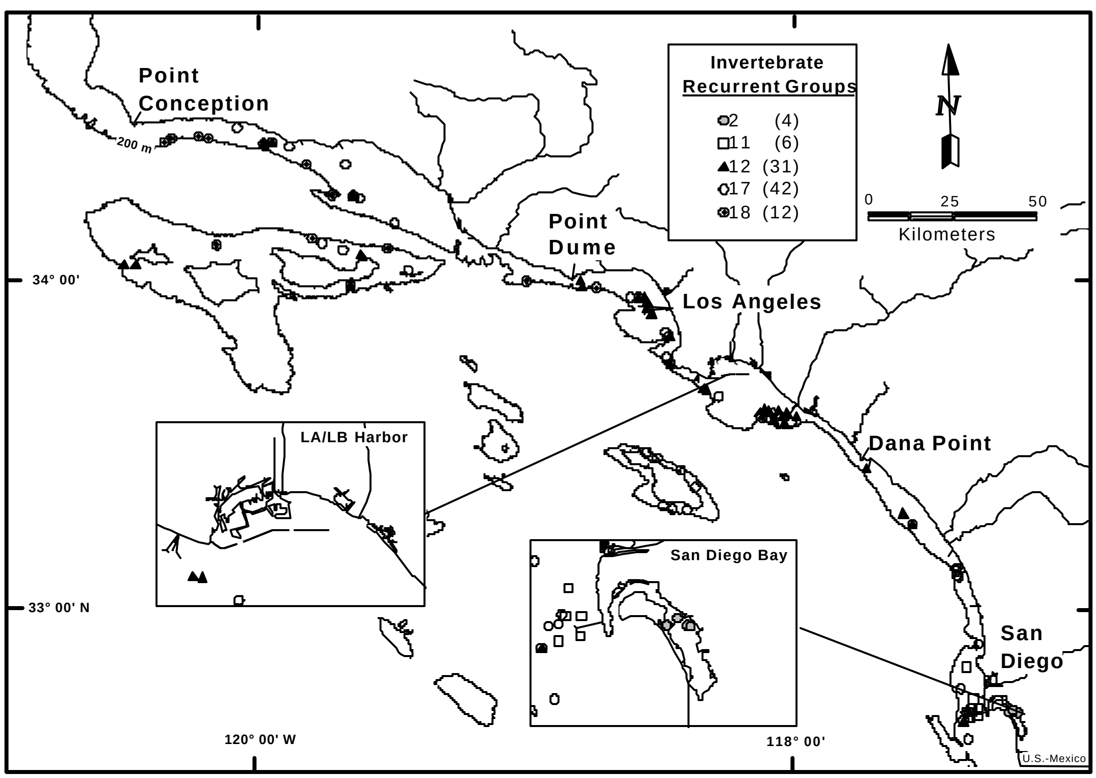


Figure 48. Distribution of megabenthic invertebrate recurrent groups on the southern California shelf at depths of 2-202 m, July-September 1998.

on the San Diego Shelf outside of the LPOTW area: Group 7 at 52 m (Station 2351) and Group 8 at 56 m (Station 2419). Four groups occurred on the Santa Catalina Island Shelf: Group 6 at 48 m (Station 2077); Group 13 at 86 m (Station 2073); Group 14 at 88 m (Station 2084); and Group 16 at 97 m (Station 2093). One (Group 10) occurred at 60 m near Anacapa Island (Station 2517) and one (Group 15) was found at 94 m near Santa Rosa Island (Station 2491).

Four single-site groups were found in the outer shelf zone. Two groups occurred at Santa Rosa Island: Group 19 at 164 m (Station 2494) and Group 20 at 174 m (Station 2097). Group 21 was found at Santa Catalina Island at 179 m (Station 2096). Group 22 was found near Newport Submarine Canyon at 193 m (Station 2119).

Invertebrate Site and Species Clusters

Selection of Species. A total of 132,827 megabenthic invertebrates and 322 taxa were collected at the 314 stations sampled in the survey. Based upon the screening criteria, 277 stations representing 130,567 invertebrates and 96 taxa were included in the cluster analysis. The cluster analysis delineated 8 major site clusters (=station clusters) denoting habitats and 7 major species clusters denoting species assemblages or communities (Figure 49[2], Appendix E4). Each site and species cluster was unique, based on the relative proportion of different species clusters within a site cluster and the relative proportion of each species cluster in different site clusters (Figures 49 and 50).

Site Clusters. The site clusters varied by region and shelf zone subpopulations (Table 53, Figures 49 and 51), and to a lesser extent by sediment type (Figure 52). Each site cluster had one or two dominant species clusters (Figures 49 and 50).

Site Cluster 1 included 11 stations, 10 from the outer shelf zone and 1 from the middle shelf zone, ranging in depth from 99-193 m (Table 53; Figures 49, 51, and 53). This site group delineated an outer shelf habitat characterized by 8 mainland region and 2 island region outer shelf sites and 1 mainland region middle shelf site (Table 53). By subregion, this cluster included 4 northern mainland region, 3 central mainland region, 2 southern mainland region, 1 northwestern Channel Islands, and 1 southeastern Channel Islands sites. Thus, there appears to be no strong latitudinal gradient associated with this outer shelf site cluster. Four species from Species Cluster E and one from Species Cluster F occurred in more than 50% of the stations within Site Cluster 1 (Table 54, Appendices E5 and E6). The four species from Species Cluster E were broadly distributed and tended to be ubiquitous for the outer/middle shelf zone and included the ridgeback rock shrimp, California sea cucumber, California sea slug, and gray sand star. The other frequently occurring species found at Site Cluster 1 included the fragile sea urchin from Species Cluster F and the five species from Species Cluster G, which included orange bigeye octopus (*Octopus californicus*), northern heart urchin, moustache bay shrimp, flagnose bay shrimp (*Neocrangon resima*), and hinged shrimp. These latter 6 species generally define an outer shelf assemblage as they occurred with low abundance in Site Cluster 2 and were essentially absent from other site clusters. Site Cluster 1 had finer sediments than Site Cluster 2 (Figure 52). Thus, these species essentially define the habitat difference between Site Clusters 1 and 2 (Figure 49).

Site Cluster 2, the largest site cluster, included 56 stations ranging in depth from 17-201 m, characterizing an outer/middle shelf habitat (Table 53; Figures 49, 51, and 53). All subregions were represented including 6 northern, 7 central, 3 southern, 16 Santa Catalina Island, 11 northwestern Channel Islands, and 13 south-

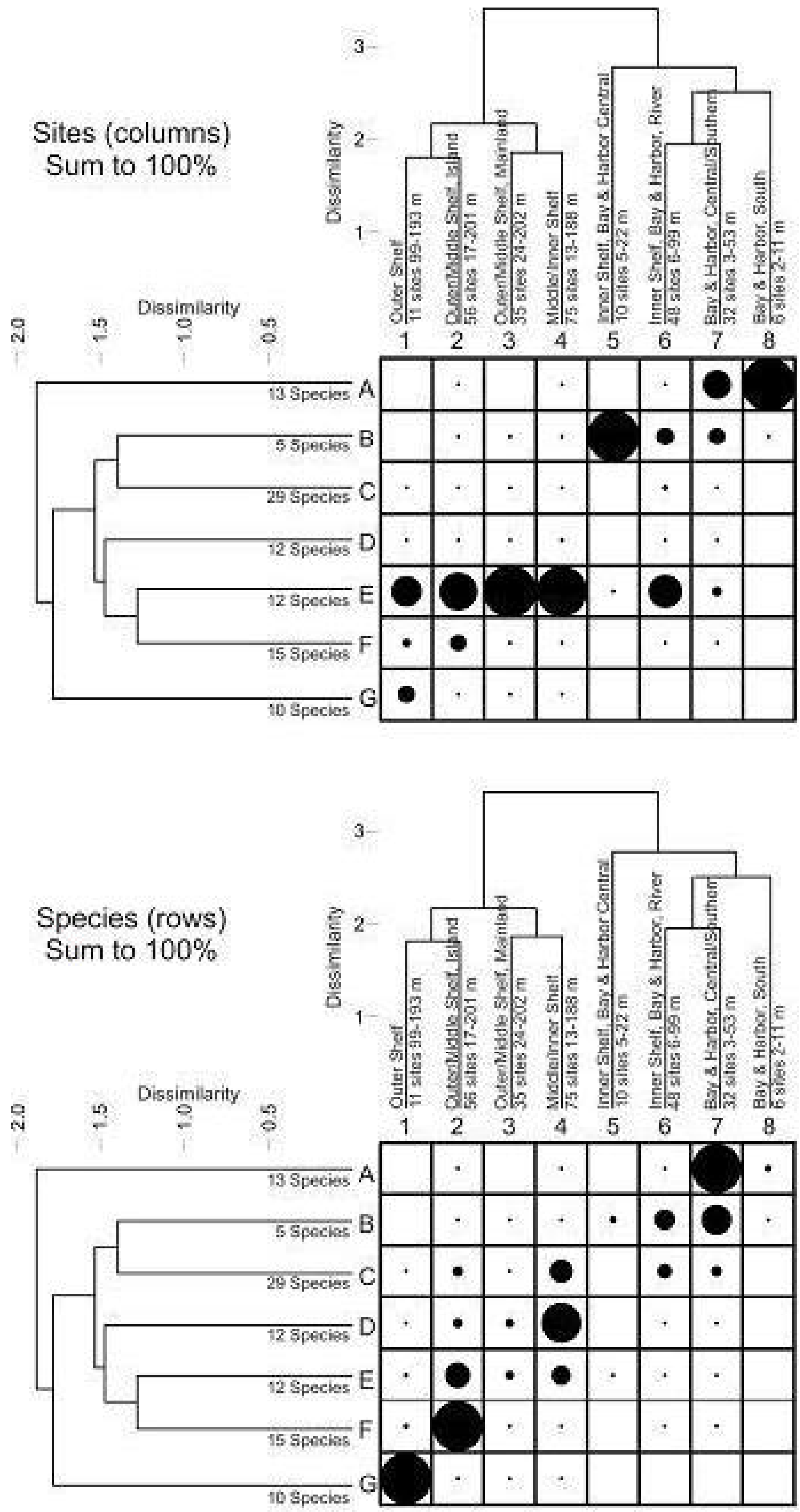


Figure 49. Summary of megabenthic invertebrate cluster analysis and relationships between site and species clusters on the southern California shelf at depths of 2-202 m, July-September 1998.

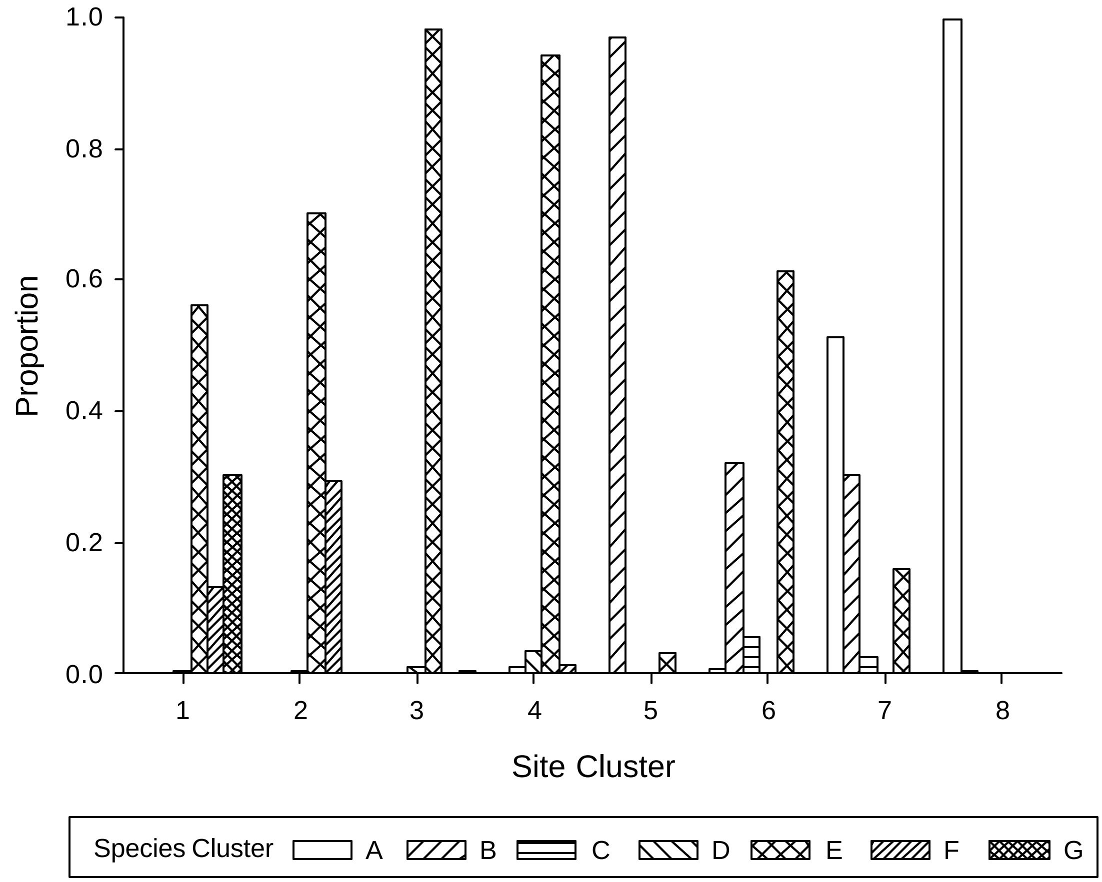


Figure 50. Proportion of megabenthic invertebrate species clusters in each invertebrate site cluster on the southern California shelf at depths of 2-202 m, July-September 1998.

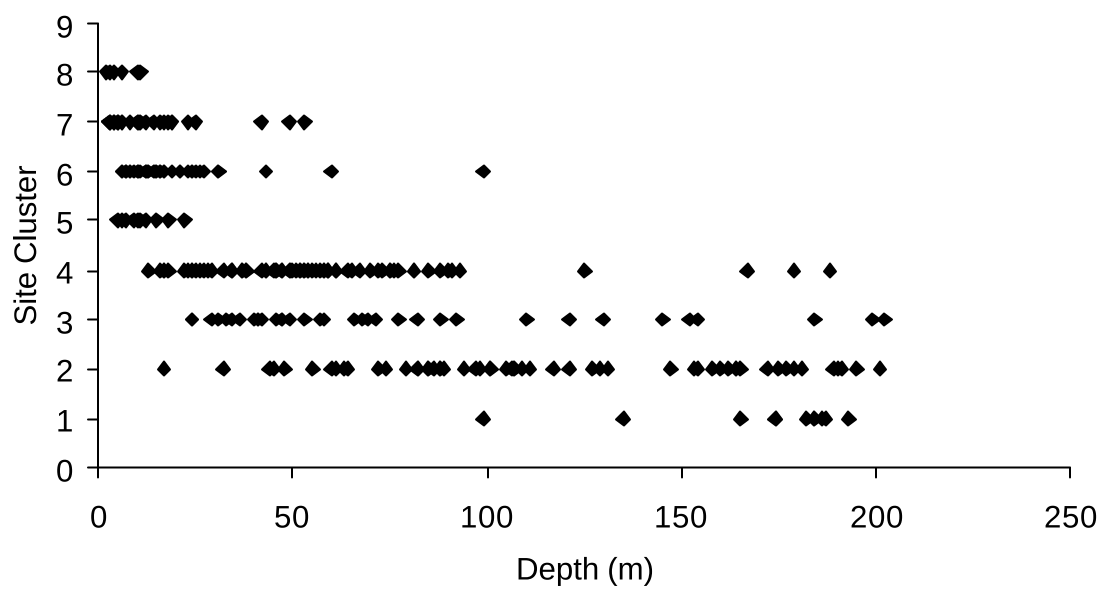


Figure 51. Bathymetric distribution of megabenthic invertebrate site clusters on the southern California shelf at depths of 2-202 m, July-September 1998.

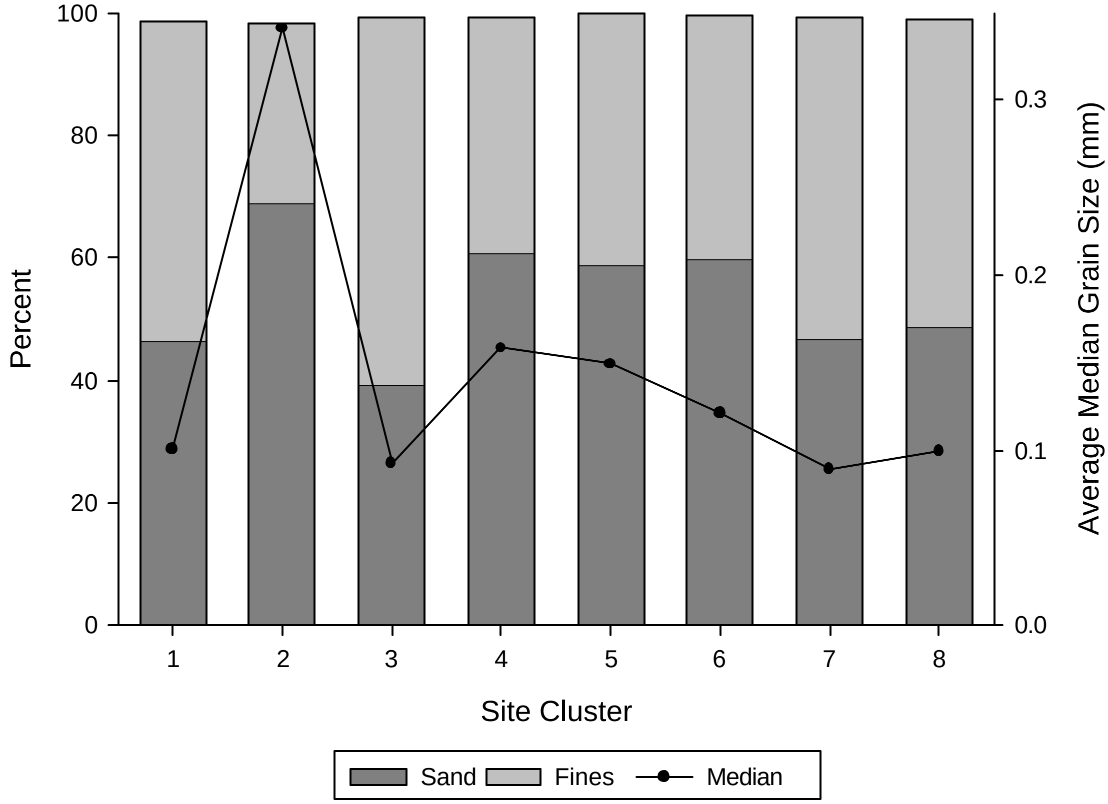


Figure 52. Average percent of sand, percent of fines, and median grain size (mm) for each megabenthic invertebrate site cluster on the southern California shelf at depths of 2-202 m, July-September 1998.

eastern Channel Islands sites (Table 53). With over 71% of the sites representing the island region, this site group is predominantly an island cluster. Sediments at sites in this cluster are relatively coarse, with the highest median grain size and greatest percent sand of any cluster (Figure 52). Thus, this is primarily a coarse bottom cluster, with many island members because island shelves have little fine sediment. By depth, this site cluster included 23 outer shelf zone, 32 middle shelf zone, and 1 bay/harbor sites. These results do not support a distinction between the outer shelf and middle shelf zone depth categories, but there does appear to be some differences between the mainland and island region sites. The outer shelf sites included 19 island region sites and only 4 mainland region sites, indicating that the island sites are somewhat different from the mainland sites. A similar pattern was evident for the middle shelf zone, with 21 stations from the island region and 11 stations from the mainland region. The mainland region sites included 6 large POTW sites, suggesting that POTW stations did not differ in assemblage type from sites far from wastewater discharges. The one bay/harbor site, located in outer LA/LB Harbor (Figure 53), had only 6 individuals of 3 shallow-water species and may be an artifact of this analysis. Both Site Clusters 1 and 2 were largely delineated by Species Cluster E, but Site Cluster 2 generally had more species from Species Cluster F while Site Cluster 1 had more species from Species Cluster G (Table 54, Appendices E5 and E6). Thus, Site Cluster 2 is similar to Cluster 1 but lacks the 10 species that characterize the outer shelf assemblage Cluster G.

Table 53. Frequency of occurrence (number of stations) of megabenthic invertebrate site clusters by region and subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	SITE CLUSTER								
	1	2	3	4	5	6	7	8	Grand Total
	Outer Shelf	Outer / Middle Shelf Island	Outer / Middle Shelf Mainland	Middle / Inner Shelf	Inner Shelf B&H C	Inner Shelf B&H River	B&H C/S	B&H S	
Depth Range (m)	99-193	17-201	24-202	13-188	5-22	6-99	3-53	2-11	
Subpopulation									
Region									
Mainland	9	16	31	68	10	48	32	6	220
Northern	4	6	12	16	-	8	2	-	48
Central	3	7	10	30	9	24	20	1	104
Southern	2	3	9	22	1	16	10	5	68
Island	2	40	4	7	-	-	4	-	57
Cool (NW Channel Islands)	1	11	-	3	-	-	-	-	15
Warm									
SE Channel Islands	1	13	-	2	-	-	-	-	16
Santa Catalina Island	-	16	4	2	-	-	4	-	26
Shelf Zone									
Bays and Harbors (2-30 m)	-	1	-	1	4	13	32	6	57
Ports	-	1	-	-	-	2	11	1	15
Marinas	-	-	-	-	-	4	13	1	18
Other Bay	-	-	-	1	4	7	8	4	24
Inner Shelf (2-30 m)	-	-	3	13	6	30	1	-	53
Small POTWs	-	-	-	3	-	3	-	-	6
River Mouths	-	-	1	2	3	17	-	-	23
Other Mainland	-	-	2	5	3	10	-	-	20
Island	-	-	-	3	-	-	1	-	4
Middle Shelf (31-120 m)	1	32	24	57	-	5	3	-	122
Small POTWs	-	-	1	-	-	-	-	-	1
Large POTWs	-	6	2	23	-	1	-	-	32
Mainland non-LPOTW	1	5	17	30	-	4	-	-	57
Island	-	21	4	4	-	-	3	-	32
Outer Shelf (121-202 m)	10	23	8	4	-	-	-	-	45
Mainland	8	4	8	4	-	-	-	-	24
Island	2	19	-	-	-	-	-	-	21
Total	11	56	35	75	10	48	36	6	277

C = Central; N = Northern; S = Southern; B&H = Bays/Harbors; POTW = Publicly owned treatment work monitoring area.

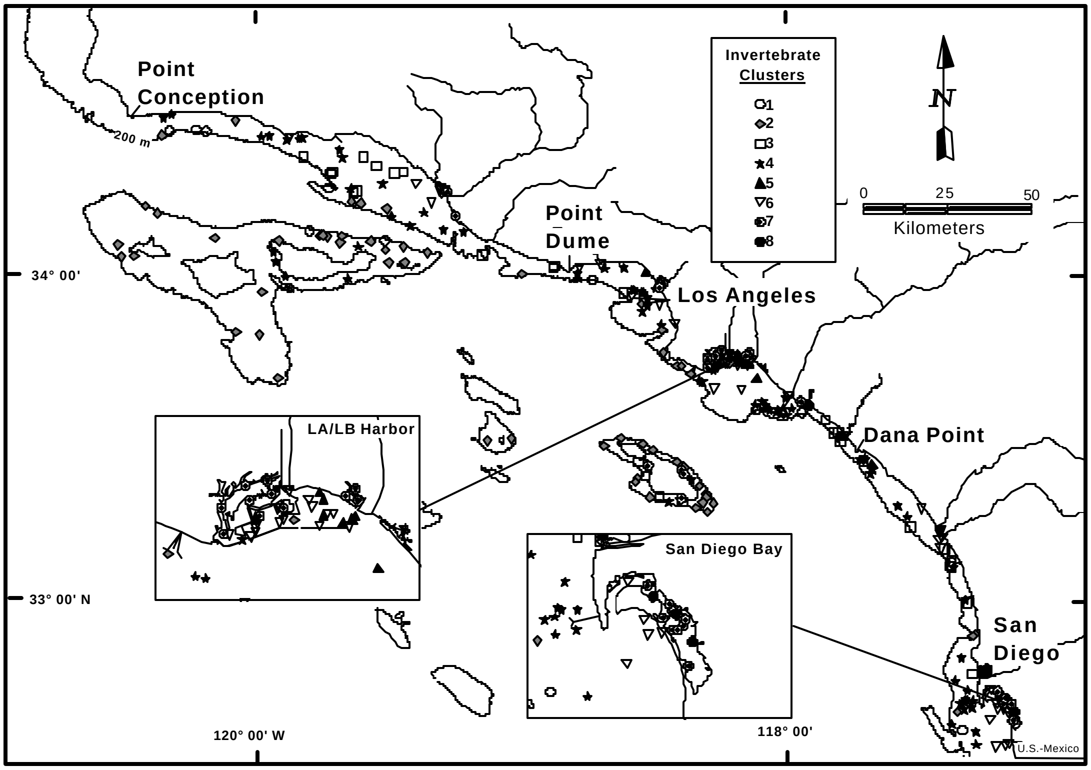


Figure 53. Distribution of megabenthic invertebrate site clusters on the southern California shelf at depths of 2-202 m, July- September 1998.

Site Cluster 3 characterizes mainland middle shelf habitat with 35 sites ranging in depth from 24-202 m (Table 53; Figures 49, 51, and 53). All mainland subregions were well represented including 12 northern region, 10 central region, and 9 southern region stations; and 4 stations from Santa Catalina Island (Table 53). By depth, there were 8 outer shelf , 24 middle shelf and 3 inner shelf sites. The 8 outer shelf sites were all mainland sites, while the 24 middle shelf sites represented 1 small POTW, 2 large POTWs, 17 non-POTW, and 4 Santa Catalina Island sites. The inner shelf sites included 1 river mouth and 2 mainland sites. Similar to Site Cluster 2, a strong distinction was not found by depth category. The ubiquitous species of Species Cluster E also delineated this site cluster; however, unlike Site Clusters 1 and 2, Site Cluster 3 has no species from Species Clusters F and G (Table 54, Appendices E5 and E6).

Site Cluster 4, the largest site cluster, included 75 sites ranging in depth from 13-188 m, characterizing a middle/inner shelf habitat (Table 53; Figures 49, 51, and 53). All regions were well represented with 16 northern, 30 central, and 22 southern sites within the mainland region; and 3 northwest Channel Islands, 2 southeast Channel Islands, and 2 Santa Catalina Island sites within the island region (Table 53). This indicates no strong latitudinal gradient for these water depths. By depth, 4 sites were characterized as outer shelf sites, 57 as middle shelf sites, 13 as inner shelf sites, and 1 as a bay/harbor site. The four outer shelf sites were all mainland sites and one bay/harbor station (Station 2168) was located in outer LA/LB Harbor. The 57 middle shelf sites included 23 of the 32 large POTW sites; 30 of the 57 mainland non-large POTW sites, and 4 island sites. This suggests that there is little difference in the assemblages at POTW and non-POTW sites in the middle shelf zone. The 13 inner shelf sites included 3 small POTW sites, 2 river mouth sites, 5 mainland sites, and 3 island sites. Similar to Site Clusters 1, 2, and 3, the 12 ubiquitous species of Species Cluster E were common at these sites, especially the

Table 54. Frequency of occurrence (percent of stations) of megabenthic invertebrate species occurring at 50% or more of the stations in at least one site cluster on the southern California shelf at depths of 2-202 m, July-September 1998.

			SITE CLUSTER							
			1	2	3	4	5	6	7	8
			Outer Shelf	Outer / Middle Shelf Island	Outer / Middle Shelf Mainland	Middle / Inner Shelf	Inner Shelf B&H C	Inner Shelf B&H River	B&H C/S	B&H S
		Number of Stations	11	56	35	75	10	48	36	6
		Depth Range (m)	99-193	17-201	24-202	13-188	5-22	6-99	3-53	2-11
Cluster Group	Common Name	Scientific Name								
A	Pacific calico scallop	*Argopecten ventricosus*	-	-	-	-	-	2	19	100
	mat mussel	*Musculista senhousia*	-	-	-	-	-	2	28	83
B	blackspotted bay shrimp	*Crangon nigromaculata*	-	-	3	1	60	60	11	-
	tuberculate pear crab	*Pyromaia tuberculata*	-	7	3	13	80	52	44	-
	spiny sand star	*Astropecten armatus*	-	2	-	7	100	21	6	-
	yellowleg shrimp	*Farfantepenaeus californiensis*	-	2	-	3	60	35	31	17
E	California sand star	*Astropecten verrilli*	36	52	69	87	30	23	11	-
	ridgeback rock shrimp	*Sicyonia ingentis*	100	61	66	67	-	8	-	-
	California sea cucumber	*Parastichopus californicus*	64	41	34	45	-	4	17	-
	white sea urchin	*Lytechinus pictus*	45	59	37	56	10	8	8	-
	California sea slug	*Pleurobranchaea californica*	100	36	6	12	-	4	6	-
	gray sand star	*Luidia foliolata*	64	52	26	25	-	-	-	-
F	fragile sea urchin	*Allocentrotus fragilis*	82	41	3	4	-	-	-	-
G	orange bigeye octopus	*Octopus californicus*	55	5	-	-	-	-	-	-
	northern heart urchin	*Brisaster latifrons*	82	5	6	1	-	-	-	-
	mustache bay shrimp	*Neocrangon zacae*	82	13	9	-	-	-	-	-
	flagnose bay shrimp	*Neocrangon resima*	55	5	9	-	-	-	-	-
	hinged shrimp	*Pantomus affinis*	64	4	9	-	-	-	-	-

C = Central; S = Southern; N = Northern; B&H = Bays/Harbors.
See Appendix E6 for complete list of species and their occurrences in site clusters.

California sand star, ridgeback rock shrimp, and white sea urchin, all of which occurred at more than 50% of the sites for this cluster (Table 54, Appendices E5 and E6). Unlike Site Clusters 1 and 2, Site Cluster 4 has no species from Species Clusters F and G. Site Cluster 4 differs from Site Cluster 3 by having more species from Species Clusters C and D.

Site Cluster 5 included 10 sites ranging in depth from 5-22 m, characterizing a centrally located inner shelf and bay/harbor habitat. (Table 53; Figures 49, 51 and 53). Nine of these sites were located in the central mainland region and one was from the southern mainland region (Table 53). The 6 inner shelf sites were equally split between the mainland and river mouth sites. The 4 bay/harbor sites represented 3 sites in the southern portion of Long Beach Harbor and 1 site in Los Angeles Harbor. The 5 species of Species Cluster B, 4 of which occurred at more than 50% of the sites, characterized this site and included blackspotted bay shrimp, tuberculate pear crab, spiny sand star (*Astropecten armatus*), and yellowleg shrimp (*Farfantepenaeus californiensis*) (Table 54, Appendices E5 and E6). This site cluster tended to have low abundance and diversity. Unlike Site Cluster 6, Site Cluster 5 had no individuals from Species Cluster C.

Site Cluster 6 contained 48 mainland sites characterizing a generalized shallow-water habitat represented by inner shelf and bay/harbor sites ranging in depth from 6-99 m (Table 53; Figures 49, 51, and 53). All regions were represented with the central/southern region (Table 53) being represented the most: 8 northern region, 24 central region, and 16 southern region sites. By depth, this site cluster included 5 sites from the middle shelf zone, 30 sites from the inner shelf zone, and 13 sites from the bays and harbors. By depth (or potential habitat type), the middle shelf sites included 1 large POTW and 4 mainland non-POTW sites. The inner shelf sites included 3 small POTW, 17 river mouth, and 10 mainland sites; the bay/harbor sites included 4 marina, 7 "other bay", and 2 port sites. This site cluster encompasses a diverse range of depths and potential habitat types; however, it appears closely associated to the river mouth sites. On the other hand, the river mouth subpopulation does not appear to represent a unique habitat type. This site cluster was largely characterized by two species from Species Cluster B, which occurred in more than 50% of the sites: blackspotted shrimp and tuberculate pear crab (Table 54; Appendices E5 and E6).

Site Cluster 7 contained 36 stations, characterizing a bay/harbor habitat ranging in depth from 3-53 m (Table 53; Figures 49, 51, and 53). By region, this site cluster included 2 northern mainland region, 20 central mainland region, and 10 southern mainland region sites, indicating a central and southern mainland region trend (Table 53). By depth, 3 sites were from the middle shelf island subpopulation, 1 from the inner shelf island subpopulation, and 32 from bays and harbors. The bay/harbor sites included 13 marina, 11 port, and 8 "other bay" sites. This site cluster was characterized by low abundances of species from Species Clusters A and B, but no species occurred at 50% of the sites (Table 54, Appendices E5 and E6).

Site Cluster 8 contained 6 sites, characterizing a shallow southern mainland region bay/harbor habitat ranging in depth from 2-11 m (Table 53; Figures 49, 51 and 53). By region, there were no sites in the northern mainland region, 1 site in the central mainland region, and 5 sites in the southern mainland region (Table 53). Within bays and harbors, there was 1 marina, 1 port, and 4 "other bay" sites. This site cluster was largely determined by two species from Species Cluster A; Pacific calico scallop (*Argopecten ventricosus*) and mat mussel (*Musculista senhousia*), which occurred at 100% and 83% of the stations, respectively (Table 54; Appendices E5 and E6).

Species Clusters. Seven major species groups were delineated by the analysis (Figure 49). The species clusters occupied successively deeper depth zones (Figure 51) . The relationship of the site clusters with depth results from depth distribution patterns of the invertebrate species found in the species clusters. All site clusters included representatives of one or more species groups (Figure 49). Species Cluster E was dominant in Site Clusters 1, 2, 3, 4, and 6; Species Cluster B in Site Cluster 5; and Species Cluster A in Site Clusters 7 and 8.

Species Cluster A included 13 species indicative of the shallow water found in bays and harbors (Table 54; Appendices E4, E5, and E6). None of these species were found in Site Clusters 1-5. Two species, Pacific calico scallop and mat mussel, had very high occurrence for Site Cluster 8 and a lower occurrence for Site Cluster 7, with a few found in Site Cluster 6. Site Cluster 7 was characterized by low abundance of all 13 species while only 5 of the 13 taxa were found in Site Clusters 5 and 8. This suggests that the 2 dominant species have a localized distribution (Figure 53; Table 54; Appendices E4, E5, and E6). Ten of the 13 taxa found in this cluster are hard-bottom or fouling-type organisms, such as oysters, tunicates (sea squirts), and mussels.

Species Cluster B included 5 species that typically characterize shallow, nearshore areas of the inner shelf and in bays and harbors (Table 54; Appendices E4, E5, and E6). Blackspotted shrimp, tuberculate pear crab, spiny sand star, and yellowleg shrimp were very abundant in Site Cluster 5, less abundant in Site Cluster 6, and not well represented in Site Clusters 4 and 7. The fifth species in this cluster, fat western nassa (*Nassarius perpinguis*), was only found in Site Clusters 4 and 6.

Species Cluster C included 29 taxa commonly found in the near-shore area (Table 54; Appendices E4, E5, and E6). Species in this cluster typically represented larger invertebrates that had low abundance and frequency of occurrence, suggesting a patchy distribution. Regardless of the site cluster in which they were found, none occurred at 50% of the sites. One species was found at 42% of the sites and the next most frequently occurring species was found at 27% of the sites. Most of the taxa were found at 15% or fewer of the sites within a cluster. None of these taxa were found in Site Clusters 5 and 8 in bays and /harbors and they were poorly represented in Site Clusters 1-3 in the middle shelf and outer shelf zones, respectively. Most of the taxa were found at sites within Site Clusters 4 and 6, indicative of the inner shelf open coast habitats.

Species Cluster D contained 12 common species, characterizing an inner shelf/middle shelf assemblage (Table 54; Appendices E4, E5, and E6). These species share many similarities to those of Species Cluster C but typically are found in deeper water along the open coast. Similar to Species Cluster C, none of these species occurred at 50% of the sites within a cluster and none were found in Species Clusters 5 and 8. All of these species were found within Site Cluster 4; most were found in Site Cluster 2; and a few were found in the remaining site clusters. Species Clusters C and D largely delineated Site Cluster 4, but Species Cluster C occurred more frequently in Site Clusters 6 and 7.

Species Cluster E contained 12 species that are typically found on the continental shelf throughout the SCB (Table 54; Appendices E4, E5, and E6). However, none of these species were found in Site Cluster 8 and they were poorly represented in Site Clusters 5-7, indicating that these are not species typically found in bays and harbors. Within Site Clusters 1-4, six of the species occurred at more than 50% of the sites in at least one site cluster: California sand star (Site Clusters 2-4), ridgeback rock shrimp (Site Clusters 1-4), California sea cucumber (Site Cluster 1), white sea urchin (Site Clusters 2 and 4), California sea slug (Site Cluster 1), and gray sand star (Site Clusters 1 and 2). By abundance and frequency of occurrence, white sea urchin was the first in abundance and third in occurrence; ridgeback rock shrimp was the second in both abundance and occurrence; California sand star was fifth in abundance and first in occurrence; and New Zealand paperbubble and California sea cucumber were the fourth and fifth most frequently occurring species, respectively.

Species Cluster F contained 15 species, characterizing a middle shelf/outer shelf assemblage (Table 54; Appendices E4, E5, and E6). Species within this cluster were essentially absent from Site Clusters 5-8, occurred occasionally in Site Clusters 3-4, were more common in Site Cluster 1, and were most abundant in Site Cluster 2. Species Cluster F delineated Site Cluster 2, in conjunction with the ubiquitous species of Species Cluster E. The fragile sea urchin was the fourth most abundant invertebrate, occurring at 41% and 82% of the sites within Site Clusters 2 and 1, respectively. California lamp shell was the third most abundant invertebrate; but it was found at only eight stations, seven of which were in Site Cluster 2 and one in Site Cluster 4. All occurrences of the California lamp shell were at island region sites. Species Cluster G contained 10 species characterizing an outer shelf assemblage (Table 54; Appendices E4, E5, and E6). None of these species were found in Site Clusters 5-8, a few were found in

Site Clusters 2-4, and most were found in Site Cluster 1 (with 5 species occurring at more than 50% of the sites). These included the orange bigeye octopus, northern heart urchin, moustache bay shrimp, flagnose bay shrimp, and the hinged shrimp. The hinged shrimp is a southern species and its presence in the survey is a reflection of the warm water associated with El Niño, present during the survey.

Combined Fish and Invertebrate Assemblages

Combined Fish and Invertebrate Recurrent Groups

Recurrent group analysis at the 0.50 level of affinity identified 39 recurrent groups based on combined fish and invertebrate data (Figure 54, Appendix E7). Groups consisted of 2-7 species per group with 9 associate species. In all, the groups and associates included 113 (25%) of the 456 species collected in the survey. Groups were found at 1-61 stations; 24 of the 39 groups occurred at only 1 site (Figures 55 and 56a,b; Appendices E7 and E8). Of the 15 groups occurring at multiple stations, 7 were found at 30 or more sites (Figure 56a,b). Combined fish and invertebrate recurrent groups were generally characteristic of specific depth zones or combinations of depth zones (Figure 55). However, whereas there was generally only one primary fish or invertebrate recurrent group of a particular depth range (Figures 36 and 47), many recurrent groups with similar depth distributions occurred in one or two of the four predetermined shelf zones (Figure 55).

Of these groups, 19 were the same as groups found in fish or invertebrate recurrent groups (Figures 35, 45, 46, and 54; Appendix E7). Fifteen of these were invertebrate recurrent groups (Figures 45 and 46) and four of these were fish recurrent groups (Figure 35). Of the combined fish/invertebrate recurrent groups, Recurrent Groups 1, 4, 5, 9, 10, 12, 14, 16, 18, 19, 25, 26, 28, 34, and 36 were the same as invertebrate Recurrent Groups 1, 2, 3, 4, 5, 7, 8, 9, 12, 11, 13, 14, 15, 20, and 21, respectively (Figures 45, 46, and 54; Appendix E7). Similarly, fish/invertebrate Recurrent Groups 8, 23, 27, and 35 were identical to fish Recurrent Groups 3, 6, 5, and 8, respectively (Figures 35 and 54; Appendix E7). Of the 15 major groups (Figure 54), the 9 unique groups will be discussed in detail.

Group 2 (San Diego Bay Mat Mussel Group). Group 2 consisted of two species, mat mussel and spotted sand bass (Figure 54). The group occurred at 12 stations and was found entirely in San Diego Bay at depths of 2-11 m (Figure 55 and 56a). The round stingray was an associate of this group.

Group 4 (San Diego Bay Oyster Group). This group was the same as Group 2 of the invertebrate recurrent groups (Figures 45 and 54), and is discussed in the Invertebrate Recurrent Group section above.

Group 7 (Harbor/Inner-Shelf Croaker/Shrimp Group). Group 7 consisted of three species: white croaker, queenfish, and blackspotted bay shrimp (Figure 54). This group occurred at 36 sites ranging in depth from 5-34 m (Figures 55 and 56b). It was found from Ventura to San Diego and occurred frequently in LA/LB Harbor; however, it did not occur in San Diego Bay or on the islands (Figure 56). California halibut and yellowleg shrimp were associates of this group (Figure 54).

Group 15 (Mainland Middle Shelf Fish/Sand Star Group). Group 15 consisted of seven species: California lizardfish, longfin sanddab, California sand star, California tonguefish, yellowchin sculpin, bigmouth sole, and hornyhead turbot (Figure 54). The group occurred at 38 sites ranging in depth from

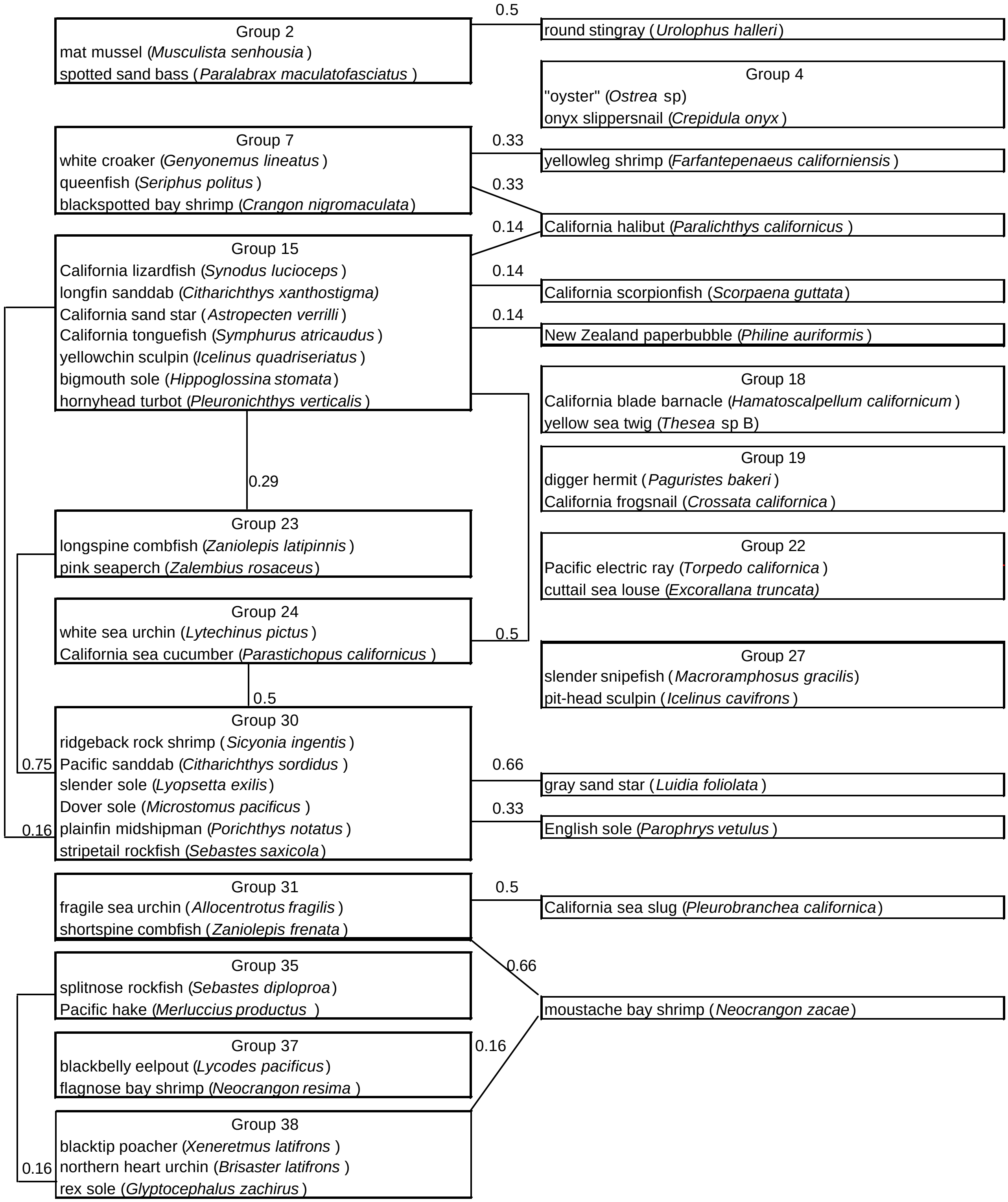


Figure 54. Recurrent groups of combined demersal fishes and megabenthic invertebrates occurring at multiple sites on the southern California shelf at depths of 2-202 m, July-September 1998. Index of affinity (I.A.) = 0.50. Species within a group are listed in order of abundance. Lines show relationships between groups and associates, with values indicating the proportion of possible pairs with I.A. = 0.50.

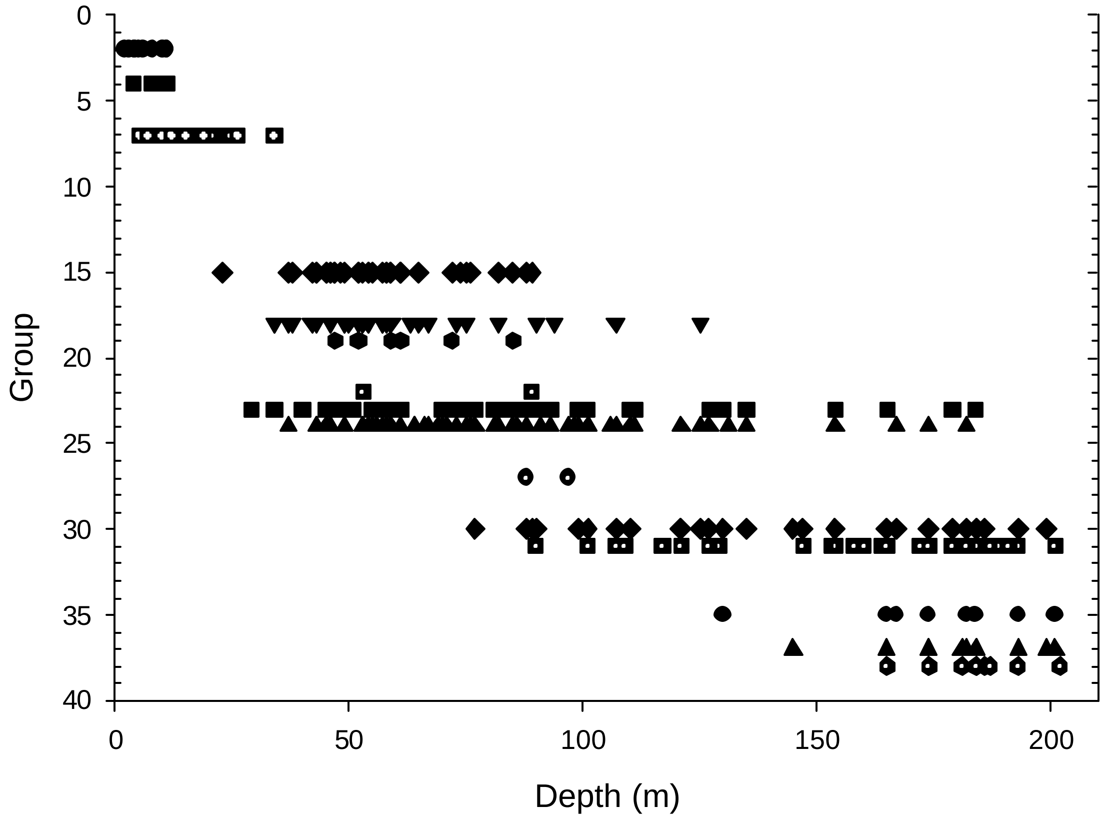


Figure 55. Bathymetric distribution of combined demersal fish and megabenthic invertebrate recurrent groups occurring at multiple sites on the southern California shelf, July-September 1998.

23-89 m (Figures 55 and 56b). It occurred throughout the mainland region middle-shelf zone but was not found at the islands (Figure 56b). California halibut; California scorpionfish; New Zealand paperbubble; and Groups 23, 24, and 30 were associates of this group (Figure 54).

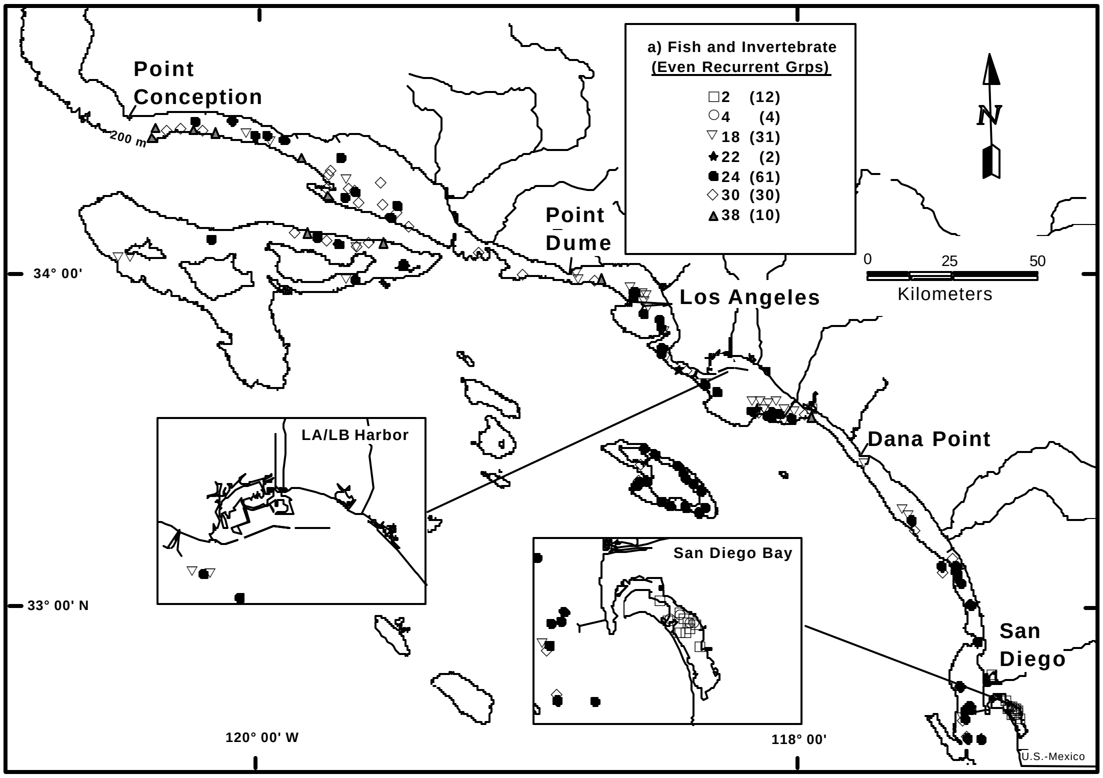
Group 18 (Middle Shelf Barnacle/Sea Twig Group). This group was the same as Group 12 of the invertebrate recurrent groups (Figures 45 and 54), and is discussed in the Invertebrate Recurrent Group section above.

Group 19 (San Diego Middle Shelf Hermit/Frogsnail Group). This group was the same as Group 11 of the invertebrate recurrent groups (Figures 45 and 54), and is discussed in the Invertebrate Recurrent Group section above.

Group 22 (Middle Shelf Electric Ray/Sea Louse Group). Group 22 consisted of two species, Pacific electric ray (*Torpedo californica*) and cut-tail sea louse (*Excorallina truncata*) (Figure 54). The group occurred at two stations and was found on the Palos Verdes Shelf and at Santa Rosa Island at depths of 53-39 m (Figures 55 and 56a). This group did not have affinities with any other group.

Group 23 (Middle Shelf/Outer Shelf Combfish/Seaperch Group). This group was the same as Group 6 of the fish recurrent groups (Figures 35 and 54), and is discussed in the Fish Recurrent Group section above.

a)



b)

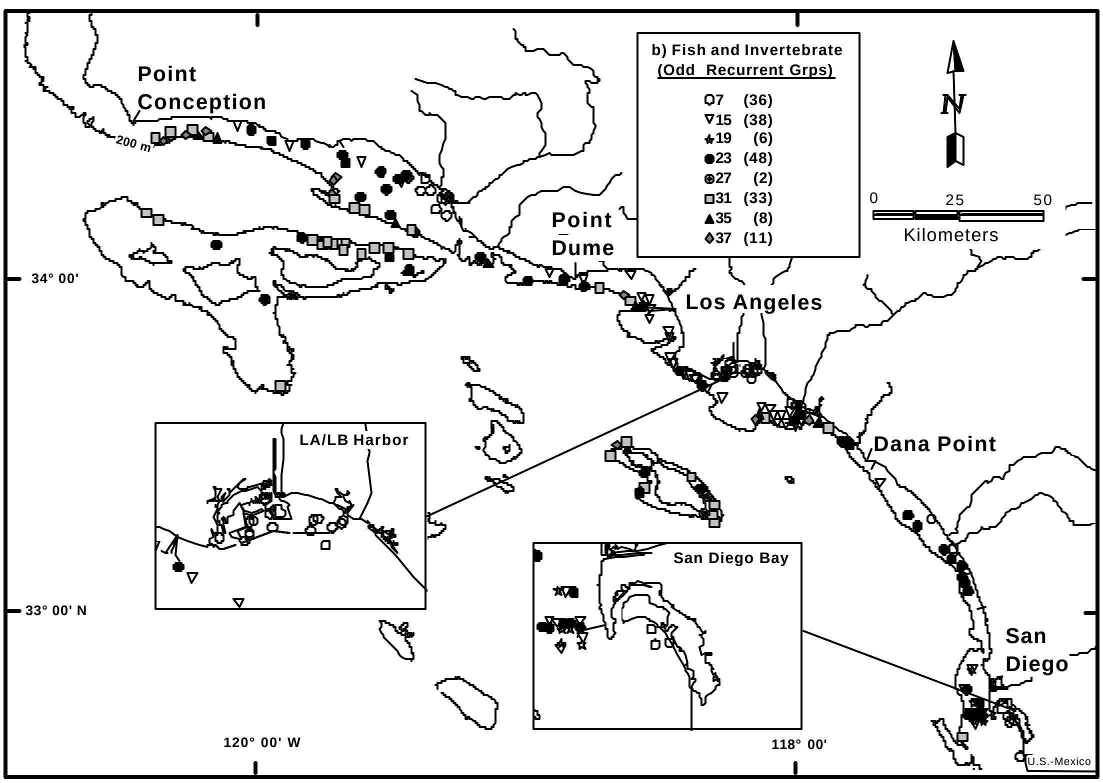


Figure 56. Distribution of combined demersal fish and megabenthic invertebrate recurrent groups on the southern California shelf at depths of 2-202 m, July-September 1998: a) even numbered groups, and b) odd numbered groups. No significance to 'odd' or 'even' other than to reduce number of groups plotted in a map.

Group 24 (Middle Shelf/Outer Shelf Sea Urchin/Sea Cucumber Group). Group 24 consisted of two species, white sea urchin and California sea cucumber (Figure 54). This was the most frequently occurring group, occurring at 61 sites at depths of 37-182 m (Figures 55 and 56a). It occurred widely in the mainland and island regions within the middle shelf and outer shelf zones (Figure 55). This group was associated with Groups 15 and 30 (Figure 54).

Group 27 (Catalina Shelf-break Fish Group). This group was the same as Group 5 of the fish recurrent groups (Figures 35 and 54), and is discussed in the Fish Recurrent Group section above.

Group 30 (Outer Shelf Fish/Rock Shrimp Group). Group 30 consisted of six species: ridgeback rock shrimp, Pacific sanddab, slender sole, Dover sole, plainfin midshipman, and stripetail rockfish (Figure 54). The group occurred at 30 sites ranging in depth from 37-199 m, and was widespread in the mainland and island regions (Figures 55 and 56a). It was associated with Groups 15, 23, and 24, and with gray sand star and English sole (Figure 54).

Group 31 (Outer Shelf Sea Urchin/Combfish Group). Group 31 consisted of two species: fragile sea urchin and shortspine combfish (Figure 54). The group occurred at 33 sites ranging in depth from 90-201 m (Figure 55 and 56b). It occurred on the outer shelf zone from Point Conception to San Diego but mostly in the Santa Barbara Channel (Figure 56). It was associated with the California sea slug and the moustache bay shrimp (Figure 54).

Group 32. (Outer Shelf/Mesobenthal Hake/Rockfish Group). This group was the same as Group 8 of the fish recurrent groups (Figures 35 and 54), and is discussed in the Fish Recurrent Group section above.

Group 37. (Outer Shelf/Mesobenthal Eelpout/Shrimp Group). Group 37 consisted of two species, blackbelly eelpout and flagnose bay shrimp (Figure 54). It was found at 11 sites ranging in depth from 145-201 m (Figures 55 and 56b). It occurred in the deeper part of the outer shelf zone from Point Conception to San Diego, and at Santa Catalina Island (Figure 56). It was not associated with another group.

Group 38. (Outer Shelf/Mesobenthal Fish/Heart Urchin Group). Group 38 consisted of three species: blacktip poacher, rex sole, and northern heart urchin (Figure 54). It occurred at 38 sites ranging in depth from 165-202 m (Figures 55 and 56a). It was found in the northern and central mainland and island regions but not in the southern mainland region or Santa Catalina Island (Figure 56). It was associated with Group 35 and the moustache bay shrimp (Figure 54).

Single-Site Groups. Of the 24 single-site groups (Appendix E7), some may represent natural associations and some associations may be coincidence. Given this, the groups can be classified into general categories according to the shelf zone of their occurrence (Appendix E8).
Three single-site groups occurred in bays. Group 1 was found at 3 m in Channel Islands Harbor (Station 2129), Group 3 occurred at 7 m in King Harbor (Station 2590), and Group 5 was found at 11 m in San Diego Bay (Station 2231).

Group 6 occurred on the coastal inner shelf zone at 12 m on the southern San Pedro Shelf off Huntington Beach (Station 2399).

Fifteen single-site groups were found in the middle shelf zone. In the northern mainland shelf zone, Group 13 was found at 54 m on the Santa Barbara Shelf (Station 2362). In the central mainland shelf zone, Group 16 was found at 57 m in the large POTW area on the Santa Monica Bay Shelf (Station 2194), Group 21 at 66 m on the Palos Verdes Shelf (Station 2205), and Group 9 at 43 m in the large POTW area of the southern San Pedro Shelf (Station 2211). On the southern (San Diego) mainland shelf, Group 10 was found at 47 m in the large POTW area off Point Loma (Station 2413) and in non-POTW areas; Group 12 was found at 54 m (Station 2351); Group 14 at 56 m (Station 2419); and Group 20 at 63 m (Station 2350). In the northwest Channel Islands, Group 28 was found at 94 m on Santa Rosa Island (Station 2491). In the southeast Channel Islands, Group 17 was found at 60 m at Anacapa Island (Station 2517). At Santa Catalina Island, Group 8 occurred at 42 m (Station 2088), Group 11 at 48 m (Station 2077), Group 25 at 86 m (Station 2073), Group 26 at 88 m (Station 2084), and Group 29 at 97 m (Station 2093).

Five single-site groups occurred in the outer shelf zone. In the northern mainland shelf zone, Group 33 was found at 165 m off Gaviota (Station 2100); and in the central mainland shelf zone, Group 39 was found at 193 m near the Newport Submarine Canyon (Station 2119). At Santa Rosa Island in the southeast Channel Islands, Group 32 was found at 164 m (Station 2494) and Group 34 at 174 m (Station 2097). At Santa Catalina Island, Group 36 occurred at 179 m (Station 2096).

Combined Fish and Invertebrate Clades

Site Clades. Several equally parsimonious reconstructions (cladograms) of the trawled catch data from the 314 sampling events (trawls) are represented by the single randomly chosen cladogram (Figure 57). The cladistic analysis used the shallow stations as the out group, thereby polarizing the data and rooting the tree with that group. The several, very similar, equally parsimonious reconstructions had a tree length of 3686, a consistency index of 0.20, and a surprisingly high retention index (measure of branch support) of 0.50. Both measure-of-fit statistics have a maximal value of 1.0.

The cladogram describes what appears to be eight distinct groups or clades (Figure 57). The most basal group (Group 1) is a grade of stations rather than a distinct monophyletic-like clade. The depth regime for this most basal station group is only 4-25 m.

Examining the apomorphy list from PAUP*'s output (showing the changes or processes at the nodes) of the mainland inner shelf and bay group shows the relevant processes or species' changes distinguishing this clade (Figure 57). The basal nodes leading to this station group exhibit abundance increases in barcheek pipefish, furrowed rock crab (*Cancer branneri*), blister glassy-bubble (*Haminoea vesicula*), Stimpson coastal shrimp (*Heptacarpus stimpsoni*), California spiny lobster (*Panulirus interruptus*), bat ray, white seaperch, yellowleg shrimp, and slough anchovy. Decreased abundance in California halibut is observed in this area of the cladogram.

The San Diego Bay clade (Figure 57) is distinguished by the relative increase and/or presence of barred sand bass, spiny cup-and-saucer (*Crucibulum spinosum*), Hemphill fileclam (*Limaria hemphilli*), diamond turbot, spotted sand bass, Pacific calico scallop, mat mussel, California halibut, and spotted turbot, with the loss of speckled sanddab.

Figure 57. Combined demersal fish and megabenthic invertebrate site cladogram for the southern California shelf at depths of 2-202 m, July-September 1998.

The central inner shelf/bays and harbors clade (Figure 57) yields increases in white croaker, queenfish, kelp bass, Alaska bay shrimp (*Crangon alaskensis*), California skate, tuberculate pear crab, blackspotted bay shrimp, barred sand bass, sheep crab, yellowleg shrimp, northern anchovy, California halibut, Pacific sardine, spiny sand star, specklefin midshipman, black croaker, and California corbina.

The small inner shelf group (Figure 57) is distinguished in part by an increase in pile perch (*Rhacochilus vacca*), spiny sand star, California sand star, thornback, English sole, bat ray, queenfish, white croaker, spotted turbot, offshore sand dollar (*Dendraster terminalis*), and sandflat elbow crab (*Heterocrypta occidentalis*).

The inner/middle shelf group (Figure 57) is distinguished by increases in brown cup coral (*Paracyathus stearnsii*), California sea cucumber, hornyhead turbot, Pacific sanddab, and blackeye goby. The small subclade of island stations is share increases in Pacific sanddab, plainfin midshipman, gray sand star, curlfin sole, pink seaperch, red sea star (*Mediaster aequalis*); and the loss of longfin sanddab, California lizardfish, and yellow sea twig. Increases in English sole and hornyhead turbot are seen in other portions of the inner shelf/ middle shelf clade.

The large middle shelf clade shows increasing numbers of white sea urchin, longfin sanddab, longspine combfish, gulf sanddab, Pacific sanddab, stripetail rockfish, lumptail searobin, California sea cucumber, Pacific argentine, greenspotted rockfish, blossom shrimp (*Solenocera mutator*), slender sea pen (*Stylatula elongata*), California scorpionfish, and gray sand star (Figure 57).

The middle/outer shelf clade has a large increase in Pacific sanddab, Dover sole, and fragile sea urchin, with small increases in pink seaperch and orange sand star (Figure 57).

The outer shelf clade exhibits increases in slender sole, splitnose rockfish, stripetail rockfish, blacktip poacher, trailtip seapen, moustache bay shrimp, fish-eating star (*Stylasterias forreri*), rex sole, blackbelly eelpout, and flagnose bay shrimp, with slight decreases or losses in moustache bay shrimp and fragile sea urchin (Figure 57).

Due to the huge number of nodes in this large analysis, only subsets of the relatively basal nodes per site-group were examined. Interestingly, the cladogram revealed very distinct station groupings based on the fish and invertebrate species assemblages. Indeed, a striking pattern showing great depth and latitudinal spatial fidelity of the communities is evident. The information that additive trees yield (longer branch lengths infer greater diversity at those stations) and the ability to map discrete changes on the tree further underscore the utility of parsimony analyses in community analyses.

Species Clades. The most parsimonious reconstruction of the trawled fish and invertebrate data (314 stations and 433 fish and invertebrate species) is represented by a species cladogram[1] (Figure 58). Similar to the site clades, the analysis resulted in many, very similar, equally parsimonious reconstructions (tree length of 3239 steps) of the data (cladograms). The cladogram possessed a consistency index of 0.0969 with a relatively high retention index (indicator of branch support) of 0.4349.

A general pattern of shallow-water associates with restricted occurrences root the tree (Figure 58). As was seen in the site clades, round stingray, spotted sand bass, and black croaker are clade members; but they are joined by Pacific calico scallop and mat mussel to form a Bay Clade (Figure 59). These species are

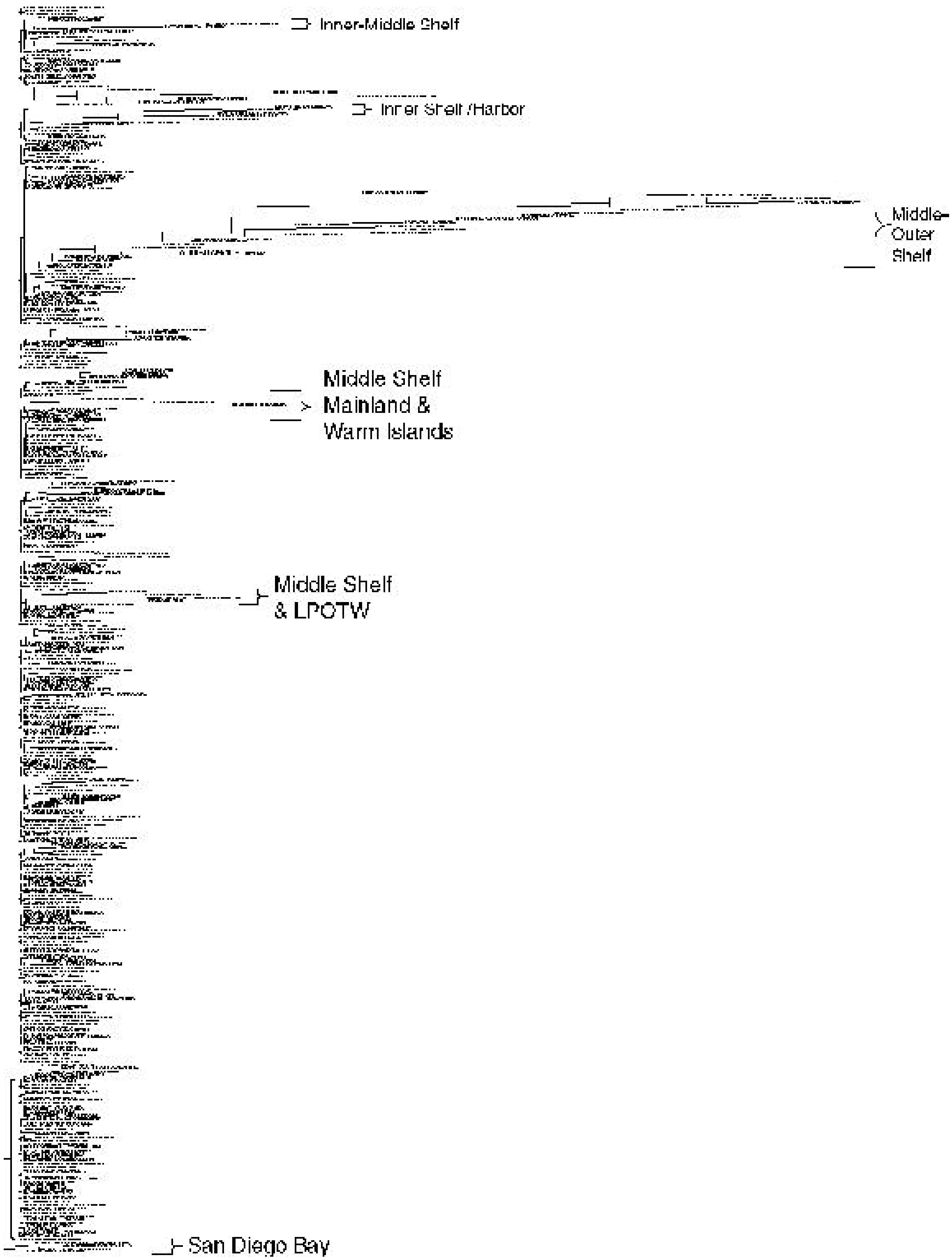


Figure 58. Combined demersal fish and megabenthic invertebrate species cladogram for the southern California shelf at depths of 2-202 m, July-September 1998.

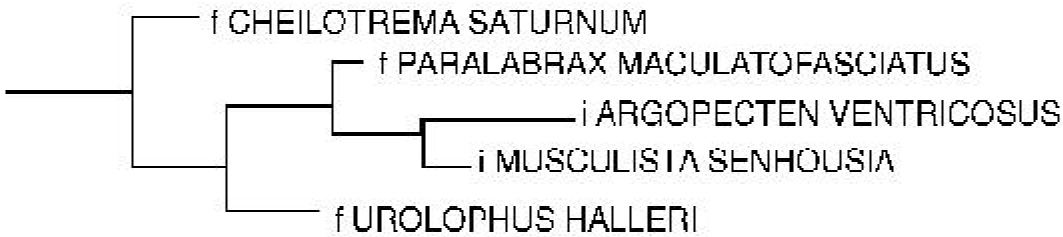


Figure 59. Bay clade of combined demersal fish and megabenthic invertebrate species cladogram for the southern California shelf at depths of 2-202 m, July-September 1998. f = fish; i = invertebrate.

predominantly found inshore (bays and harbors) from San Diego north to Newport Bay. In general, the rest of the cladogram shows the same repeating patterns seen in the previous analysis with the same fish species retaining their community-clade membership and "new" invertebrate members present. One somewhat elongate clade had relatively high species occurrance, predominantly inshore (4-24 m depth range), from as far south as the Tijuana area to LA/LB Harbor. This inner shelf clade splits into two branches, with barred sand bass and California halibut as terminal species in one branch and white croaker and queenfish in the second branch (Figure 60). An extremely long clade (due to these species' widespread occurrences) had the same fish species from the middle shelf to outer shelf (depth ranges from 42-201 m). The deepest occurring species were found near the base of the subclade, and were joined by northern heart urchin, Pacific heart urchin (*Brissopsis pacifica*), fragile urchin, white sea urchin, and others (Figure 61).

Combined Fish and Invertebrate Site and Species Clusters

Selection of Species. A total of 195,093 fish and megabenthic invertebrates representing 465 taxa were collected at 314 stations in this survey. Based upon the screening criteria, 312 stations representing 192,506 individuals and 169 taxa were included in the combined fish and megabenthic invertebrate cluster analysis. This cluster analysis delineated nine major site clusters denoting habitats and eight major species clusters denoting species assemblages or communities (Figure 62, Appendix E9). Each site and species cluster was unique, based on the relative proportion of different species clusters within a site cluster and the relative proportion of each species cluster in different site clusters (Figures 62 and 63).

Site Clusters. The site clusters varied by region, depth, and subpopulation (Figures 62 and 64, Table 55, Appendix E9), as well as to a lesser extent by sediment type (Figure 65). Each site cluster had one or two dominant species clusters (Figures 62 and 63).

Site Cluster 1 included 33 stations ranging in depth from 73-202 m, with the majority of the sites (26) in the outer shelf zone and 7 in the middle shelf zone (Table 55, Figures 62, Appendix E9). This site group characterizes an outer shelf habitat or an outer shelf/middle shelf habitat with 24 mainland sites, 8 island sites, and 1 large POTW site. By region, this cluster included 17 northern mainland, 4 central mainland, 4 southern mainland, 1 Santa Catalina Island, 2 northwestern Channel Islands, and 5 southeastern Channel Islands sites. Thus, while Site Cluster 1 appeared to represent northern region sites, all areas were represented in this site cluster (Table 55, Figure 66). This site cluster was delineated by the deep-water species found in Species Cluster H, the ubiquitous species from Species Cluster G, and a few species in Species Cluster D (Table 56, Appendix E9). This site cluster differs from Site Cluster 2, which only had

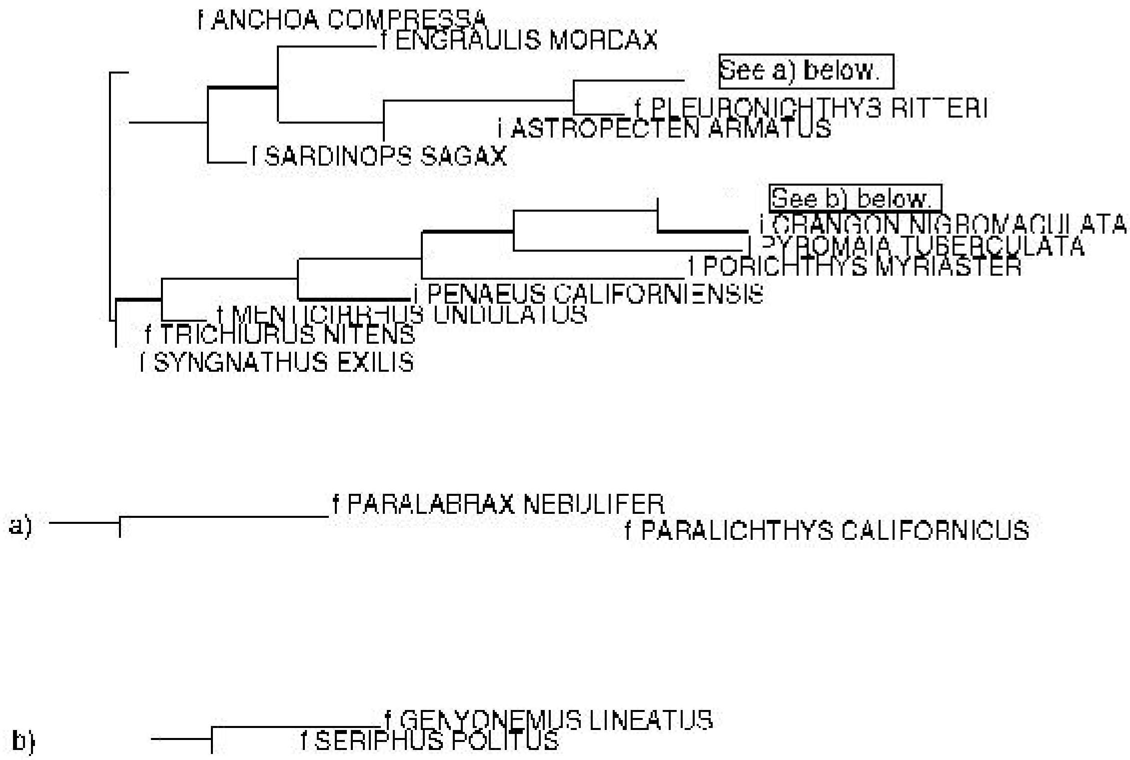


Figure 60. Inner shelf clade of combined demersal fish and megabenthic invertebrate species cladogram for the southern California shelf at depths of 2-202 m, July-September 1998. f = fish; i = invertebrate.

a few of the species from Site Cluster H. Two species from Species Cluster D, 10 species from Species Cluster G, and 2 species from Species Cluster E occurred in more than 50% of the stations within Site Cluster 1 (Table 56, Appendices E10 and E11). The two most prevalent and abundant species in Site Cluster 1, slender sole (91%) and fragile sea urchin (61%) (both from Species Cluster D), were less prevalent in Site Cluster 2, even less prevalent in Site Cluster 3, and absent in all the other site clusters. The frequency of occurrence was similar for the 10 species in Species Cluster G: California sea cucumber (64%), gray sand star (64%), California sea slug (61%), Dover sole (94%), plainfin midshipman (88%), Pacific sanddab (94%), shortspine combfish (82%), English sole (64%), stripetail rockfish (82%), and ridgeback rock shrimp (94%). The two species from Species Cluster H included moustache bay shrimp (54%) and blacktip poacher (52%). Both of these species occurred with low abundance in Site Cluster 2 and were not found elsewhere. The 10 species from Species Cluster G were a few broadly distributed shelf species including the California sea cucumber, gray sand star, Pacific sanddab, and English sole.

Site Cluster 2 included 40 stations ranging in depth from 44-195 m, delineating an island region habitat (Figures 62, 64, and 66; Appendix E9). This cluster included 16 sites from the outer shelf zone and 24 sites from the middle shelf zone, with 39 of the 40 sites were from the island region (Table 55). Thus, Site Cluster 2 clearly represented an island region habitat that was essentially independent of the depth categories. This site group was labeled as an outer shelf/middle shelf island subpopulation site cluster. However, aside from the superabundance of the California lamp shell at a few of the island sites, no

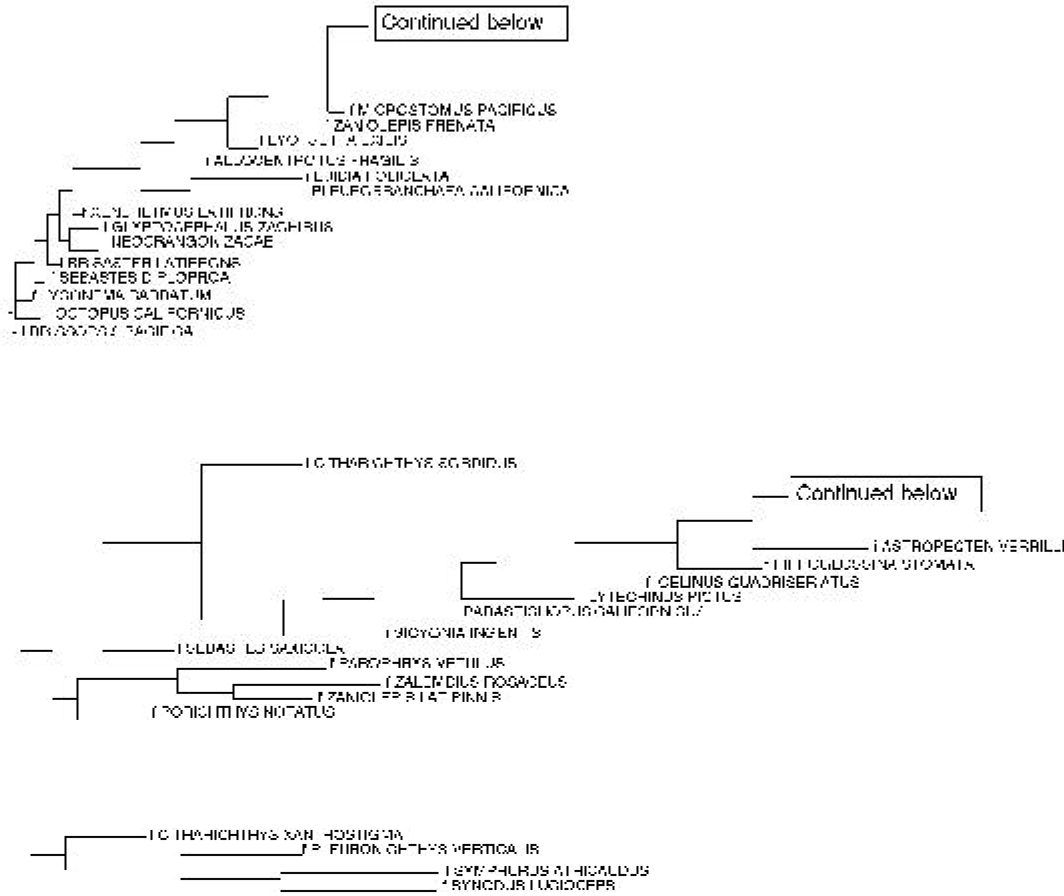


Figure 61. Middle/outer shelf clade of combined demersal fish and megabenthic invertebrate species cladogram for the southern California shelf at depths of 2-202 m, July-September 1998.

species was unique to this site cluster (Appendix E9). In addition to the high abundance of California lamp shell, the apparent uniqueness of Site Cluster 2 results in part from the absence of a few species (e.g., eastern Pacific bobtail, *Rossia pacifica*; bluebarred prickleback, and California skate). However, its uniqueness is primarily determined by a greater abundance of species from Species Cluster D. Two species from Species Cluster D, one from Species Cluster F, and eight from Species Cluster G occurred in more than 50% of the stations within Site Cluster 2 (Table 55, Appendices E10 and E11). Species Cluster D included the spotfin sculpin and the red sea star, which occurred at 53% and 58% of the island region sites, respectively. These sites accounted for 95% and 99% of these species caught, respectively. Bigmouth sole (55%) was the one species from Species Cluster F, but this species was more common at other middle shelf sites. Species Cluster G included pink seaperch (63%), white sea urchin (68%) (extremely abundant and averaged over 1,000 individuals/haul for the island sites), Dover sole (78%), plainfin midshipman (60%), Pacific sanddab (98%), shortspine combfish (70%), trailtip seapen (53%), and the ridgeback rock shrimp (53%). Species from Species Cluster G tended to be the ubiquitous species of the shelf and were common in Site Clusters 1-5. Site Cluster 2 had large contributions from species in Species Cluster D; however, it lacked the abundance of species from Species Cluster H that characterized Site Cluster 1.

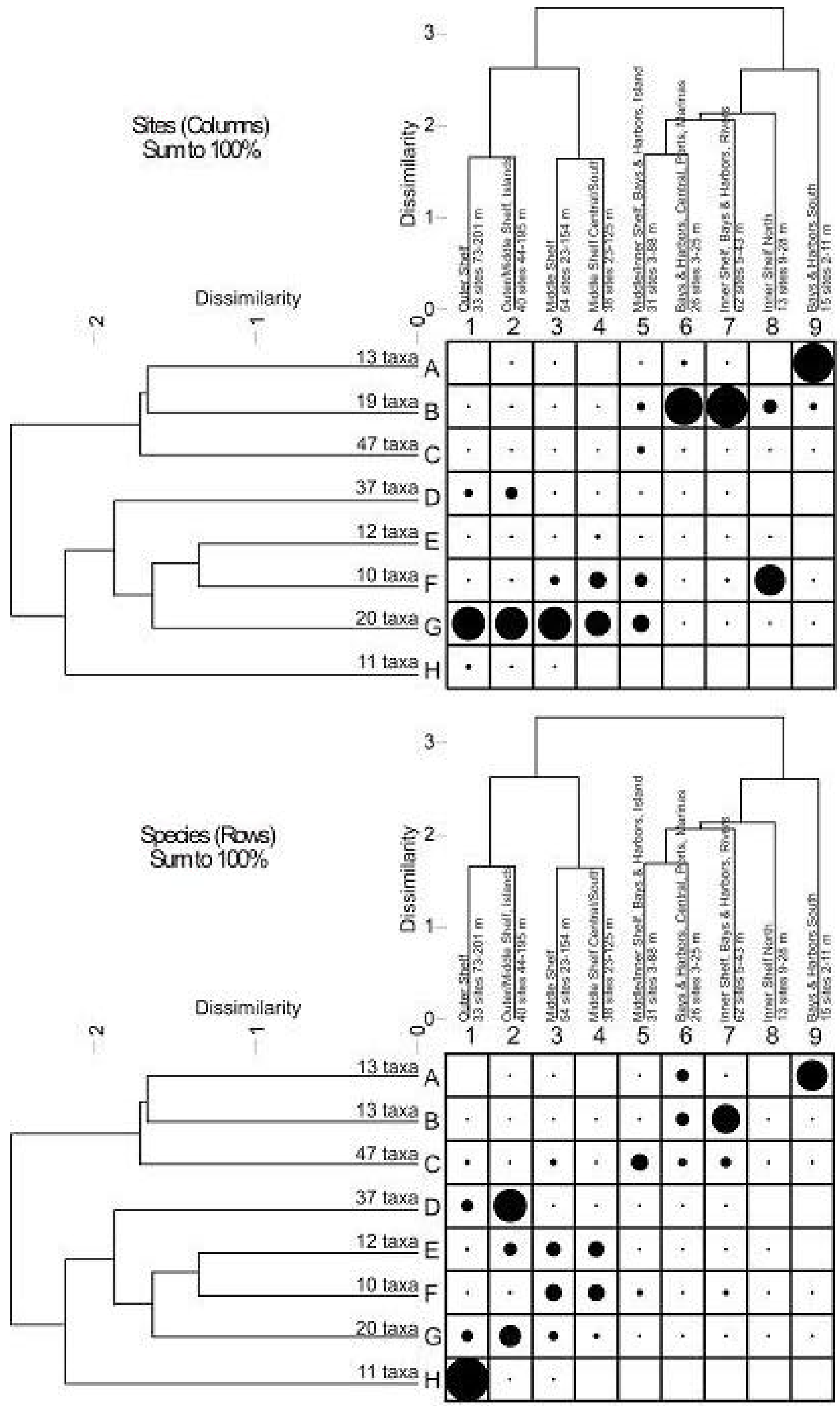


Figure 62. Summary of demersal fish and megabenthic invertebrate cluster analysis and relationships among site and species clusters on the southern California shelf at depths of 2-202 m, July-September 1998.

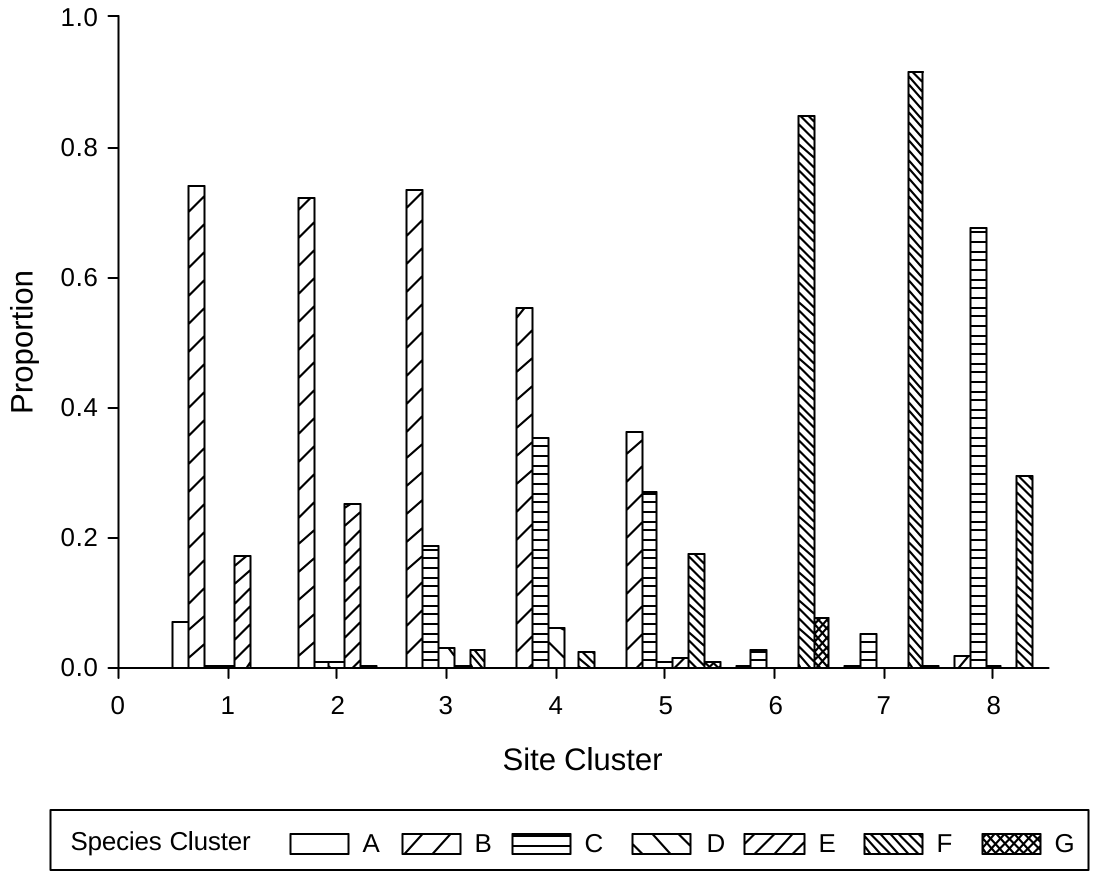


Figure 63. Proportion of demersal fish and megabenthic invertebrate species clusters in each fish and invertebrate site cluster on the southern California shelf at depths of 2-202 m, July-September 1998.

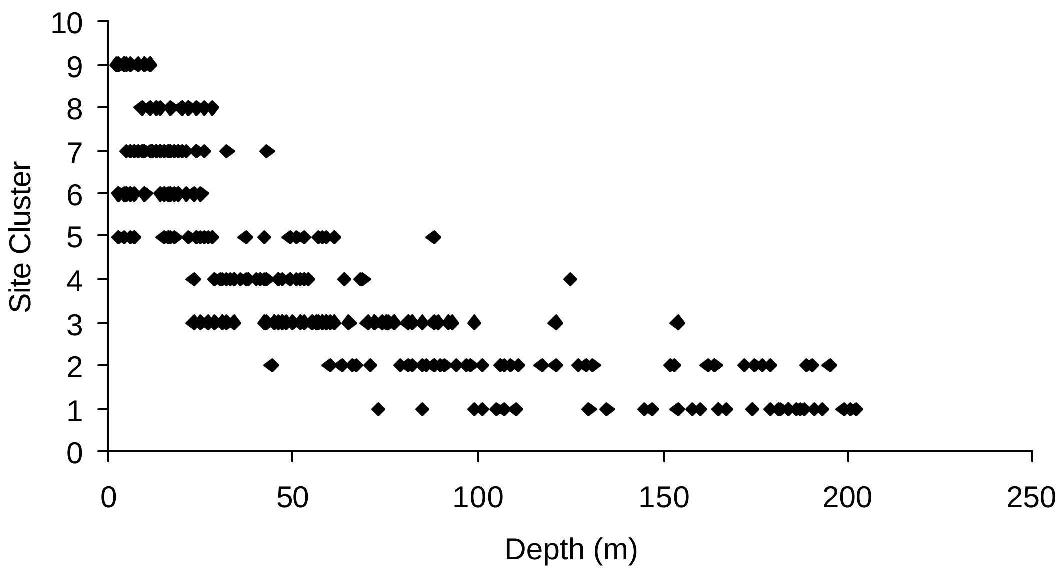


Figure 64. Bathymetric distribution of combined demersal fish and megabenthic invertebrate site clusters on the southern California shelf at depths of 2-202 m, July-September 1998.

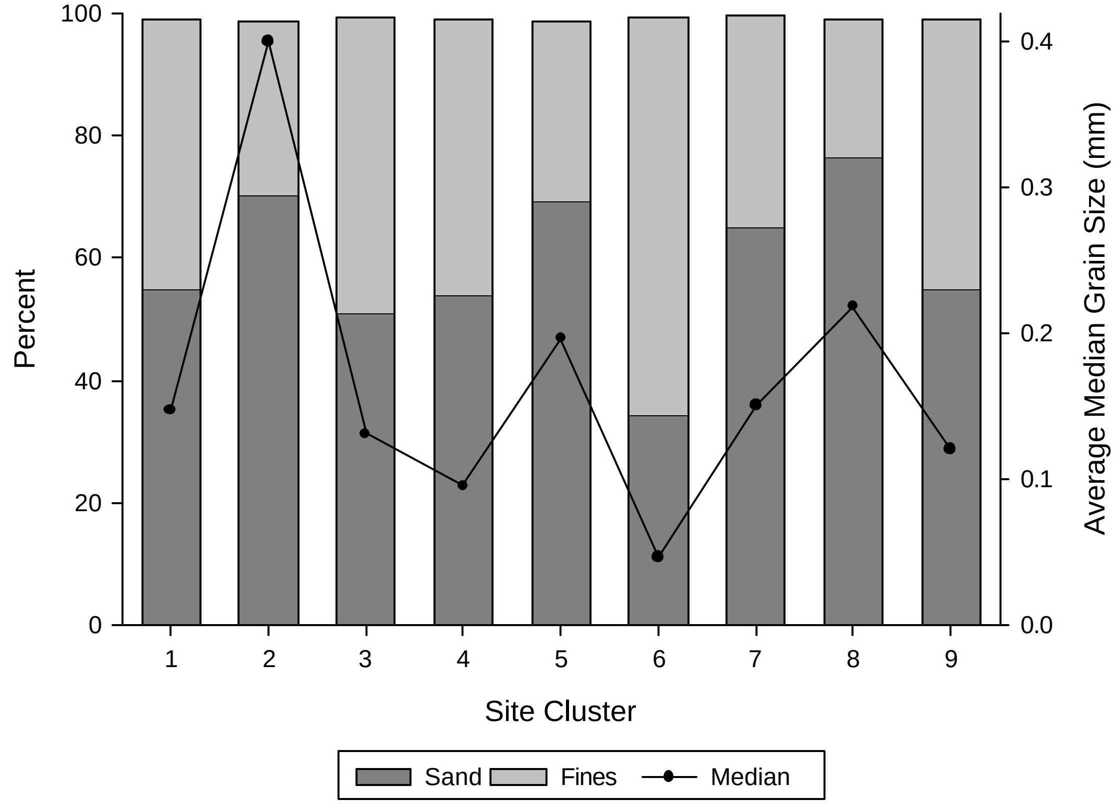


Figure 65. Average percent of sand, percent of fines, and median grain size (mm) for each demersal fish and megabenthic invertebrate site cluster on the southern California shelf at depths of 2-202 m, July-September 1998.

The separate cluster analysis for fish and invertebrates resulted in a more clearly delineated outer shelf habitat and a broad, poorly defined middle shelf habitat. The combined cluster analysis for fish and invertebrates resulted in a more clearly delineated middle shelf habitat and a poorly defined outer shelf habitat. Site Cluster 2, the outer/middle shelf island group, had coarser sediments (i.e., more sands and less fines) compared to Site Clusters 1, 3, and 4 (Figure 65). Thus, grain size factors may have influenced the delineation of several middle shelf habitats.

Site Cluster 3 included 54 stations ranging in depth from 23-154 m, delineating a mainland middle shelf habitat (Figures 62 and 64, Appendix E9). All mainland regions were represented including 12 northern mainland, 18 central mainland, and 23 southern mainland sites; and 1 northwest Channel Islands site. This site cluster included 48 middle shelf, sites 2 outer shelf sites, and 4 inner shelf sites. The middle shelf sites included 15 large POTW, 32 mainland non-POTW, and 1 island sites. The absence of significantly different POTW and non-POTW sites suggests that wastewater outfalls do not significantly affect community composition. The four inner shelf sites included three mainland non-POTW subpopulation and one small POTW subpopulation sites. There was no cluster of predominantly POTW sites, indicating that POTW sites are not different from other sites on the shelf. Six species from Species Cluster F and six species from Species Cluster G occurred in more than 50% of the stations within Site Cluster 3 (Table 56, Appendices E10 and E11). Species Cluster F included bigmouth sole (83%), California sand star (83%), California lizardfish (93%), longfin sanddab (83%), hornyhead turbot (72%), and California tonguefish (83%). These broadly distributed species delineated Site Clusters 3 and 4, but Site Cluster 3 had more species from Site Cluster G and

Table 55. Frequency of occurrence (number of stations) of combined demersal fish and megabenthic invertebrate site clusters by region and subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	SITE CLUSTER									
	1	2	3	4	5	6	7	8	9	Grand Total
	Outer Shelf	Outer / Middle Shelf Island	Middle Shelf	Middle Shelf C/S	Middle/ Inner Shelf B&H Island	B&H C Ports Marinas	Inner Shelf B&H Rivers	Inner Shelf N	B&H S	
Depth Range (m)	73-202	44-195	23-154	23-125	3-88	3-25	5-43	9-28	2-11	
Subpopulation										
Region										
Mainland	25	1	53	37	25	24	62	13	15	255
Northern	17	1	12	3	8	2	14	9	-	66
Central	4	-	18	25	11	20	33	2	1	114
Southern	4	-	23	9	6	2	15	2	14	75
Island	8	39	1	1	7	1	-	-	-	57
Cool (NW Channel Islands)	2	9	1	-	3	-	-	-	-	15
Warm										
SE Channel Islands	5	10	-	-	1	-	-	-	-	16
Santa Catalina Island	1	20	-	1	3	1	-	-	-	26
Shelf Zone										
Bays and Harbors (2-30 m)	-	-	-	-	9	24	12	-	15	60
Ports	-	-	-	-		11	-	-	4	15
Marinas	-	-	-	-	6	11	-	-	1	18
Other Bay	-	-	-	-	3	2	12	-	10	27
Inner Shelf (2-30 m)	-	-	4	4	12	1	48	13	-	82
Small POTWs	-	-	1	1	3	-	7	3	-	15
River Mouths	-	-	-	-	2	-	27	2	-	31
Other Mainland	-	-	3	3	4	-	14	8	-	32
Island	-	-	-	-	3	1	-	-	-	4
Middle Shelf (31-120 m)	7	24	48	33	11	-	2	-	-	125
Small POTWs	-	-	-	1	-	-	-	-	-	1
Large POTWs	1	-	15	12	4	-	-	-	-	32
Mainland non-LPOTW	4	-	32	19	3	-	2	-	-	60
Island	2	24	1	1	4	-	-	-	-	32
Outer Shelf (121-202 m)	26	16	2	1	-	-	-	-	-	45
Mainland	20	1	2	1	-	-	-	-	-	24
Island	6	15	-	-	-	-	-	-	-	21
Total (all stations)	33	40	54	38	32	25	62	13	15	312

C = Central; N = Northern; S = Southern; B&H = Bays/Harbors; POTW = Publicly owned treatment work monitoring area.

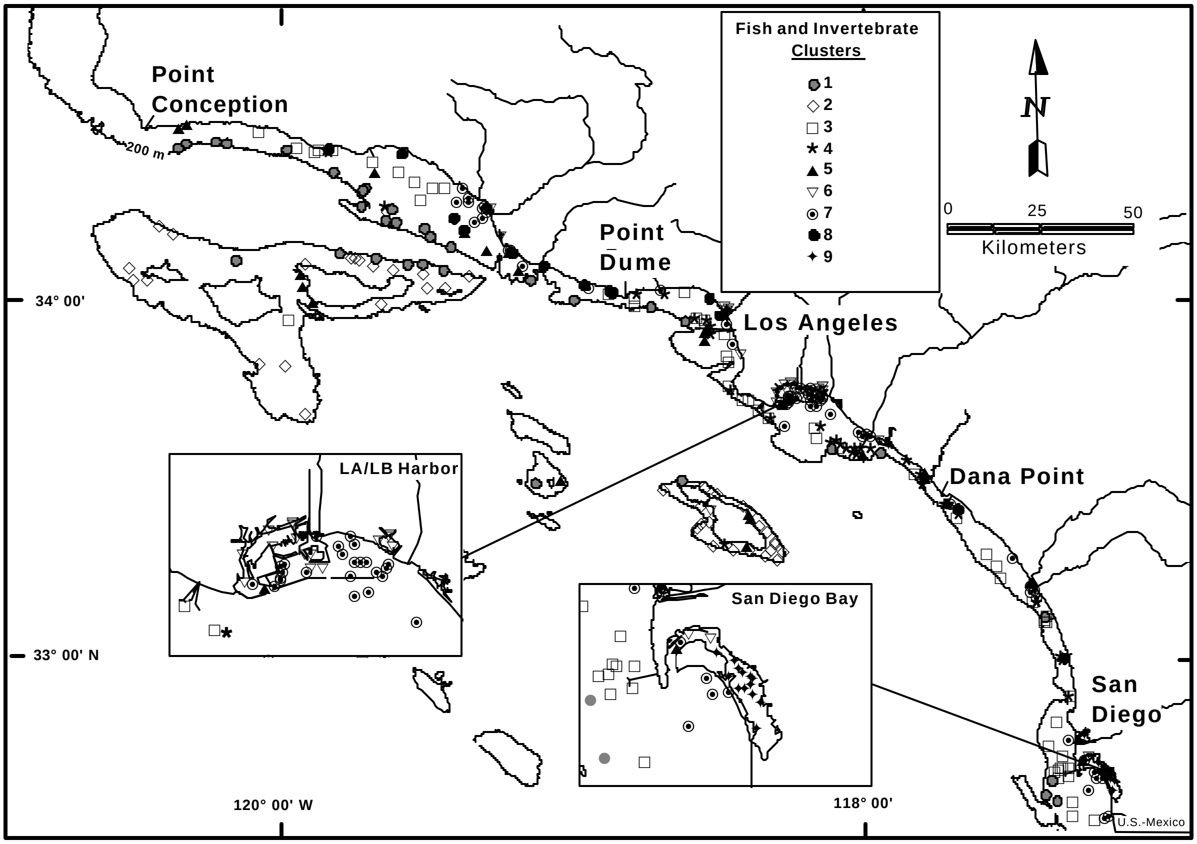


Figure 66. Distribution of demersal fish and megabenthic invertebrate site clusters on the southern California shelf at depths of 2-202 m, July- September 1998.

fewer species from Site Cluster F than did Site Cluster 4. The six most common species in Species Cluster G were yellowchin sculpin (81%), pink seaperch (63%), longspine combfish (61%), white sea urchin (54%), Pacific sanddab (63%), and ridgeback rock shrimp (81%).

Site Cluster 4 included 38 stations ranging in depth from 23-125 m and delineated a mainland region middle shelf habitat (Figures 62 and 64, Appendix E9). Sites were from the central mainland region (25), southern mainland region (9), northern mainland region (3) and at Santa Catalina Island (1) (Table 55). By depth zone, this site cluster included 1 outer shelf mainland subpopulation site, 33 middle shelf sites, and 4 inner shelf sites. The middle shelf sites included 1 small POTW, 12 large POTW, and 19 mainland non-POTW sites. The inner shelf sites included 1 small POTW and 3 mainland non-POTW sites. Similar to Site Cluster 3, POTW areas did not significantly differ from non-POTW sites. Site Cluster 4 was most similar to Site Cluster 3; but it had greater abundance of species from Species Clusters E and F and fewer species from Species Cluster G. Species that occurred at more than 50% of the sites within a cluster included the California halibut (50%, Species Cluster B), California blade barnacle (50%, Species Cluster E), yellowchin sculpin (50%, Species Cluster G) and eight species from Species Cluster F (bigmouth sole 79%; California sand star, 100%; California lizardfish, 87%; longfin sanddab, 95%; hornyhead turbot, 68%; California tonguefish, 84%; and California scorpionfish, 50% (Table 56; Appendices E10 and E11).

Table 56. Frequency of occurrence (percent of stations) of demersal fish and megabenthic invertebrate species occurring at 50% or more of the stations of at least one site cluster on the southern California shelf at depths of 2-202 m, July-September 1998.

			SITE CLUSTER								
			1	2	3	4	5	6	7	8	9
			Outer Shelf	Outer / Middle Shelf Island	Middle Shelf	Middle Shelf C/S	Middle / Inner Shelf B&H Island	B&H C Ports Marinas	Inner Shelf B&H Rivers	Inner Shelf N	B&H S
		Number of Stations	33	40	54	38	32	25	62	13	15
		Depth Range (m)	73-202	44-195	23-154	23-125	3-88	3-25	5-43	9-28	2-11
Species Cluster	Common Name	Scientific Name									
A	mat mussel	*Musculista senshousia*	-	-	-	-	-	12	2	-	80
	spotted sand bass	*Paralabrax maculatofasciatus*	-	-	-	-	3	4	2	-	100
	round stingray	*Urolophus halleri*	-	-	-	-	-	12	8	-	60
	Pacific calico scallop	*Argopecten ventricosus*	-	-	-	-	10	12	-	-	53
B	white croaker	*Genyonemus lineatus*	3	-	19	16	26	50	82	8	7
	queenfish	*Seriphus politus*	-	-	7	3	13	31	69	15	-
	blackspotted bay shrimp	*Crangon nigromaculata*	-	-	6	5	6	19	61	-	-
	tuberculate pear crab	*Pyromaia tuberculata*	-	-	9	18	26	54	45	31	7
	barred sand bass	*Paralabrax nebulifer*	-	-	2	11	29	58	35	8	93
	California halibut	*Paralichthys californicus*	-	-	30	50	32	73	61	54	73
D	spotfin sculpin	*Icelinus tenuis*	6	53	2	-	-	-	-	-	-
	red sea star	*Mediaster aequalis*	12	58	6	3	-	-	-	-	-
	slender sole	*Lyopsetta exilis*	91	40	7	3	-	-	-	-	-
	fragile sea urchin	*Allocentrotus fragilis*	61	38	2	-	-	-	-	-	-
E	California blade barnacle	*Hamatoscalpellum californicum*	27	23	26	50	6	-	2	-	-
F	bigmouth sole	*Hippoglossina stomata*	21	55	83	79	29	-	3	-	-
	California sand star	*Astropecten verrilli*	45	45	83	100	45	4	16	31	-
	California lizardfish	*Synodus lucioceps*	12	18	93	87	61	38	53	77	7
	longfin sanddab	*Citharichthys xanthostigma*	9	10	83	95	32	-	13	23	-
	hornyhead turbot	*Pleuronichthys verticalis*	9	23	72	68	39	-	31	31	-
	California tonguefish	*Symphurus atricaudus*	6	5	83	84	52	31	45	46	7
	speckled sanddab	*Citharichthys stigmaeus*	-	13	30	29	55	8	32	92	-
	California scorpionfish	*Scorpeana guttata*	6	20	26	50	16	4	5	-	-
G	yellowchin sculpin	*Icelinus quadriseriatus*	18	30	81	53	19	-	2	-	-
	pink seaperch	*Zalembius rosaceus*	42	63	63	24	6	-	-	-	-
	longspin combfish	*Zaniolepus latipinnis*	45	28	61	13	6	-	-	-	-
	white sea urchin	*Lytechinus pictus*	42	68	54	45	35	-	6	8	-
	California sea cucumber	*Parastichopus californicus*	64	43	39	39	23	12	2	-	-
	gray sand star	*Luidia foliolata*	64	48	20	26	6	-	-	8	-
	California sea slug	*Pleurobranchaea californica*	61	33	17	3	13	-	-	-	-
	Dover sole	*Microstomus pacificus*	94	78	28	3	-	-	-	-	-
	plainfin midshipman	*Porichthys notatus*	88	60	46	8	10	4	-	-	-
	Pacific sanddab	*Citharichthys sordidus*	94	98	63	34	19	-	2	8	-
	shortspine combfish	*Zaniolepus frenata*	82	70	4	-	3	-	-	-	-
	trailtip seapen	*Acanthoptilum sp*	42	53	24	21	3	4	-	-	-
	English sole	*Parophrys vetulus*	64	30	43	26	16	-	10	31	-
	stripetail rockfish	*Sebastes saxicola*	82	48	43	3	-	-	-	-	-
	ridgeback rock shrimp	*Sicyonia ingentis*	94	53	81	42	23	-	5	-	-
H	moustache bay shrimp	*Neocrangon zacae*	52	5	-	-	-	-	-	-	-
	blacktip poacher	*Xeneretmus latifrons*	52	3	-	-	-	-	-	-	-

C = Central; S = Southern; N = Northern; B&H = Bays/Harbors.
See Appendix E11 for a complete listing of species and their occurrences in site clusters.

Site Cluster 5 included 32 stations ranging in depth from 3-88 m (Figures 62 and 66; Appendix E9). Exclusive of outer shelf sites, this site cluster uniquely included sites from all regions and most habitat types (Table 55). It contains shallow-water species from Species Clusters B and C and deep-water species from Species Clusters F and G (Figure 63). By region, this site cluster included 8 northern mainland region, 11 central mainland region; 6 southern mainland region, 3 northwest Channel Islands, 1 southwest Channel Islands, and 3 Santa Catalina Island sites. By depth category, this site cluster included 11 middle shelf zone, 12 inner shelf zone, and 9 bay/harbor sites. The 11 middle shelf sites included 4 large POTW, 3 mainland non-POTW, and 4 island sites. The inner shelf sites included 3 small POTW, 2 river mouth, 4 mainland non-POTW, and 3 island sites. The 9 bays/harbor sites included 6 marina and 3 "other bay" sites. Stations within this site cluster were characterized as sandy, with sediments averaging a little over 60% sand (Figure 65). Three species from Species Cluster F occurred at more than 50% of the stations within Site Cluster 5: California lizardfish (61%), California tonguefish (52%), and speckled sanddab (55%) (Table 56; Appendices E10 and E11).

Site Cluster 6 included 25 stations ranging in depth from 3-25 m, characterizing a shallow-water habitat of bays and harbors (Figures 62 and 66; Appendix E9). Most of these sites were located within LA/LB Harbor (Figure 66); 20 from the central mainland region, 2 from the northern mainland region, 2 from the southern mainland region, and 1 inner shelf site at Santa Catalina Island (Table 55). Within the bays and harbors, 11 sites were classified as port, 11 as marina, and 2 as "other bay" sites. This cluster indicates an association between port and marina sites but suggests that these sites differ from "other bay" sites. Similar to Site Cluster 7, Site Cluster 6 was largely delineated by the species of Species Cluster B; however, Site Cluster 6 had more species from Species Cluster A than did Site Cluster 7 (Figure 62 and 63). Only four species occurred at more than 50% of the stations within Site Cluster 6 and all were from Species Cluster B; these included white croaker (50%), tuberculate pear crab (54%), barred sand bass (58%), and California halibut (73%) (Table 56, Appendices E10 and E11).

Site Cluster 7 was the largest site cluster at 62 stations ranging in depths from 5-43 m and essentially characterizing a shallow-water habitat found on the inner shelf and within bays and harbors (Figures 62 and 66, Appendix E9). All regions except the island region were well represented with 14 northern mainland region, 33 central mainland region, and 15 southern mainland region sites. By depth zone, this site cluster included 2 mainland region middle shelf sites, 12 bay/harbor sites, and 48 inner shelf sites consisting of 7 small POTW, 27 river mouth, and 14 "other mainland" sites (Table 55). This site cluster contained 27 of the 31 river mouth sites sampled and suggests that river mouths may be somewhat different than other mainland region inner shelf sites. Four species occurred at more than 50% of the stations within this cluster and all were from Species Cluster B: white croaker (82%), queenfish (69%), blackspotted bay shrimp (61%), and California halibut (61%) (Table 56, Appendices E10 and E11).

Site Cluster 8 included 13 stations ranging in depth from 9-28 m and characterized an inner shelf habitat (Table 55). Nine of the sites were from the northern mainland region, 2 from the central mainland region, and 2 from the southern mainland region, indicating an association with the northern areas. All 13 sites were inner shelf sites and included 3 small POTW, 2 river mouth, and 8 "other mainland" sites. This site cluster was unique and was delineated largely by the species from Species Cluster F with a smaller contribution from species in Species Cluster B. Three species occurred in more than 50% of the stations including California halibut (54%), California lizardfish (77%), and speckled sanddab (92%) (Table 56, Appendices E10 and E11).

Site Cluster 9 included 15 stations ranging in depth from 2-11 m and characterized a southern mainland region bay/harbor habitat (Figures 62, 64, and 66; Appendix E9). Fourteen of the sites were from the southern mainland region and one site was from the central mainland region. All 15 sites were from the bay/harbor category and included 4 port, 1 marina, and 10 "other bay" sites (Table 55). Species from Species Cluster A largely delineated this site cluster and distinguished it from Site Cluster 5, which was comprised of bay/harbor sites from the central mainland region. Six species occurred at more than 50% of the sites within this cluster and included species from Species Cluster A (mat mussel, 80%; spotted sand bass, 100%; round stingray, 60%; and Pacific calico scallop, 53%); and species from Species Cluster B (barred sand bass, 93%; and California halibut, 73%) (Table 56, Appendices E10 and E11).

Species Clusters. Eight major species groups were delineated by the analysis (Figure 62). The species clusters occupied successively deeper depth zones (Figure 64) The relationship of the site clusters with water depth results from depth distribution patterns of the fish species found in the species clusters. All site clusters included representatives of one or more species groups (Figure 63). Species Cluster B was the dominant species cluster in Site Clusters 1, 2, 3, 4, and 5; Species Cluster F in Site Clusters 6 and 7; and Species Cluster C in Site Cluster 8.

Species Cluster A included 13 taxa that characterize shallow-water habitats of the SCB, especially those from the bay/harbor zone (Table 56; Appendices E9, E10, and E11). These species were essentially only found in Site Clusters 6 (LA/LB Harbor) and 9 (San Diego Bay) with a greater proportion being found in San Diego Bay, characterizing a San Diego Bay fauna (Table 56, Figure 66). Many of the species in this cluster are attached fauna (e.g., sea squirt, *Ciona* sp; scaly tunicate, *Microcosmus squamiger*; unidentified oysters; cobblestone sea squirt, *Styela plicata*), suggesting that San Diego Bay may have a more heterogeneous bottom than other bays and harbors. The most abundant species were mat mussels, California bubble (*Bulla gouldiana*), scaly tunicate, and round stingray (Appendix E9). The most frequently occurring species were diamond turbot, spotted sand bass, round stingray, and mat mussel (Table 56, Appendices E10 and E11).

Species Cluster B included 13 taxa that largely delineated Site Cluster 7 and to a lesser extent Site Cluster 6 (Table 56; Appendices E9, E10, and E11). Thus, Species Cluster B also represents shallow-water taxa with species typically found in deeper waters of the bays/harbor and along the open coast. Species Cluster B also included some attached fauna (e.g., Mediterranean mussel, *Mytilus galloprovincialis*; longstalk sea squirt, *Styela montereyensis*; and yellow-green sea squirt, *Ciona intestinalis*) and several species considered to be in the upper portion of the water column and not restricted to demersal habitats (e.g., northern anchovy, Pacific sardine, and queenfish). The most abundant species in this cluster were white croaker, queenfish, northern anchovy, and tuberculate pear crab (Appendix E9). The most frequently occurring species were California halibut, white croaker, New Zealand paperbubble, and tuberculate pear crab (Table 56, Appendices E10 and E11). The introduced species, New Zealand paperbubble, was found in all site clusters except Site Cluster 9 (i.e., San Diego Bay) (Figure 66).

Species Cluster C was the largest species cluster with 47 taxa that were not abundant, occurred infrequently, and can best be characterized as miscellaneous taxa (Table 56; Appendices E9, E10, and E11). However, some taxa within this cluster were found at all site clusters. Species Cluster C was most important in delineating Site Clusters 5, 6, and 7, characterizing a shallow-water and inner shelf fauna. While this cluster included many taxa, few were attached or upper-water column species. None of the taxa within this cluster occurred in 50% or more of the stations within a site cluster (Table 56). The most abundant species were deepbody anchovy, shiner perch, white seaperch, and blossom shrimp (Appendix E9). Blossom shrimp is a warm-water southern species whose presence in this survey was most likely a result of the warm-water conditions associated with the El Niño event. The most frequently occurring species were white seaperch, gulf sanddab, shiner perch, and tower snail (*Megasurcula carpenteriana*) (Appendices E10 and E11).

Species Cluster D included 37 taxa that delineated Site Cluster 2 (island region) and to a lesser extent Site Cluster 1 (outer shelf zone) (Table 56; Appendices E9, E10, and E11). Species within this cluster were not found in Site Clusters 8 and 9 and occurred infrequently in Site Clusters 3-7. Thus, species within this cluster represent middle shelf and outer shelf fauna. The most abundant species were California lamp shell (13,013 individuals; only at 8 sites), fragile sea urchin, slender sole, and orange sand star (which was predominantly found at stations within Site Cluster 2) (Appendix E9). The most frequently occurring species were slender sole, fragile sea urchin, red sea star, and roughback sculpin (Appendices E10 and E11).

Species Cluster E included 12 taxa that were broadly distributed but these species helped delineate Site Clusters 2, 3, and 4 from all others (Table 56; Appendices E9, E10, and E11). Thus, this species cluster represents middle shelf fauna associated with soft-bottom gorgonians and other affiliated species. This cluster included two gorgonians (yellow sea twig and *Heterogorgia tortuosa)*, the California blade barnacle, and two nudibranchs (*Dendronotus* sp and Spanish shawl, *Flabellina iodinea*) most likely to be found with the gorgonians. This cluster also included the slender sea pen and the Pacific spiny brittlestar, which also provide structure to the soft-bottom habitat. Vermilion rockfish and copper rockfish were also associated with this cluster. Thus, the species of this cluster appear to represent a specialized middle shelf fauna. The most abundant species were Pacific spiny brittlestar, California blade barnacle, yellow sea twig, and the gorgonian *Heterogorgia tortuosa* (Appendix E9). The most frequently occurring species were yellow sea twig, California blade barnacle, Pacific spiny brittlestar, and mosaic sand star (*Luidia armata*) (Appendices E10 and E11).

Species Cluster F included 10 species found throughout all areas of the SCB except for the shallow waters of bays and harbors (Table 56; Appendices E9, E10, and E11). Thus, these 10 species are best characterized as a middle shelf fauna and/or the ubiquitous species of the SCB shelf. Nine of the species were fish and one was an invertebrate, the California sand star. This species cluster was much less common for the island sites and the deepest stations, which helped to delineate Site Clusters 3 and 4 from the others (Table 55). The most abundant species were California lizardfish, longfin sanddab, California sand star, and California tonguefish (Appendix E9). The most frequently occurring species were California lizardfish, California sand star, California tonguefish, and bigmouth sole (Appendices E10 and E11).

Species Cluster G included 20 taxa that were less broadly distributed than species from Species Custer F and may best be characterized as the ubiquitous fauna of the middle shelf and outer shelf zone (Table 56; Appendices E9, E10, and E11). This cluster group largely delineated the middle shelf and outer shelf sites from the shallower sites. Species within this cluster were common in Site Clusters 1-5, but were most abundant in Site Clusters 1-3. The most abundant species were white sea urchin, ridgeback rock shrimp, Pacific sanddab, and yellowchin sculpin (Appendix E9). The most frequently occurring species were Pacific sanddab, ridgeback rock shrimp, white sea urchin, and yellowchin sculpin (Appendix E10).

Species Cluster H included 11 taxa found only at stations within Site Cluster 1, the deepest sites and thus may be characterized as an outer shelf fauna (Table 56; Appendices E9, E10, and E11). The most abundant species were hinged shrimp, mustache bay shrimp, blacktip poacher, and northern heart urchin. The most frequently occurring species were moustache bay shrimp, blacktip poacher, and northern heart urchin.

The hinged shrimp is a southern species that was present most likely because of the warm waters associated with the El Niño event.

Biointegrity Assessment

Recently developed (Allen *et al.* 2001a) biointegrity indices for fish, invertebrates, and combined fishes and invertebrates were used to assess the extent of altered assemblages on the southern California shelf. Two fish indices, the fish response index (FRI) and fish foraging guild (FFG) index were used to assess alterations in fish assemblages. The FRI was applied to the entire survey area whereas the FFG was applied only to the middle shelf area. The invertebrate response index (IRI) was used for invertebrate effects and the trawl response index (TRI) was used for combined fish and invertebrate effects. Index values by station are given in Appendix E12.

Based on the FRI, 97% of the area of the SCB was classified as reference and 2% as nonreference; no index could be calculated in 1% of the area due to an inadequate number of index species (Figure 67). The highest percent of nonreference area for fish assemblages was in the bays and harbors (16%), followed by the inner shelf zone (11%); none of the middle shelf or outer shelf sites were classified as nonreference (Figure 67). River mouths had the highest percent of area in the inner shelf zone (42%); the marina subpopulation had the highest percent of area (33%) in the bay/harbor subpopulation (Figure 68). The inner shelf zone island and port subpopulations had similar percents of nonreference areas (26 and 22%, respectively). Nonreference areas were most concentrated near the mouths of the Santa Clara and Ventura rivers (Figure 69).

The FFG index indicated that 83% of the middle shelf zone was classified as reference and 17% classified as nonreference for fish assemblages (Figure 70). In the middle shelf zone where the index was applied, the island region had the highest percent of nonreference area (28%); mainland middle shelf subpopulations had 6-9% nonreference. Nonreference did not have a noticeable distribution pattern (Figure 71).

For the IRI index, 85% of the area of the SCB was classified as reference and 12% as nonreference; an index could not be calculated for 2% of the area (Figure 72). By shelf zone, the highest percent of nonreference area for invertebrate assemblages was in bays and harbors (53%), followed by the inner shelf zone (32%) (Figure 72). By human-influence subpopulation, all bay/harbor subpopulations were relatively high in nonreference areas, with the "other bay" subpopulation being the highest (64%) (Figure 73). Similarly, all mainland region inner shelf populations were relatively high in nonreference areas, with the river mouth subpopulation being the highest (64%). In the bay/harbor subpopulation, nonreference sites were most common in LA/LB Harbor (Figure 74). The index could not be calculated for a relatively high number of sites in San Diego Bay due to insufficient numbers of appropriate species for calculating the index (Figure 74).

Using the TRI, 93% of the area of the SCB was classified as reference and 7% as nonreference (Figure 75). The TRI generally followed that of the IRI, in that the highest percent of nonreference area occurred in the bays and harbors (55%), followed by the middle shelf zone (27%) (Figure 75). Subpopulations within the bay/harbor subpopulation ranged from 48% ("other bay" subpopulation) to 66% (port subpopulation) (Figure 76). In the inner shelf zone, the river mouth subpopulation had the highest percent of nonreference area (77%) (Figure 77).

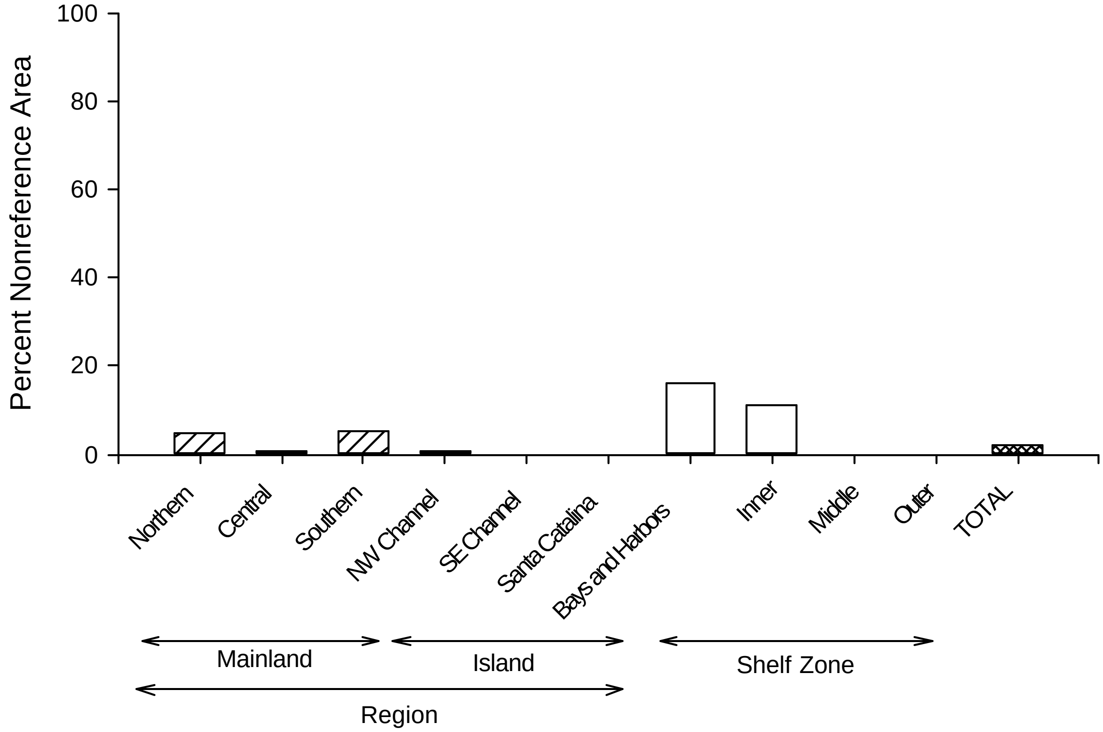


Figure 67. Percent of nonreference area by subpopulation on the southern California shelf at depths of 2-202 m)for Fish Response Index (FRI), July-September 1998.

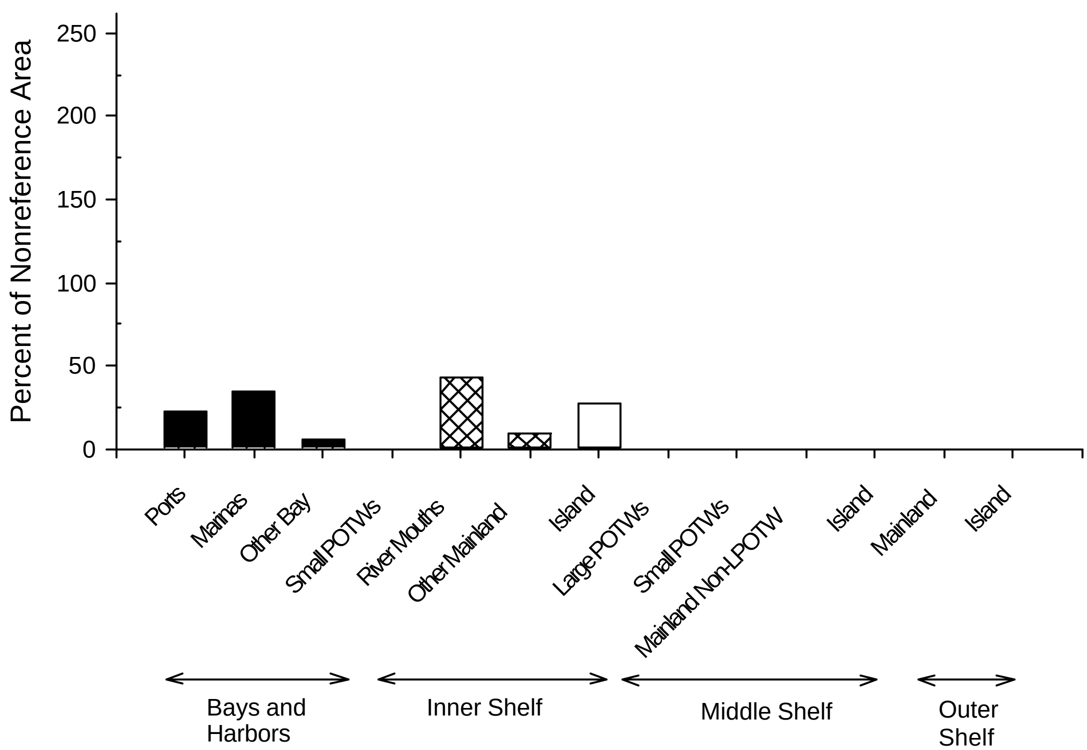


Figure 68. Percent of nonreference area by shelf zone subpopulation on the southern California shelf at depths of 2-202 m for Fish Response Index (FRI), July-September 1998.

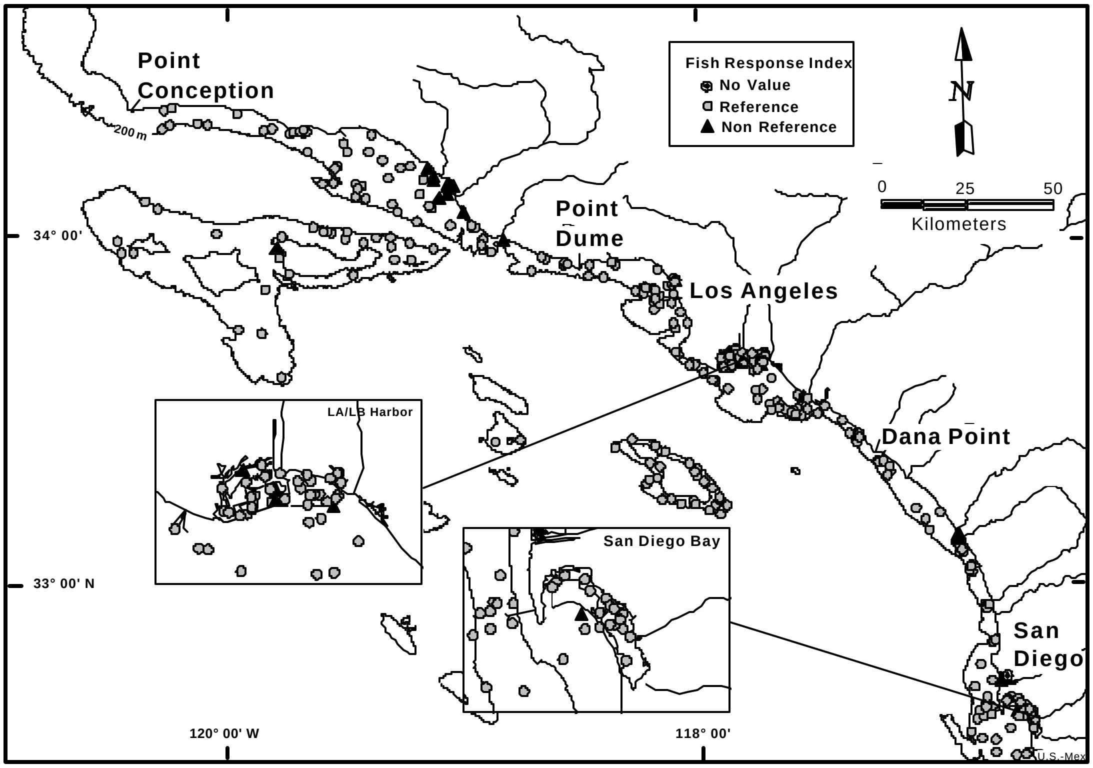


Figure 69. Distribution of response levels for Fish Response Index (FRI) on the southern California shelf at depths of 2-202 m, July-September 1998.

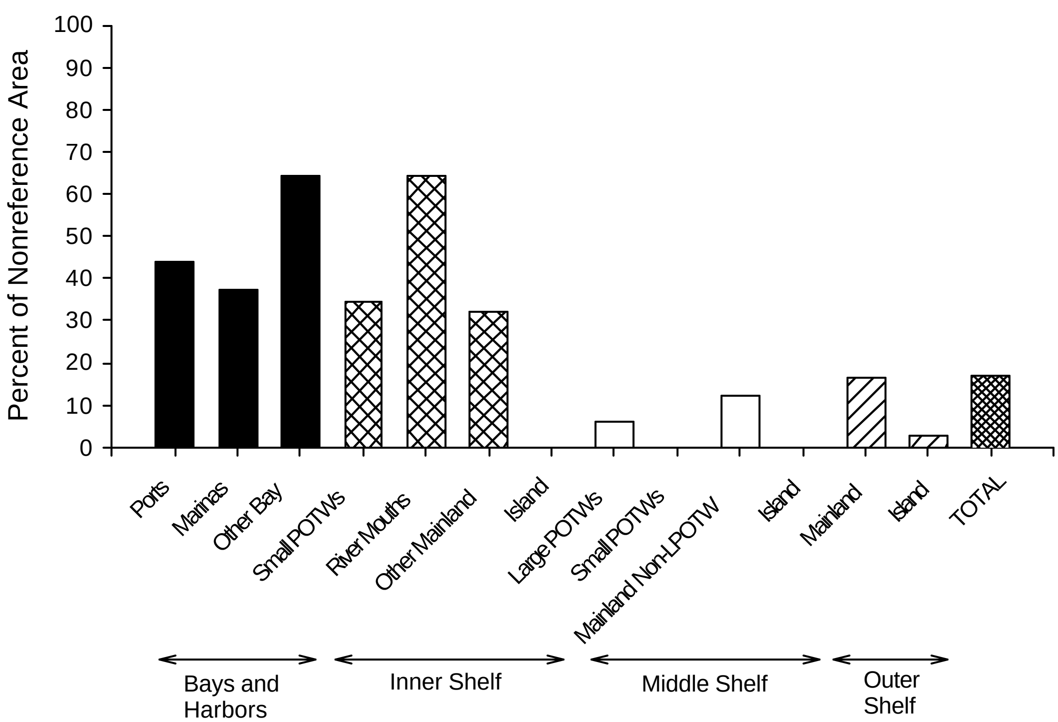


Figure 70. Percent of nonreference area by subpopulation on the middle shelf (31-120 m depth) of southern California for Fish Foraging Guild Index (FFG), July-September 1998.

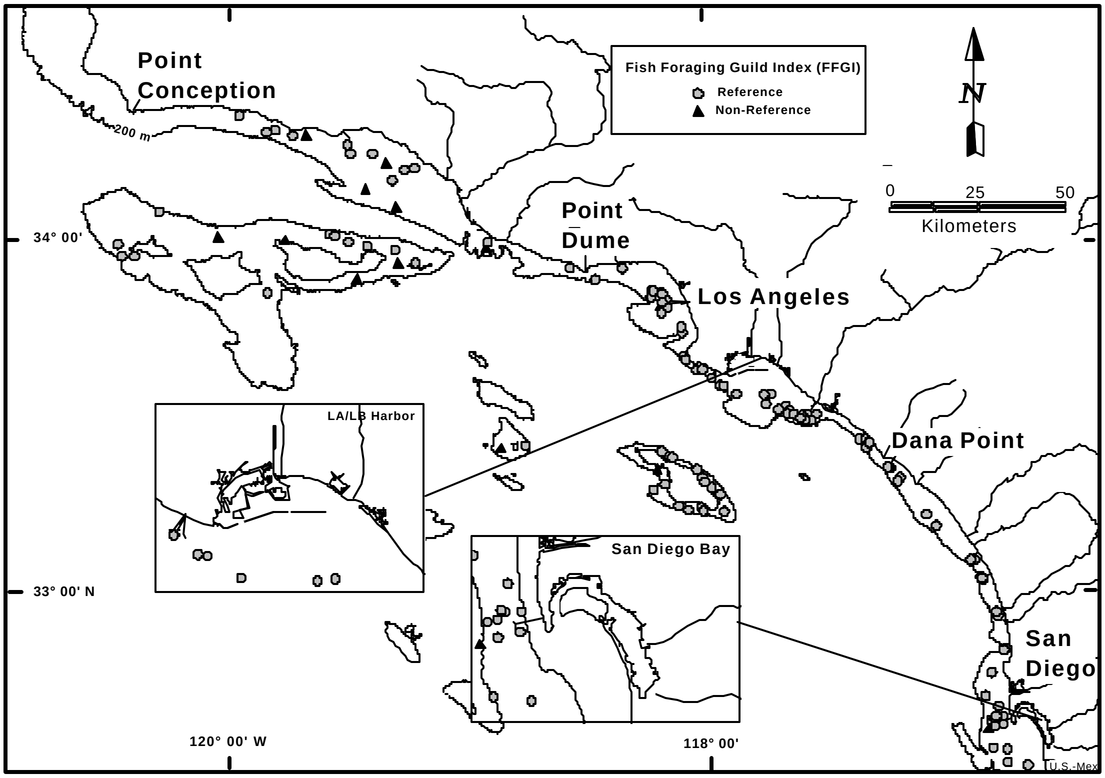


Figure 71. Distribution of response levels for Fish Foraging Guild Index (FFG) on the southern California shelf (middle shelf only, 31-120 m), July-September 1998.

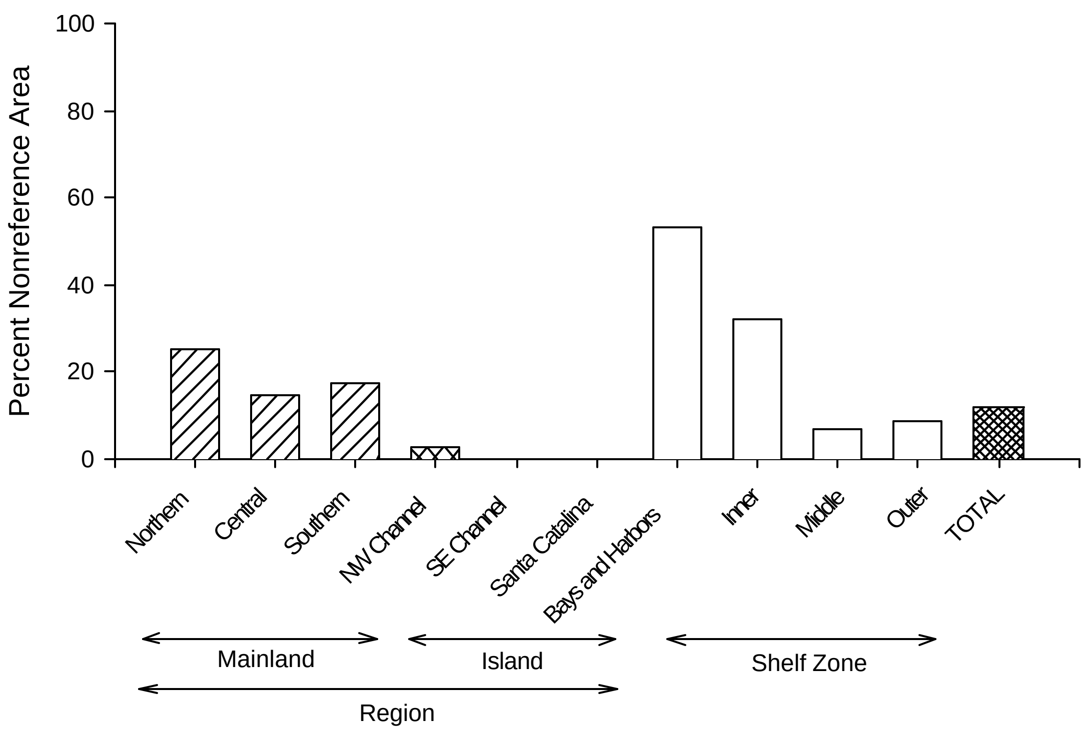


Figure 72. Percent of nonreference area by subpopulation on the southern California shelf at depths of 2-202 m for Invertebrate Response Index (IRI), July-September 1998.

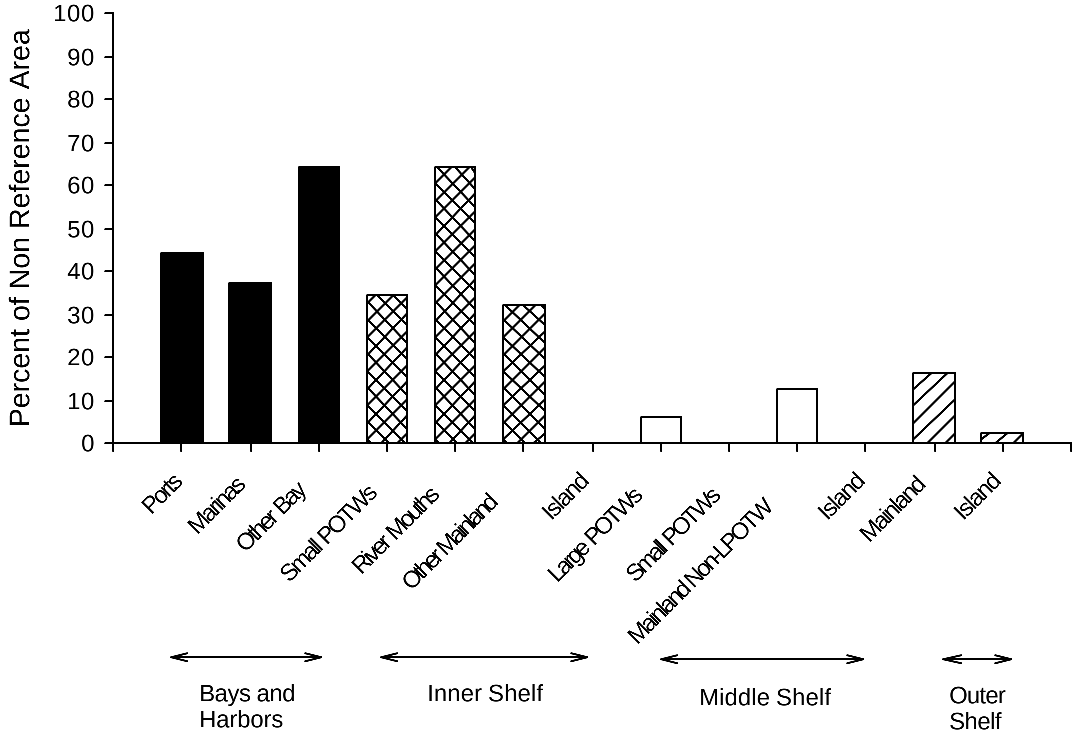


Figure 73. Percent of nonreference area by shelf zone subpopulation on the southern California shelf at depths of 2-202 m for Invertebrate Response Index (IRI), July-September 1998.

DISCUSSION

Biointegrity Assessment

The biointegrity indices that were applied to the SCB as a whole (i.e., FRI, IRI, and TRI) showed that 85-97% of the SCB area was classified as reference with 2-12% being nonreference. These indices could not be calculated in 0-2% of the area. For the middle shelf zone, the FFG index indicated that 17% of the area was classified as nonreference. For the SCB-wide indices, the highest percent of nonreference area were found in the bay/harbor and in the inner shelf river mouth subpopulation (particularly near the Santa Clara River mouth). Most of the sites where the IRI could not be calculated were in San Diego Bay, with others in LA/LB Harbor and river mouth areas (Figure 74). These areas had insufficient index species because species richness was greatly reduced (e.g., river mouth areas) or the fauna was dramatically different from the coastal fauna upon which the indices are based (e.g., San Diego Bay). All of the response indices (FRI, IRI, and TRI) were developed from fish data collected on the mainland shelf from 10-200 m from 1973 to 1994 (Allen *et al.* 2001a). Since bay fauna differs from the coast, the indices become less effective in this region. However, nonreference assemblages also occurred in LA/LB Harbor, and on the Santa Barbara Shelf, suggesting that other explanations are needed.

Although the IRI showed many nonreference shelf sites in the Santa Barbara Channel (Figure 74), the FRI and TRI did not (Figures 69 and 77). Similar to the IRI, the TRI showed nonreference areas in bays/harbors whereas the FRI did not. River mouths (particularly the Santa Clara River area) had relatively high numbers of nonreference sites for all three indices.

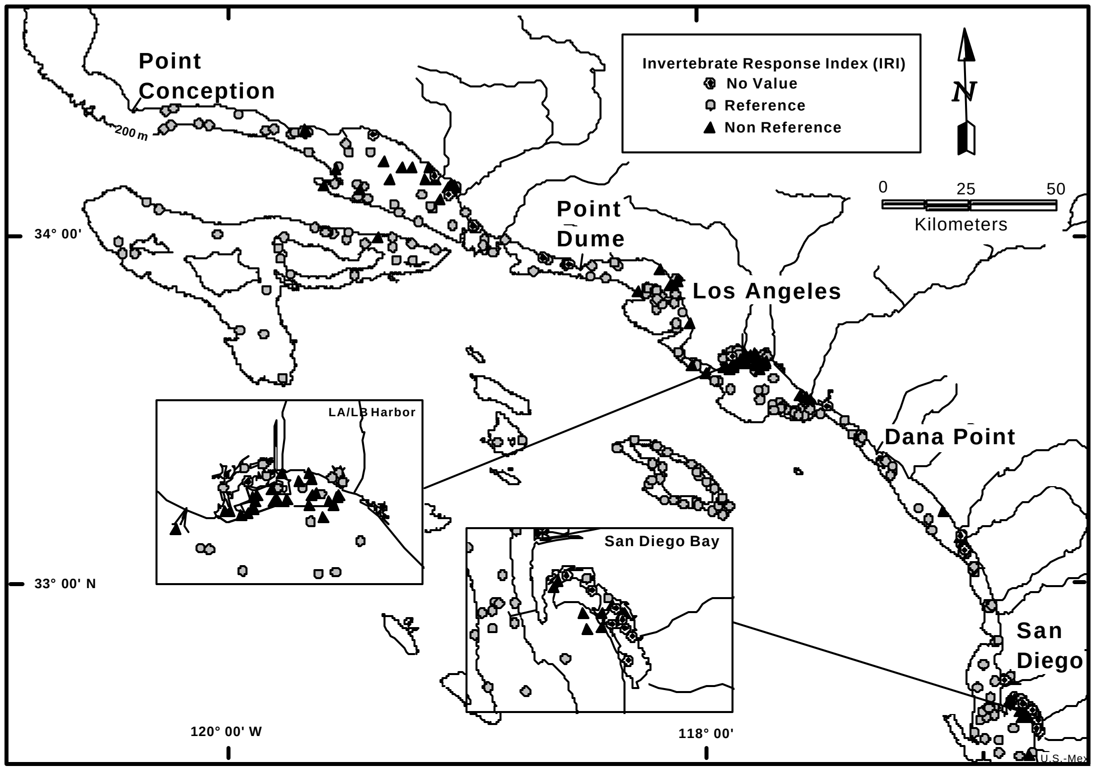


Figure 74. Distribution of response levels for Invertebrate Response Index (IRI) on the southern California shelf at depths of 2-202 m, July-September 1998.

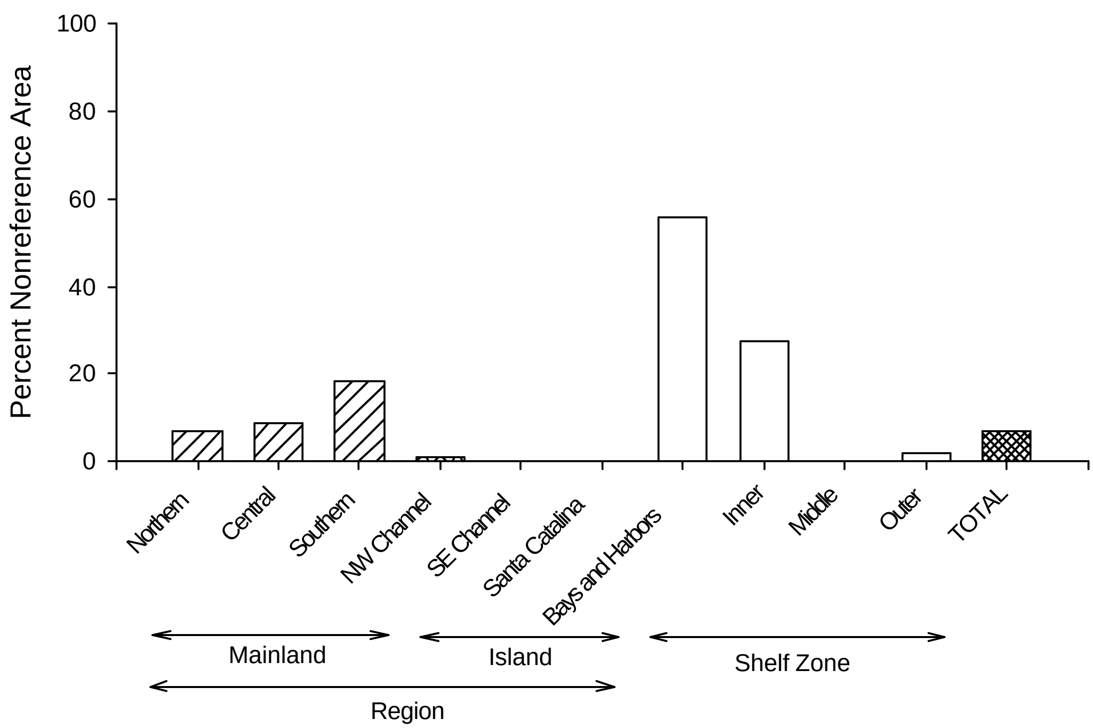


Figure 75. Percent of nonreference area by subpopulation on the southern California shelf at depths of 2-202 m for Trawl Response Index (TRI) (combined fish and invertebrate index), July-September 1998.

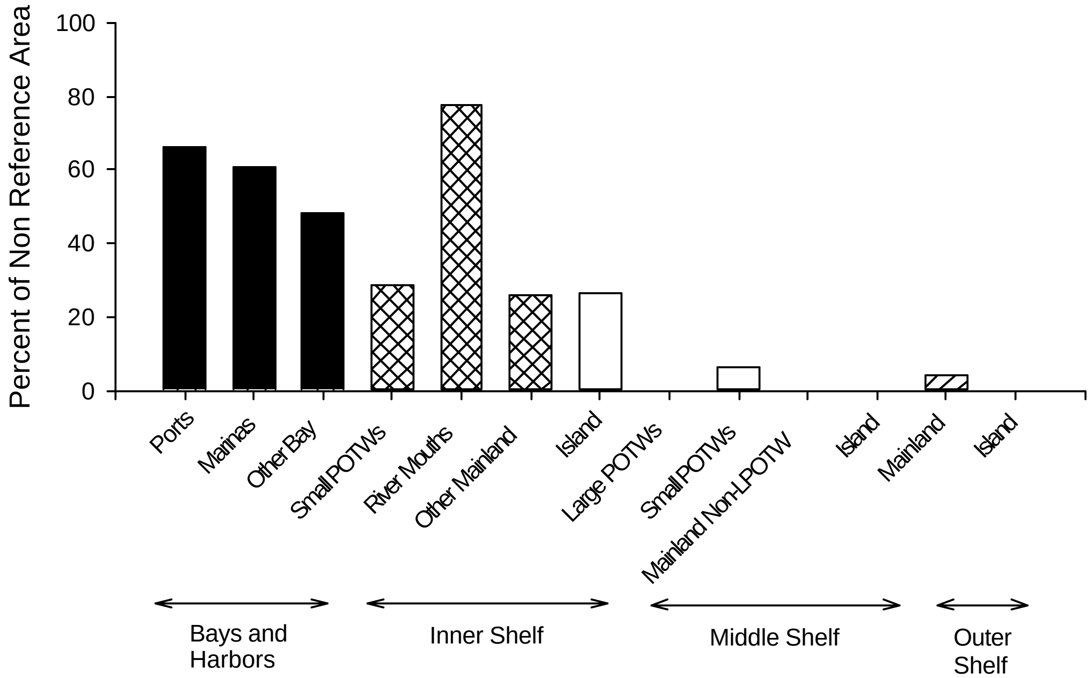


Figure 76. Percent of nonreference area by shelf zone subpopulation on the southern California shelf at depths of 2-202 m for Trawl Response Index (TRI) (combined fish and invertebrate index), July-September 1998.

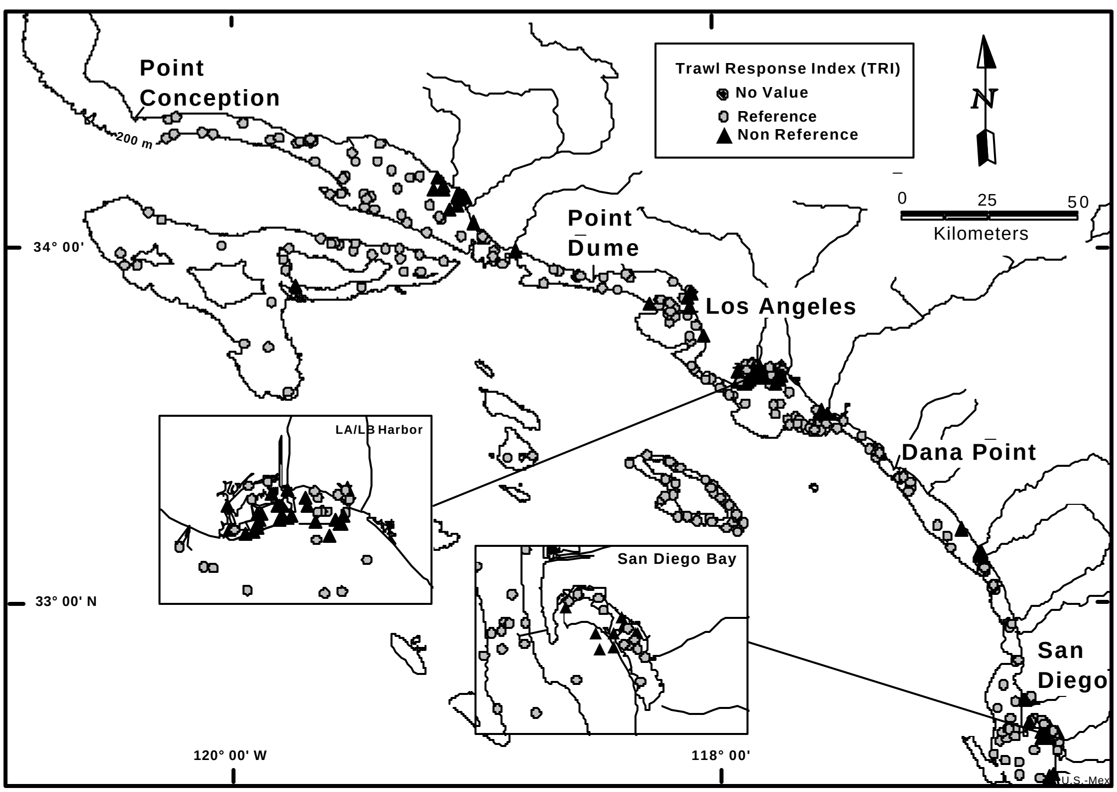


Figure 77. Distribution of response levels for Trawl Response Index (TRI) (combined fish and invertebrate index) on the southern California shelf at depths of 2-202 m, July-September 1998.

Whereas the response indices are based on the relative distribution of many species to a pollution gradient regardless of their biology, the FFG index is based on relative abundances of three foraging guilds. These are the generalists (benthic pelagobenthivores, sanddab guild), polychaete feeders (benthic extracting benthivores, turbot guild), and nekton ambushers (benthic pelagivores, lizardfish guild) (Allen *et al.* 2001a). Typically, turbot guild species are abundant near wastewater discharge sites and sanddab and lizardfish guild species are not. Thus, the index addresses ecological conditions in polluted areas, such as food type availability and sediment type (as this often determines food type availability). Whereas both sanddab guild and turbot guild species are widespread on the shelf, lizardfish guild species (e.g., California lizardfish, bigmouth sole, California halibut) were less common and abundant in 1994. In this survey, it is important to note that California lizardfish and bigmouth sole (both warm, temperate species with more southerly distributions) were absent in many stations in southeast Channel Islands area (Appendices C22 and C24), which most likely resulted in the many nonreference sites there (Figure 71).

These indices were developed using (in part) nearly three decades of trawl data from the Palos Verdes Shelf in the early 1970s (Allen *et al.* 2001a), the most contaminated sites along the southern California coast (Mearns *et al.* 1976). Heavily impacted sites occurred in this area, particularly in the middle shelf zone, but also in the outer shelf zone. However, sites of similar high impact were not identified in the inner shelf zone (or subsequently for bays and harbors, where fish assemblage sampling was done along with sediment chemistry sampling). These indices, while not perfect, performed nearly as well as the BRI (Smith *et al.* 1998; Smith, 2002) in following improving conditions over time on the Palos Verdes Shelf. Their real value is likely to become apparent when applied to historical data with clearly defined impact sites, as has been done in CSDLAC (2002). Although impact levels were not defined for the response indices, such a level was defined for the FFG index (Allen *et al.* 2001a). It should be noted that no site in the middle shelf zone was classified as impacted for the FFG index in 1998. Overall, the condition of the fish and invertebrate assemblages on the southern California shelf in 1998 was generally good, except perhaps in river mouth areas (particularly near the Santa Clara River) and LA/LB Harbor.

Based on its relative performance along historical spatial and temporal gradients in contamination, Allen *et al.* (2001a) recommended the FRI as the best index for use in assessing the biointegrity of demersal fish assemblages on the southern California shelf. Based on that index, 97% of the area of the southern California shelf had healthy fish assemblages in 1998.

Assemblages in 1998

Evaluation of Methods

Three different methods were used for describing assemblages: recurrent group analysis, cladistic analysis, and cluster analysis. Species groups were described using recurrent group, cladistic, and cluster analyses. Site groups were defined using cladistic and cluster analyses. Recurrent group analysis uses binary (presence/absence) data and describes groups of species that frequently co-occur. Cladistic analysis uses abundance data for describing site clades and binary data for describing species clades. Cluster analysis uses species abundance data for site and species clusters. The recurrent group analysis and cladistic analysis used all species whereas cluster analysis eliminated species and stations with low abundance. As a result, recurrent group analysis showed many single-site groups, which may or may not be meaningful. Also, because it describes species groups based on a predetermined index value, it only describes groups at the determined level and does not provide detailed relationships of species in the database. However, it may get to the core species in a community more directly because it does not provide detailed relationships. Cladistic and cluster analyses show more detailed relationships of sites and species in the assemblages in cladograms (former) and dendrograms (latter). Cluster analysis provided a detailed description of the site and species clusters, along with depictions of abundance and frequency of occurrence of species within site and species clusters. The following represents a brief summary of the similarities and differences of the assemblages defined by these different approaches.

All methods used showed that demersal assemblages in the SCB are largely organized around depth, although cluster analysis also showed influence of sediment type on some assemblages. Most analyses identified unique species or site assemblages in San Diego Bay and shelf assemblages that generally included inner shelf/bay and harbor assemblages; inner shelf assemblages, outer shelf assemblages, and various forms of middle shelf assemblages (e.g., inner shelf/middle shelf, middle shelf, and/or middle shelf/outer shelf).

General Results Across Methods

Fish and combined fish and invertebrate analyses showed distinctly different recurrent groups and site clusters in LA/LB Harbor and San Diego Bay (Figures 37, 43, 56, and 66); differences were present but less distinct for invertebrates (Figure 53). Both LA/LB Harbor and San Diego Bay were combined into a bays and harbors subpopulation in the survey design, due to their similarities in human activities (e.g., shipping and recreational boating). However, the distinct assemblages emphasize the ecological differences in the two regions. San Diego Bay is a large natural bay with a bay fauna similar to that of other natural embayments (e.g., lagoons) along the southern California coast. LA/LB Harbor is an artificially enclosed part of the inner shelf zone, and hence has a typical inner shelf fauna with enhanced abundance of some schooling species (e.g., white croaker, queenfish). Future regional surveys should consider the ecological differences between the two embayments.

Islands generally did not show such distinct assemblages, although cluster analysis identified some outer shelf/middle shelf site clusters for invertebrates and combined fish/invertebrates with strong island affinities (Figures 49 and 62). Cluster analysis found some site assemblages in the middle shelf and outer shelf zones that were defined in part by sediment type.

Fish assemblages showed a greater relationship to shelf zones than did invertebrate assemblages. A few invertebrate species (e.g., white sea urchin, ridgeback rock shrimp, California sand star, California sea cucumber, California sea slug) comprised a large assemblage in the middle shelf and outer shelf zones. However, most invertebrate species were not frequently caught. Combined fish/invertebrate assemblages showed potentially interesting relationships between fishes and invertebrates that were found at the site. For example, the occurrence of rex sole in the same recurrent group with northern heart urchin may be related to the presumed ability of rex sole to detect vibrations of heart urchins beneath the sediments, as stellate tube feet of buried heart urchins are part of its diet (Allen 1982).

Recurrent Group Results. Recurrent group analysis worked well for fish, giving a number of groups that were associated with bays and harbors and shelf zones. However, the analysis produced many single-site groups for invertebrates and combined fish/invertebrates. Whereas fish recurrent groups were generally well developed at different depths, multisite invertebrate recurrent groups consisted of relatively few species. Major multisite recurrent groups of combined fishes/invertebrates largely followed the fish recurrent group pattern, with individual invertebrate species dispersing among the fish groups. However, species in multispecies recurrent groups were generally important components of similar species assemblages defined by cluster and cladistic analyses.

Cluster Analysis Results. The three cluster analyses delineated several habitat and species assemblages, mainly correlated with water depth and geography. While each analysis described different habitats (i.e., site clusters) and assemblages or communities (i.e., species clusters), all were in agreement that the open coast has several habitats distributed across the shelf and generally distinguishable from bay/harbor sites. Surprisingly, the fish analysis was the least discriminating while the combined fish/invertebrate analysis identified several small-scale habitats and assemblage features.

None of the analyses identified a unique POTW assemblage, suggesting that the wastewater outfalls of the SCB are currently having limited impact on nearby demersal assemblages. This is a significant finding and is generally consistent with the 1994 analysis, which found some enhancement effect for fish near outfalls. Wastewater outfalls are now less likely to be the focus of significant adverse impacts to the demersal communities.

The invertebrate analysis identified an island region assemblage and denoted a possible assemblage localized near river mouth sites. The combined fish and megabenthic invertebrate analysis clearly delineated an island region assemblage with greater or lesser species abundance that differed from other areas on the shelf. The combined analysis also delineated several middle shelf invertebrate microhabitats that provide structure for other species (see Species Cluster E for the combined analysis). The combined analysis also delineated that port and marina subpopulation sites were somewhat different from “other bay” subpopulation sites; it also identified a river mouth subpopulation assemblage. This latter finding is indicative of effects from river discharges or physical environmental differences near river mouths. These results suggest that future surveys should redirect some of the effort focused on outfalls to the study of river mouths.

Finally, there was ample evidence that sampling during a major El Niño event had a significant influence on the survey results. Many species sampled during this survey were not present during the 1994 survey, the direct result of the warmer-than-usual seawater temperatures. In addition, the altered species distributions were not typical of patterns observed during more normal sea temperatures. For example, Pacific sanddabs were less abundant and appear to have been displaced offshore to deeper waters and/or to the north. Consequently, it is important that the next regional survey make a significant effort to match the spatial area and number of sites sampled in 1998 to be able to understand the significance of El Niño events on regional populations.

Cladistic Analysis: Comparison of Results. Results of the parsimony analyses of association yielded congruent results with the phenetically derived species clusters and the recurrent group analyses and almost all levels. Large clusters mirrored the large clade members, which in turn shared the same members with the recurrent groups. Interestingly, some of the smallest recurrent groups showed up as small two-member clades within larger clades on the cladograms (see recurrent group and species cluster sections).

As previously stated, one of the advantages of cladistic analysis is that the trees are additive. Hence, the number of changes, such as the number of occurrences or number of stations the species are found at, will be represented by branch length. Thus, the more widespread a species is, the longer the branch(es) leading up to it will be. A further discussion of cladistics theory and method as it relates to this study is given in Appendix E13. [3]

Historical Comparison of Assemblages

Revised 1994 Recurrent Group Analysis

Fish and invertebrate recurrent groups described from 1994 data (Allen and Moore 1997a,b; Allen *et al.* 1998) were inadvertently based on an index of affinity (I.A.) value of 0.5, rather than 0.50, which was recommended by Fager (1963). Thus, values greater than 0.45 were rounded to 0.5, rather than rounding values greater than 0.495 to 0.50. Hence, the 1994 study did not describe recurrent groups based on the same criterion described in this study. Recurrent groups for fish and invertebrates based on 1994 data and using an I.A. of 0.50 are presented in Appendices E14 and E15.

The deeper groups were generally the same in both of the analyses, but the shallow groups differed. Fish groups that are the same in Allen and Moore (1997a), Allen *et al.* (1998), and in Appendix E14 are Group 10 (Group 4, outer shelf group in the 1994 study) and Group 11 (Group 5, Hueneme Canyon group in the 1994 study). Invertebrate groups that are the same in Allen and Moore (1997b), Allen *et al.* (1998), and in Appendix E15 are Group 13 (Group 2, middle shelf group in 1994), Group 16 (Group 3, middle/outer shelf group in 1994), Group 26 (Group 6, outer shelf group in 1994), and Group 28 (Group 7, upper slope group in 1994).

Fish Assemblages

Recurrent Groups. Recurrent groups of fishes have been defined in a number of studies during the past three decades (SCCWRP 1973, Mearns 1974, Allen 1982, Allen and Moore 1997a, Allen *et al.* 1998). Allen (1982) described recurrent groups of fishes based on 342 samples collected in 1972-1973 during the cool-water period from the central region (Point Dume to Dana Point) of the mainland shelf at depths of 10-190 m. Earlier studies (SCCWRP 1973, Mearns 1974) were based on a portion of the database eventually used in Allen (1982). The next large-scale description was in 1994 (Allen and Moore 1997a, Allen *et al.* 1998). However, as noted above, this study described recurrent groups using a slightly different index value than in the present (1998) study (Appendix E14). Hence, the 1998 results will be compared to the revised 1994 results, as well as to recurrent groups in Allen (1982). Thus, recurrent groups were described in a cool period (1972-1973), warm period (1994), and El Niño period.

At the 0.50 affinity level, Allen (1982) identified nine recurrent groups with two to seven species per group and seven closely associated non-group species. These groups and associates comprised 34 (27%) of the 126 species collected in the survey. Three groups probably represented important depth-related communities on

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[3] Both the raw data files and tree files in NEXUS format used in this study are available from the cladistics author for this chapter, Gregory Deets (City of Los Angeles, Environmental Monitoring Program, Los Angeles, CA) or www.sccwrp.org. This will allow those with access to MacClade programs to interactively map station data, station by station, across the species group cladogram for specific species distribution information.

the inner/middle, middle/outer, and outer shelf zones. In 1994 (Appendix E14), 11 recurrent groups with 2-6 species per group were described with 5 closely associated non-group species. These groups and associates represented 39 (45%) of the 87 species collected. Two recurrent groups in 1972-1973 and four in 1994 were found at single sites; the species in these groups accounted for 11% of the total species in the survey. In 1998, 10 recurrent groups were found with 2-6 species per group, and 4 associated non-group species. These represented 33 species (23%) of the 143 species collected. In 1998, bays/harbors and islands were added to the mainland shelf survey. Hence, it is not surprising that a bay recurrent group (consisting of round stingray and spotted sand bass), as well as a single-site island group (consisting of bluebanded goby and zebra goby) were found from the islands (Figure 35). In addition, a recurrent group of white croaker and queenfish was typical of the LA/LB Harbor. In contrast to 1972-1973, which had major recurrent groups representing three distinct depth zones, those in 1994 represented about six depth categories and those in 1998 about five (excluding bays).

In spite of changing oceanic conditions off southern California during the past three decades (Smith 1995, Hayward 2000), some species occurred together in recurrent groups in all three years: a) California tonguefish, hornyhead turbot (inner shelf/middle shelf zones); b) Pacific sanddab, Dover sole, plainfin midshipman, stripetail rockfish (middle shelf/outer shelf zones); c) slender sole and shortspine combfish (outer shelf zone); and d) rex sole and blacktip poacher (outer shelf zone) (Figure 35, Appendix E14; Allen 1982). These species represent core community members, and hence probably represent the biogeographic communities (i.e., groups of species that live together over a large area and, probably, over a long time period) of the southern California shelf (Allen 1982).

Allen (1982) found that a high proportion of the species on the soft-bottom habitat of the mainland shelf of southern California are either incidental to the habitat or region, or are inadequately sampled by trawl. Of 126 fish species collected in the early 1970s, 26% formed recurrent groups, 68% were incidental (being more commonly found in other habitats or biogeographic zones), and 6% were characteristic of the area but ineffectively sampled by trawl. A similar relationship appeared to continue, with 45% of the 87 species in 1994 and 23% of the 143 species in 1998 forming recurrent groups.

Site and Species Clusters. Although site and species clusters of southern California fishes have been analyzed (e.g., CSDOC 1996); few studies have examined these fish assemblages on a large scale. Allen (1985) described fish habitat assemblages based on a compilation of ecological 38 ichthyofaunal studies conducted during the 1950s to early 1980s in different habitats using different collecting methods. Allen et al. (1998, 1999a) described soft-bottom fish site and species assemblages on the southern California mainland shelf.

The fish cluster analysis for the 1994 regional survey of the Southern California Bight Pilot Project analyzed 113 sites located along the open coast in water depths from 9-215 m (this survey did not sample in bays/harbors or near the Channel Islands) (Allen *et al.* 1998). The 1994 analysis identified 5 site and 4 species clusters based upon 40 fish species that fulfilled the screening criteria. The five site clusters characterized outer shelf (107-215 m), middle shelf (13-86 m), and inner shelf (9-24 m) habitats. Two intermediate habitats were the inner/middle shelf (18-97 m) and middle/outer shelf (72-160 m) habitats. The site cluster dendrogram shows that the two deeper site clusters (outer and middle/outer shelf) have low similarity with the three shallower site clusters (inner, inner/middle, and middle) (Allen *et al*. 1998). The 1998 survey identified three major site clusters with eight subgroups characterizing a middle/outer shelf, middle/inner shelf, and a shallow-water bay/harbor habitat. Exclusive of bay and harbor sites the 1998 analysis also identified two major open coast sites or habitat clusters with five subgroups: outer shelf (130-202 m), middle shelf (16-109 m), inner shelf (13-29 m), inner/middle shelf (22-69 m), and middle/outer shelf (17-190 m). Similarly, the site cluster dendrogram for the 1998 survey showed that the deeper habitat had low similarity to the shallow habitats (Figure 39). Thus, while there were more stations and species utilized for the 1998 analysis, both analyses defined similar soft-bottom habitats on the open coast.

The analysis of the 1994 survey data delineated two major species assemblages with four subgroups characterizing a shallow and a deeper water assemblage (Allen *et*. 1998). The deeper water assemblage had two subgroups. The subgroup with a preference for the deepest depths included 8 species delineating an outer shelf assemblage while the other subgroup had 11 species more broadly distributed, characterizing a middle shelf/outer shelf assemblage. The shallow-water assemblage also had two subgroups but both of these subgroups were broadly distributed among inner and middle-shelf sites. Ten of the species had a preference for the shallower depths while 11 species had a preference for slightly deeper waters. All 21 species of this shallow assemblage were generally found at inner shelf, inner/middle shelf, and middle shelf water depths reflecting their broad depth distributions and a lack of distinction between inner and middle shelf sites. Similarly, the 1998 analysis identified two major species assemblages with seven subgroups, characterizing a shallow and a deeper water assemblage. The deeper water assemblage contained 43 species divided into 4 subgroups: 9 species characterize an outer shelf assemblage (Species Cluster G), 13 species that occurred infrequently characterizing a middle/outer shelf assemblage (Species Cluster F), 13 species broadly distributed representing ubiquitous deeper water species found from the middle shelf to the outer shelf (Cluster E), and 8 ubiquitous species found from the inner shelf to the outer shelf (Cluster D). The shallow-water assemblage included 30 species divided into three subgroups: 3 species characterizing the shallow waters of bays and harbors (Cluster A), 16 species characterizing a shallow-water assemblage found in both the inner shelf and bays and harbors (Cluster B), and 11 ubiquitous species more broadly distributed with a few found in the middle shelf as well as the inner shelf and bays and harbors (Cluster C).

The 1994 outer shelf assemblage included splitnose rockfish, bluebarred prickleback, blackbelly eelpout, rex sole, slender sole, shortspine combfish, blacktip poacher, and Pacific hake. The 1998 outer shelf assemblage was almost identical to the 1994 analysis with the exception that the shortspine combfish was more dominant in the middle/outer shelf assemblage instead of the outer shelf, and two additional species characterized this deep water assemblage: bearded eelpout and the spotted ratfish. These latter two species have never been common on the shelf in the SCB, and the addition of Channel Island sites for the 1998 survey may have influenced their presence in the most recent survey.

The middle/outer shelf assemblage identified in 1994 included stripetail rockfish, greenblotched rockfish, greenstriped rockfish, greenspotted rockfish, and halfbanded rockfish, English sole, Pacific sanddab, Dover sole, plainfin midshipman, Pacific argentine, and spotted cusk-eel. The 1998 analysis found these same 11 species distributed in Species Clusters E and F with Species Cluster F representing species that occurred infrequently, while the majority of species in Species Cluster E were abundant and more broadly distributed (Appendix E1).

The 21 species comprising the two shallow subgroup assemblages identified in the 1994 analysis were also found in the 1998 analysis, but they were distributed in several species clusters. For the 1994 analysis, 7 of the 11 species with a slight preference for the middle shelf depths were found in Species Cluster D, the ubiquitous species of the inner and middle shelf zone. These included California skate, yellowchin sculpin, hornyhead turbot, bigmouth sole, longfin sanddab, California lizardfish, and California tonguefish. The longspine combfish, pink seaperch, and bay goby were found in Species Cluster E, ubiquitous species of the middle and outer shelf and the speckled sanddab, occurred in Species Cluster C. The shallowest assemblage identified from the 1994 analysis consisted of 10 species, 5 of which occurred in Species Cluster C, the ubiquitous species of shallow water and included spotted turbot, California halibut, fantail sole, specklefin midshipman, and white croaker. The California scorpionfish was found in Species Cluster D, the gulf sanddab in Species Cluster E (possibly indicating a misidentification of this species in 1994), and pygmy poacher and roughback sculpin were found in Species Cluster F. Included in this cluster was the calico rockfish *(Sebastes dallii),* which was uncommon in 1998. The increase in depth distribution for some of these latter species may also reflect the El Niño event that occurred during the winter preceding the 1998 survey, and some of the nearshore species may thus have been found in deeper waters than normal.

Both the 1994 and 1998 analyses identified a middle-shelf assemblage, which overlapped in composition with inner/middle shelf and middle/outer shelf assmblages (Allen *et al.* 1998; Appendix E1). This suggests that the middle shelf is an overlap zone, where the outer shelf assemblage intergrades with the inner shelf assemblage. The middle shelf assemblage for the 1998 analysis consisted of about equal proportions of species from Species Clusters D and E (Figure 39). Species Cluster D represented species most often found in the 13-109 m range, while Species Cluster E represented those species found in the 16-202 m depth range. Most of the fish species in these assemblages had broad depth distributions and the middle shelf assemblage might be characterized as the mixing zone where both shallow and deeper water shelf species are found. However, despite the apparent lack of fish species that are limited to the middle shelf depth assemblage in Appendix E1, it should be noted that this table shows the distribution of species by assemblages, not by depth. A number of species that are characteristic of the middle shelf have much reduced occurrence or are absent in other shelf zones (Appendix C14; Appendix C7 in Allen *et al.* 1998). These include calico rockfish, yellowchin sculpin, roughback sculpin, pygmy poacher, longspine combfish, bay goby, and curlfin sole, and to a lesser extent, California scorpionfish and bigmouth sole. The importance of the middle shelf occurrence of these species appears to be masked by their occurrence in one or more assemblages that overlaps between the middle shelf and another life zone.

Invertebrate Assemblages

Recurrent Groups. Recurrent groups of megabenthic invertebrates were first described for the mainland shelf of southern California based on data collected in the 1994 regional survey (Allen and Moore 1997b, Allen *et al.* 1998). As noted above, this study described recurrent groups using a slightly different index value than in the present (1998) study (Appendix E15). Hence, the 1998 results will be compared to the revised 1994 results.

In 1994 (Appendix E15), eight recurrent groups with two to six species per group were described with seven closely associated non-group species. These groups and associates represented 31 (15%) of the 204 species collected. In 1998, there were 22 recurrent groups with 2-4 species per group and 1 closely associated non-group species (Figure 45, 46). Whereas in 1994, all groups were found at 2 or more stations; in 1998 17 of 22 groups occurred at a single site (Figure 46). These represented 46 species (15%) of the 313 species collected in the survey. In 1998, bays/harbors and islands were added to the mainland shelf survey, and a distinct San Diego Bay recurrent group (consisting of an unidentified oyster and the onyx slippersnail) was identified. None of the multispecies recurrent groups were island groups but some single-site groups occurred at islands. A group consisting of California blade barnacle and yellow sea twig was associated with POTW areas.

Some species occurred together in recurrent groups in both 1994 and 1998: a) white sea urchin, ridgeback rock shrimp, California sand star, California sea cucumber (middle shelf/outer shelf group); and b) northern heart urchin, moustache bay shrimp (outer shelf group) (Figure 45, Appendix E14). As with the fishes, these species may represent core community members that may occur together throughout changing oceanic conditions.

Site and Species Clusters. The first description of megabenthic invertebrate assemblages on the southern California shelf was based on data compiled from surveys conducted from 1971-1985 (Thompson *et al*. 1993a). This study described site and species clusters at depths of 10-490 m, using similar methods as used in the 1994 and 1998 surveys. It identified eight site clusters: a) Pre-1980 Palos Verdes Shelf (23-137 m); b) Post-1981 Storm/El Niño (18-37 m); c) Normal Mainland Shelf (10-137 m); d) Outer shelf/ Upper slope (45-315 m); e) Midslope (300-490 m); f) "Short" trawls; g) Lower-slope (478-780 m); and h) Subsill Basins (715-878 m). The normal mainland shelf assemblage was dominated by white sea urchin and ridgeback rock shrimp.

The megabenthic invertebrate cluster analysis for the 1994 survey analyzed 45 megabenthic invertebrate taxa from 109 open coast sites (Allen *et al*. 1998). This analysis, like the fish cluster analysis, identified five major site clusters but only three species clusters (Allen *et al*. 1998). The five site clusters characterized outer shelf (75-215 m), middle shelf (25-91 m), and inner shelf (13-23 m) habitats; and two intermediate habitats: inner/middle shelf (9-72 m) and middle/outer shelf (53-175 m) habitats. The site cluster dendrogram shows that the outer shelf habitat shared some similarities with the middle and middle/outer shelf habitat, which were most similar to each other. These three deeper habitats were quite dissimilar from the inner and inner/middle shelf habitats, which were most similar to each other. The 1998 survey based on 96 taxa identified 8 major site and 7 species clusters characterizing deeper water habitats as distinct with little similarity to shallow habitats. Generally, exclusive of the shallow habitats of bays and harbors, which were not surveyed in 1994 (Site Clusters 5, 7, and 8), 5 site clusters characterized an outer shelf habitat (99-193 m), an inner shelf habitat (6-99 m, including some bay and harbor stations), and three broader habitats: outer/middle island shelf (17-201 m), outer/middle mainland shelf (24-202 m) and middle/inner shelf (13-188 m). The megabenthic invertebrate site clusters generally exhibited broader depth ranges than the fish habitats and this was also consistent with the lack of a distinct middle shelf habitat. The 1998 analysis is similar to the 1994 analysis in showing a distinct outer shelf habitat and a broadly distributed inner shelf habitat, which extends to the middle shelf zone.

The 1994 analysis delineated two major species assemblages, a broadly distributed shallow-water assemblage comprised of 14 taxa found throughout the inner and middle shelf sites and a deeper water assemblage with two subgroups. The two subgroups included 17 taxa broadly distributed throughout the middle and outer shelf site groups and 14 taxa generally limited to the outer shelf zone. The 1998 survey delineated 4 major assemblages with 3 subgroups characterizing an outer shelf assemblage; an outer/middle shelf assemblage with an island subgroup and a mainland assemblage of ubiquitous species; a rather infrequently occurring middle/inner shelf assemblage; and a shallow-water assemblage with two subgroups characterizing both an inner shelf, bays and harbors, and river mouth assemblage, and a very distinct bay/harbor assemblage.

Twelve of the 14 taxa characterizing the 1994 outer shelf assemblages were distributed in 4 different species clusters in the 1998 analysis. Two species, sea dandelion *(Dromelia alexandri*) and roughdisk brittlestar (*Amphichondrius granulosus*) did not occur frequently enough for inclusion in the 1998 analysis. Five of the 14 species sampled in 1994 were found in the 1998 Species Cluster G, characterizing a deeper water outer-shelf assemblage. These included Pacific heart urchin, northern heart urchin, mustache bay shrimp, flagnose bay shrimp, and southern spinyhead (*Metacrangon spinosissima)*. Other invertebrates included in Species Cluster G for the 1998 analysis were the blossom shrimp, hinged shrimp, spot shrimp (*Pandalus platyceros*), slender blade shrimp (*Spirontocaris holmesi*), and the orange bigeye octopus. The two former species are southern species that were probably associated with the 1997-1998 El Niño event. The latter three species are typical deeper water species for the SCB and the spot shrimp is fished commercially. Three of the 14 species from the 1994 analysis were found in the 1998 Species Cluster F, these included the slenderclaw hermit (*Paguristes turgidus*), California heart urchin (*Spatangus californicus*), and the fragile sea urchin. Species Cluster F tended to be representative of island assemblages as this cluster included the California lamp shell which occurred in large numbers but only at a few island sites. The remaining deep water species identified in the 1994 analysis were found in 1998 Species Cluster C (eastern Pacific bobtail, California armina (*Armina californica*), and tower snail, and one in Species Cluster D (rosy tritonia, *Tritonia diomedea*) representing infrequently occurring species but generally found in shallower water for the 1998 survey.

Fifteen of the 17 taxa characterizing midshelf depths for the 1994 survey were found in four different species clusters for the 1998 analysis. Vidler spindlesnail (*Neosimnia aequalis*) and spindle topsnail (*Calliostoma turbinum*) did not occur frequently enough to be included in the 1998 analysis, although seapen spindlesnail was reported and was part of the Species Cluster D assemblage. Eleven of the taxa were found in Species Cluster E representing the ubiquitous taxa of the SCB shelf and included California sand star, New Zealand paperbubble, ridgeback rock shrimp, California sea cucumber, white sea urchin, trailtip sea pen, brokenspine brittlestar, California sea slug, gray sand star, red octopus (*Octopus rubescens*), and California market squid. This assemblage appears relatively consistent and the 1998 El Niño event appears to have had little affect upon the ubiquitous species. Two of the 17 taxa were found in Species Cluster F (fleshy sea pen, *Ptilosarcus gurneyi* and gigantic anemone), one in Species Cluster D (slender sea pen), and the Alaska bay shrimp in Species Cluster C. Eleven of the 14 taxa that characterized a shallow-water assemblage for the 1994 survey were also found in 4 different assemblages for the 1998 analysis. Three species that occurred in 1994 did not occur frequently enough to be included in the 1998 analysis and these were sea porcupine (*Lovenia cordiformis*), graceful rock crab (*Cancer gracilis*), and brown spiny doris (*Acanthodoris brunnea*). Four of the species were found in Species Cluster B, representing the ubiquitous shallow water taxa and included the blackspotted shrimp, tuberculate pear crab, spiny sand star, and fat western nassa. Species Cluster B also had the yellowleg shrimp, which was more abundant in 1998 than in 1994. Four species occurred in Species Cluster C, which were infrequently occurring but broadly distributed and included sandflat elbow crab, shortspined sea star

(*Pisaster brevispinus*), spotwrist hermit (*Pagurus spilocarpus*), and globose sand crab (*Randallia ornata*). Two of the final three species were located in Species Cluster D (mosaic sand star and thinbeak neck crab, *Podochela lobifrons*) and Pacific spiny brittlestar in Species Cluster E.

The comparison of the 1994 and 1998 megabenthic invertebrate cluster analyses shows that the ubiquitous and more common species tended to show a fair degree of similarity between the two surveys. However, for the less abundant species there was low similarity between assemblages for the two analyses. Some of the differences in the species clusters were related to the different habitats sampled in 1998 as well as the influence of the 1998 El Niño, which appears to have influenced some southern species to be found within the SCB that typically would not be representative of the area.

Historical Changes in the Functional Structure of Fish Communities

Allen (1982) described the functional organization of soft-bottom fish communities on the southern California shelf based on the ecological segregation of the most common species. Examination of fish recurrent groups from 1972-1973 showed that in general, species occurring together in recurrent groups are ecologically and morphologically different, whereas species that were most similar in their foraging morphology were found in different recurrent groups at different depths. Species with similar foraging behavior were grouped into foraging guilds (Figure 5). Species comprising a guild generally displaced each other by depth across the southern California shelf from 10-200 m. The functional organization was described as the number and type of guilds found at a given depth and the composition of the communities as the dominant species of each guild found at that depth (Figure 6).

Areal Extent of Foraging Guilds

Allen (1982) described 18 foraging guilds that comprise most of the soft-bottom fish communities of the southern California shelf. These foraging guilds differed in their occurrence on the southern California shelf in 1998 (Table 57). The most widespread guild was the benthic pelagivore (lizardfish) guild, occurring in 75% of the area. The benthic pelagobenthivore (sanddab) guild was next in occurrence (72%), followed by the benthic extracting benthivore (turbot) guild (68%) and the benthic nonvisual benthivore (tonguefish) guild (62%).

As the 1998 survey included mainland shelf, islands, and bays, these results cannot be compared directly to those of 1994 (Allen *et al.* 1998). However, this can be done if only the mainland shelf is compared, as this was the habitat sampled in common in the two years. In contrast to the southern California shelf as a whole in 1998, the foraging guild that was most widespread on the mainland shelf in 1994 and 1998 was the benthic pelagivore (sanddab) guild, occurring in 96% of the area of the shelf in 1994 and 93% in 1998 (Table 57). The next most widespread mainland shelf guilds in 1998 were the benthic pelagivore (lizardfish guild) and extracting benthivore guild (turbot guild), occurring in 87% and 80% of the area, respectively. In 1994, the turbot guild was second (92% of the area) and the lizardfish guild was third (75% of the area). Of the 18 foraging guilds, half increased their areal occurrence in 1998 and half decreased their occurrence. Of eight water-column (and bottom-refuge) guilds, five increased in occurrence (although in general only slightly) and three decreased. In contrast, of 10 benthic guilds, four increased in occurrence and six decreased in occurrence. Guilds showing the greatest difference in percent of occurrence between 1994 and 1998 were the benthic cruising nocturnal benthopelagivores (croaker) guild (19% increase), bottom-refuge visual pelagivore (rockfish) guild (17% decrease), and pursuing benthopelagivore (combfish) guild (15% decrease).

Table 57. Percent occurrence of foraging guilds on the mainland shelf (10-200 m) of southern California in 1994 and 1998.

Guild No.	Guild Name (Allen 1982)	Identifier	% FO SC Shelf 1998 (n=314)	% FO Mainland Shelf 1994 (n=114)	% FO Mainland Shelf 1998 (n=185)
2B	Benthic Pelagobenthivores (1)	sanddab	72	96	93
2A	Benthic Pelagivores (3)	lizardfish	75	75	87
2D1A	Benthic Extracting Benthivores (2)	turbot	68	92	80
2D2	Benthic Nonvisual Benthivores (4)	tonguefish	62	72	80
2C2B	Benthic Ambushing Benthivores, Small (6)	sculpin/poacher	42	65	62
1A2B	Bottom-refuge Nonvisual Pelagivores (8)	midshipman	42	56	57
2C1	Benthic Pursuing Benthivores (5)	combfish	32	66	51
1C1	Water-Column Diurnal Benthopelagivores	seaperch	40	42	48
2D1B	Benthic Excavating Benthivores (9)	eelpout	34	54	46
2C2D	Benthic Ambushing Benthoplagivores, Large	scorpionfish	22	29	43
2C2C	Benthic Ambushing Benthivopelagivores, Med. (10)	sculpin	40	53	41
1A2A	Bottom-refuge Visual Pelagivores (7)	rockfish	29	57	40
1A1	Water-Column Schooling Pelagivores	queenfish	40	38	32
1C2	Water-Column Nocturnal Benthopelagivores	croaker	33	6	25
2C2A	Benthic Ambushing Benthoplagivores, Tiny	pygmy poacher	6	7	15
1B2	Water-Column Cruising Pelagobenthivores	sandbass	24	4	9
1D	Water-Column Cruising Benthivores	cusk-eel	17	16	7
1B1	Water-Column Schooling Pelagobenthivores	shiner perch	10	0	4

Increase (light shading)
Decrease (dark shading)

Numbers in parentheses give rank of guild in 1994.
*FO = Frequency of Occurrence
SC Shelf = Southern California shelf (2-202 m): includes mainland shelf, islands, and bays/harbors.

Changes in the croaker guild may be due to chance. The white croaker (the predominant representative of the croaker guild) on the mainland shelf is a schooling species (Clarke *et al*. 1967), and trawling may miss schools of fish since it does not specifically locate schools. In contrast, the decrease in the rockfish guild (primarily represented by stripetail rockfish on the soft-bottom habitat of the shelf), may be part of a general decrease in rockfish populations in southern California and rockfish catches in California as a whole since the early 1980s (Love *et al*. 1998, Leet *et al.* 2001, Love *et al*. 2002) This decrease is probably due to a reduction in recruitment success due to overfishing (in central and northern California) and long-term changes in ocean conditions from cool conditions in the 1970s to warm since the early 1980s (Smith 1995, Love *et al*. 1998). The causes of changes in the other guilds are less easily interpreted.

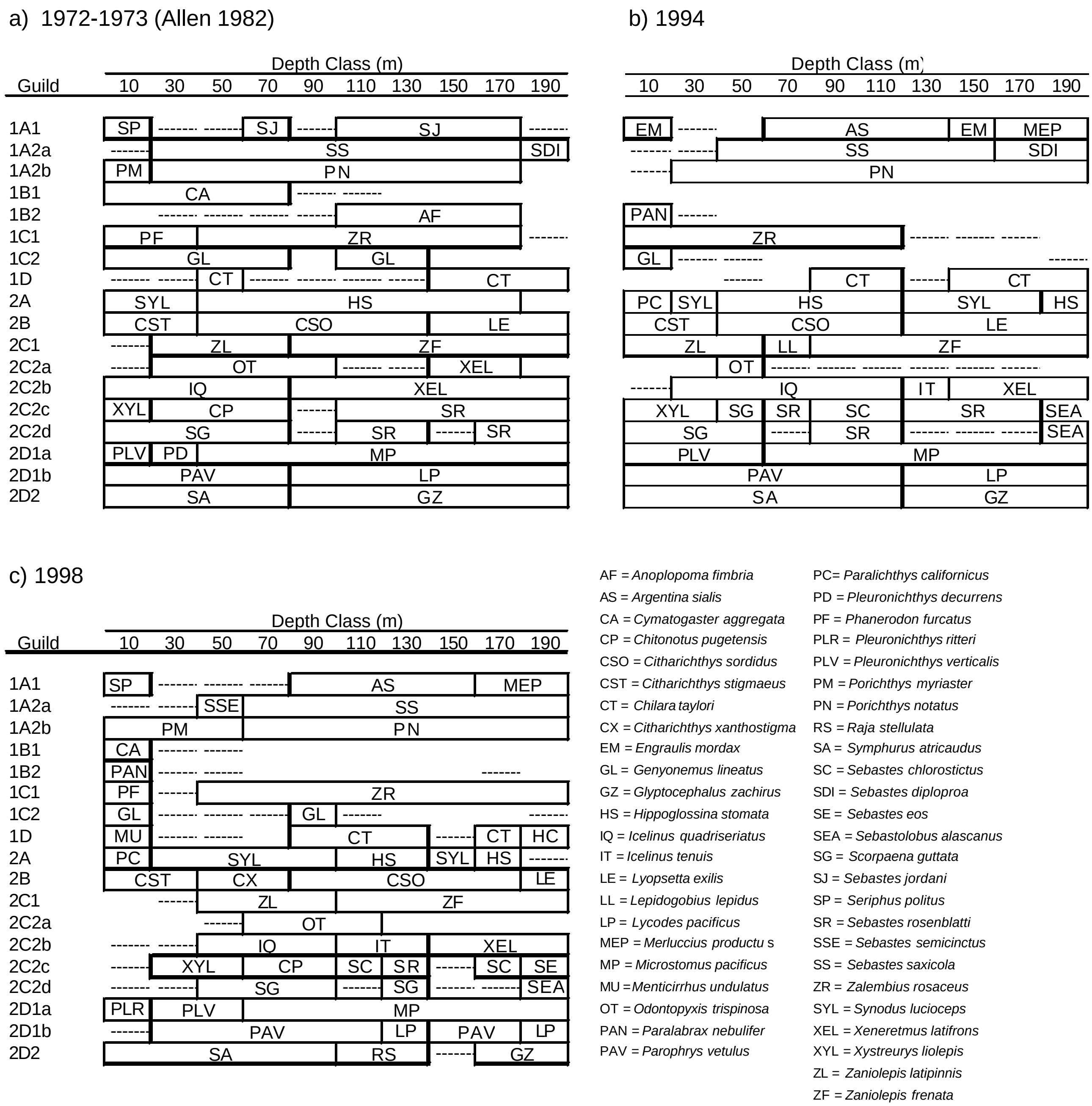
Changes in Functional Organization of the Communities

Allen (1982) described the functional organization of the soft-bottom fish community of the southern California shelf. This description of the community was based on the depth displacement patterns of species within each of 18 foraging guilds. The community model in Allen (1982) was based on data collected in 1972-1973 during a cool regime. Although the oceanic regime has warmed since the 1980s (Smith 1995), the model provides a framework for examining changes in the functional organization of the communities with changing ocean regimes. Thus, the organization of the soft-bottom fish communities of the southern California shelf can be compared in three different oceanic periods: 1972-1973 (cool regime) (Allen 1982); 1994 (warm regime) (Allen *et al.* 1998); and shortly following an El Niño event (1998; this study) (Figure 78). In general, the distribution of the 18 foraging guilds across the depth range of 10-200 m was most complete in 1972-1973, with relatively few guilds showing large gaps in occurrence (these largely occurring with some midwater pelagobenthivore guilds (Guilds 1B1 and 1B2) and with the cruising benthivore guild (1D). In contrast, relatively large gaps of occurrence occurred among cruising nocturnal benthopelagivores (1C2), and benthic ambushing benthopelagivores sizes A (pygmy poacher guild; 2C2a) and D (scorpionfish guild; 2C2d). The organization is generally stable if a single dominant guild member occupies a broad depth range on the shelf. However, if an expected dominant (from Allen 1982) is missing, there may be no good replacement. This is particularly apparent in the outer shelf representative of the sculpin (2C2c) and scorpionfish guild (2C2d). Whereas the greenblotched rockfish (SR) was dominant on the outer shelf in these guilds in 1972-1973, larger members of this species (2C2d) were rare in 1994, and were very rare in 1998, with many closely related species (green spotted rockfish, SC; pink rockfish, SE) and some less closely related species (shortspine thornyhead, SEA; California scorpionfish, SG) being caught within the outer shelf. This suggests that the best-adapted species of this guild for the outer shelf soft-bottom habitat of southern California is the greenblotched rockfish.

Different guilds showed differing patterns of depth displacement during the three oceanic periods examined (Figure 79). In the bottom-refuge nonvisual pelagivore (midshipman) guild, the specklefin midshipman (PM) occupies the inner shelf and the plainfin midshipman (PN) occupies the middle and outer shelf (Figure 79a). In this guild, the inner shelf species (specklefin midshipman) showed a limited inner shelf distribution in the cold period (1972-1973), was rare on the inner shelf in the warm period (1994), and expanded its range to include both the inner shelf and shallow middle shelf following the 1998 El Niño event, displacing the plainfin midshipman as the dominant guild member at depths to 60 m.

In the benthic ambushing benthopelagivore guild (sculpin/poacher guild), the dominant of the inner and middle shelf, yellowchin sculpin (IQ) in the cool period, retreated from the inner shelf in 1994 and moved even deeper in 1998 (Figure 79b). In addition, the outer shelf dominant (blacktip poacher, XEL) retreated in 1994 and 1998 from the middle shelf (where it was found in 1972-1973). In these warmer years, both species were replaced by the spotfin sculpin (IT) around the shelf break (at 100-130 m).

In the benthic extracting benthivore guild (turbot guild), Dover sole (MP) was the clear dominant on the middle shelf and outer shelf in all years (Figure 79c). However, each period differed in the pattern of dominance on the inner shelf. In 1972-1973, the hornyhead turbot (PLV) was the dominant species at depths of 0-20 m with curlfin sole (PD) being the dominant at 20-40 m. In 1994, hornyhead turbot was the only dominant form in 0-40 m. However, in 1998, the spotted turbot (PLR) was dominant at 0-20 m, and the hornyhead turbot from 20-60 m. The curlfin sole is a cool water species that ranges as far north as Alaska (Eschmeyer *et al.* 1983), whereas the hornyhead turbot and spotted turbot generally occur from southern California to southern Baja California. However, in southern California the spotted turbot appears to prefer warmer waters as it generally occurs in bays and the shallow inner shelf while the



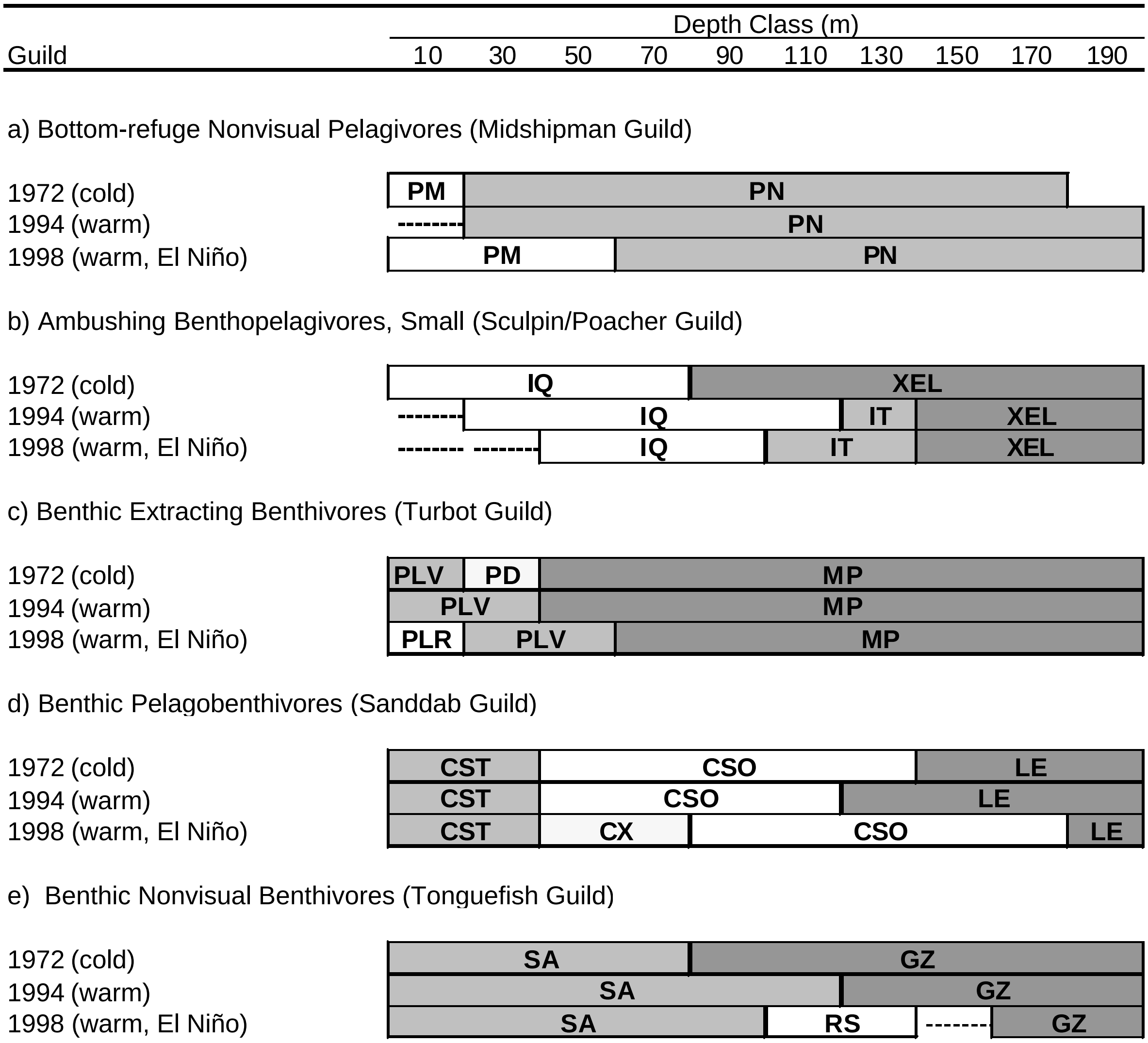
Boxes indicate that guild occurred in 20% or more of stations in depth class.

Dashes indicate guild occurred in less than 20% of stations in depth class.

Dominant species in guild is identified by abbreviations.

See Glossary G2 for common names of fish species.

Figure 78. Functional organization of demersal fish communities on the southern California shelf in 1972-1973 (Allen 1982), 1994 (Allen et al. 1998), and 1998.



CSO = *Citharichthys sordidus*
CST = *Citharichthys stigmaeus*
CX = *Citharichthys xanthostigma*
GZ = *Glyptocephalus zachirus*
IQ = *Icelinus quadriseriatus*
IT = *Icelinus tenuis*
LE = *Lyopsetta exilis*
MP = *Microstomus pacificus*
PD = *Pleuronichthys decurrens*
PLR = *Pleuronichthys ritteri*
PLV = *Pleuronichthys verticalis*
PM = *Porichthys myriaster*
PN = *Porichthys notatus*
RS = *Raja stellulata*
SA = *Symphurus atricaudus*
XEL = *Xeneretmus latifrons*

See Glossary G2 for common names of fish species.

Figure 79. Comparison of changes in selected guilds of demersal fish communities on the mainland shelf of southern California in 1972-1973 (Allen 1982), 1994 (Allen et al. 1998) and 1998.

hornyhead turbot occurs much deeper on the shelf (Eschmeyer *et al*. 1998, Allen *et al.* 1998). Thus, in the cool period, a coldwater species partially replaced the typical inner/middle shelf dominant whereas following the El Niño event, a warmwater species partially replaced this species.

In the benthic pelagobenthivore (sanddab) guild, the depth displacement pattern was similar in cool and warm periods but was altered dramatically in 1998 (Figure 79d). The inner shelf dominant (speckled sanddab, CST) remained unchanged in all three years, and as well as the order of displacement of the middle shelf and outer shelf dominants (Pacific sanddab, CSO, and slender sole, LE). However, the Pacific sanddab shifted much deeper in 1998, in part due to the intrusion of a southerly species (longfin sanddab, CX) on the shallow middle shelf (primarily on the central and southern mainland shelf). Pacific sanddab became dominant over much of the outer shelf, limiting the dominance of the slender sole (an outer shelf-mesobenthal species; Allen and Smith 1988) to the deeper outer shelf.

In the benthic nonvisual benthivore (tonguefish) guild, the inner shelf and middle shelf dominant (California tonguefish, SA) remained relatively constant in all periods (Figure 79e). However, the occurrence of the outer shelf dominant (rex sole, GZ) decreased dramatically. Whereas in 1994 the expansion of the California tonguefish suggests that it may simply be becoming more abundant than rex sole on the middle shelf, the rare occurrence of the rex sole on the shallow outer shelf without replacement by California tonguefish indicates that rex sole retreated from the shallow middle shelf. The only species that occurred in that zone that is similar in foraging behavior was starry skate (RS) (all individuals collected were very small juveniles).

Thus, responses of different foraging guilds to changing ocean conditions varied between different oceanic periods. In some cases, these suggest a response to ocean warming of the 1980s (Figures 79b,c). During this period, ocean temperatures increased and zooplankton abundance decreased (Roemmich and McGowan 1995, Smith 1995). In all cases (Figures 79a, b, c, d, and e), there appears to be an El Niño effect in 1998 that is greater than the differences between 1972-1973 and 1994. These responses occur primarily on the inner shelf and shallow middle shelf, but in some guilds, responses occurred at the interface of the middle shelf and outer shelf. During an El Niño, the thermocline deepens and bottom water temperatures are warmer on the shelf (Dark and Wilkins 1994, Hayward 2000), perhaps causing species to expand or contract their depth or geographic ranges. Some changes occurring during this period may be related to zooplankton abundance or decreased transport of larvae in the California Current from the north, whereas others may be due to movement of juveniles and adults to more desirable conditions.

BIOACCUMULATION

INTRODUCTION

For more than 50 years, chemical contaminants have been discharged into coastal waters of the Southern California Bight via numerous point and nonpoint sources. These contaminants are dispersed into the water column in a dissolved state or on particulates, and are accumulated by fishes via contact with water, sediment, or food sources. High levels of contaminants (particularly chlorinated hydrocarbons such as DDT and PCBs) have been found in many southern California fishes for more than three decades (Mearns *et al*. 1991). Levels near Los Angeles (particularly on the Palos Verdes Shelf) have long been known to be particularly high. The first assessment of the areal extent of contaminated fishes on the mainland shelf of southern California was made in 1994 (Allen *et al*. 1998, Schiff and Allen 2000). Although this study provided substantial background information on the fauna of the southern California mainland shelf (10-202 m depth), it was not able to assess the extent of area with fish with contamination levels of concern because 1) no single species occurred across the entire shelf; and 2) no threshold of concern had been established for fish liver contamination for the species examined in that survey. Since the 1994 survey, Allen *et al*. (2002) showed that sanddab guild species (Allen 1982) had similar uptake of DDT when exposed to the same sediments, and these, in combination, occurred across the entire shelf. In addition, by examining contamination in whole fish composites of the guild species, contaminant levels could be compared to predator-risk (e.g., wildlife protection) guidelines or thresholds (NAS 1974; Environment Canada 1997, 1998).

The primary objective of this chapter is to determine the extent of area on the southern California shelf with contaminant levels of concern. The study will focus on whole fish composites of the sanddab guild species and on DDT, PCBs, and chlordane. In addition to the primary objective of this chapter, a secondary objective is to describe the general distribution of fish tissue contamination in these species by region, shelf zone (depth), and anthropogenic subpopulation on the southern California mainland and island shelf, and in bays and harbors.

RESULTS

Distribution of Contamination in Fish

Pesticides

DDT. Total DDT was analyzed in sanddab guild composites from 225 stations (Table 58, Appendix F1). Of these, 99% had detectable levels of tDDT, with concentrations ranging from 0.0 (nondetect) to 10,462.4 µg/kg (ppb) (Table 58). Concentrations of *p,p*-DDE were higher than the other five DDT isomers analyzed in all composites (Appendix F2). All composites from the central and southern mainland regions, and from the southeast Channel Islands, had detectable concentrations. The highest values occurred on the Palos Verdes Shelf (Figure 80) and hence occurred in the central mainland region within the middle shelf large POTW subpopulation (Table 58). The lowest values occurred in the northern mainland region within the inner shelf "other mainland" subpopulation and at Santa Catalina Island in the middle shelf zone (Table 58, Figure 80).

Table 58. Summary of tDDT (µg/kg) concentrations in sanddab guild composites by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI	% of Guild Above Threshold*
Region								
Mainland	170	99	0.0	10,462.4	20.5	146.6	72.0	76
North	42	95	0.0	202.9	10.5	20.3	8.1	60
Central	71	100	2.8	10,462.4	42.9	361.6	184.3	92
South	57	100	2.1	70.0	16.2	17.4	3.0	96
Island	55	98	0.0	160.2	22.1	25.4	7.9	59
Cool (NW Channel Islands)	14	100	5.2	35.7	18.7	19.1	6.1	45
Warm	41	98	0.0	160.2	27.5	37.1	16.7	93
SE Channel Islands	15	100	15.1	160.2	29.1	43.0	23.2	100
Santa Catalina Island	26	96	0.0	65.7	19.2	23.1	6.4	82
Shelf Zone								
Bays and Harbors (2-30 m)	18	100	7.4	234.7	30.4	54.7	27.0	92
Ports	3	100	18.1	42.0	18.5	26.4	12.5	100
Marinas	9	100	7.4	234.7	48.4	83.0	51.8	83
Other Bay	6	100	26.0	70.0	27.5	34.4	9.6	100
Inner Shelf (2-30 m)	46	96	0.0	184.3	9.7	22.3	14.1	81
Small POTWs	9	100	2.6	19.2	3.8	6.0	3.2	22
River Mouths	8	100	3.0	48.2	9.2	21.1	10.8	47
Other Mainland	25	92	0.0	184.3	9.8	23.4	15.3	23
Island	4	100	6.8	11.6	7.0	9.0	2.2	0
Middle Shelf (31-120 m)	119	99	0.0	10,462.4	22.0	129.0	67.7	59
Small POTWs	14	100	2.1	30.6	5.5	7.3	3.4	3
Large POTWs	32	100	13.5	10,462.4	160.2	1,415.0	910.2	98
Mainland non-LPOTW	42	100	4.2	1,061.4	21.6	115.4	89.9	82
Island	31	97	0.0	160.2	19.3	24.3	10.3	45
Outer Shelf (121-202 m)	42	100	2.0	217.6	29.3	38.2	12.6	87
Mainland	22	100	4.2	217.6	29.5	48.3	26.8	77
Island	20	100	2.0	63.0	28.5	30.3	4.1	97
Total (all stations)	225	99	0.0	10,462.4	21.8	96.6	44.3	66

* Threshold = 14 µg/kg, Environment Canada (1997).

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

Median and mean concentrations of tDDT differed substantially. Overall, the median concentration was 21.8 µg/kg and the mean concentration was 96.6 µg/kg (Table 58). Median concentrations ranged from 3.8 µg/kg for the inner shelf small POTW subpopulation to 160.2 µg/kg for the middle shelf large POTW subpopulation. Mean concentrations ranged from 6.0 to 1,415.0 µg/kg, with low and high values occurring in the same subpopulations as the median. The greatest difference between these parameters occurred in the middle shelf large POTW subpopulation (160.2 µg/kg median, 1,415.0 µg/kg mean).

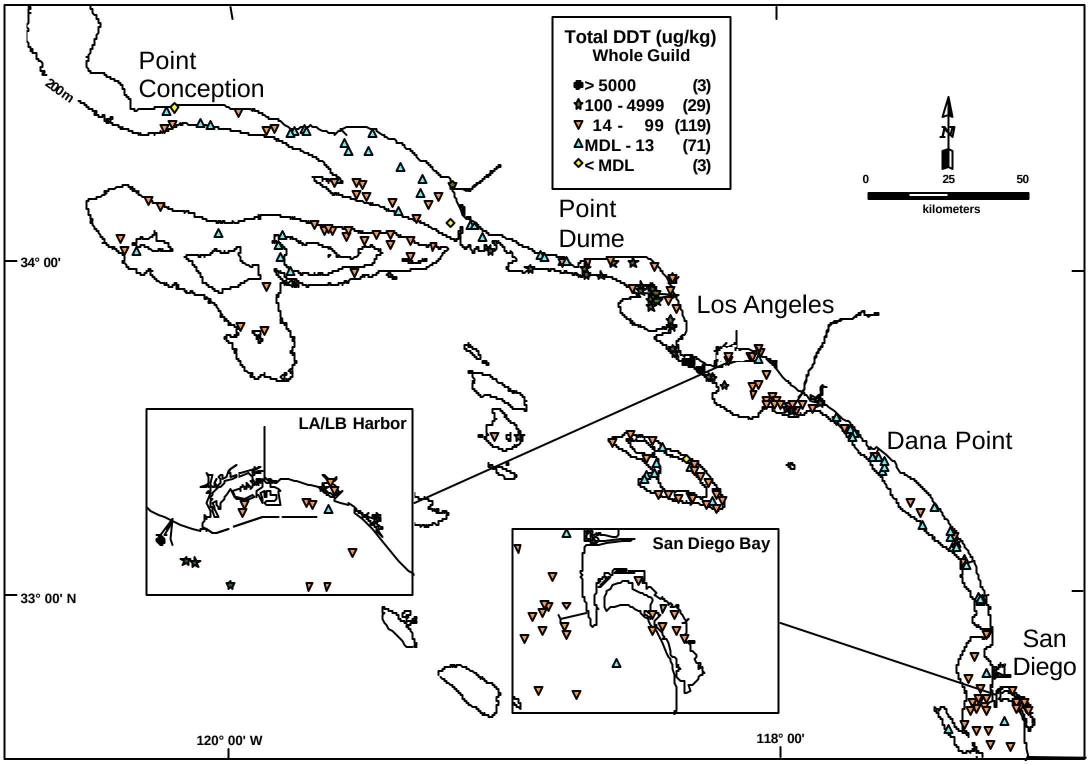


Figure 80. Distribution of tDDT concentrations in sanddab guild fishes on the southern California shelf at depths of 2-202 m, July-September 1998.

Total DDT concentrations were above the predator-risk guideline (Environment Canada 1997) of 14 µg/kg in 66% of the sanddab guild population (= fish) on the southern California shelf (Table 58). By region, 76% of the fish of this guild in the mainland region and 59% in the island region were above this guideline. In the mainland region, the percent of fish above the threshold increased from north to south (60 to 96%) (Table 58, Appendix F3). In the island region, 100% of the fish in the southeast Channel Islands had tDDT levels above the threshold, whereas only 45% were above the threshold at the northwest Channel Islands. By depth, the percent of fish above the threshold was highest in the bays and harbors (92%) and lowest on the middle shelf (59%). Within the human influence subpopulations, the percent of fish above the threshold was highest in the port and “other bays” (100%), and lowest on the island inner shelf zone (0%) and middle shelf small POTW subpopulation (3%).

Total DDT levels were also above the predator-risk guideline in 71% of the area of the southern California shelf (Table 59). Stations below the guideline were largely concentrated along the northern and southern mainland shelf areas, around Santa Rosa Island, and on the central Santa Catalina Island shelf (Figure 81). The percent of area over the threshold was similar for the mainland (70%) and island regions (74%) (Table 59, Appendix F4). In the mainland region, the percent of area above the threshold was highest (95%) in the central region and lowest (77%) in the northern region. At the islands, 100% of the southeast Channel Islands area, 69% of the Santa Catalina Island area, and 65% of the northwest Channel Islands area were above the threshold. By depth, the percent of area above the threshold was highest (91%) in the bays and harbors, and lowest (35%) on the inner shelf, with the outer shelf (86%) and middle shelf (76%) being intermediate. For human influence subpopulations, the percent of area above the threshold was highest (100%)

Table 59. Percent of area by subpopulation on the southern California shelf with tDDT concentrations in sanddab guild species above the predator-risk guideline[a], July-September 1998.

	Percent of Area					
	Species Name[b]					
Subpopulation	CX	CSo	CSt	PC	LE	Guild
Region						
Mainland	78	82	54	62	76	70
Northern	1	77	24	100	83	42
Central	96	100	100	82	80	95
Southern	88	85	0	56	48	77
Island	60	73	44	---	95	74
Cool (NW Channel Islands)		64	37	---	100	65
Warm	60	93	13	---	91	91
SE Channel Islands		100	100	---	100	100
Santa Catalina Island	60	72	50	---	80	69
Shelf Zone						
Bays and Harbors (2-30 m)	---	---	---	91	---	91
Ports	---	---	---	100	---	100
Marinas	---	---	---	79	---	79
Other Bay	---	---	---	100	---	100
Inner Shelf (2-30 m)	32	0	37	51	---	35
Small POTWs	0	---	0	100	---	10
River Mouths	---	---	50	50	---	50
Other Mainland	33	0	40	50	---	37
Island	---	---	0	---	---	0
Middle Shelf (31-120 m)	81	75	66	---	---	76
Small POTWs	17	---	---	---	---	7
Large POTWs	96	100	60	---	---	97
Mainland non-LPOTW	82	91	74	---	---	83
Island	60	67	58	---	---	68
Outer Shelf (121-202 m)	0	85	0	---	84	86
Mainland	0	63	---	---	76	70
Island	---	98	0	---	95	98
Total (all stations)	77	76	48	62	84	71

[a] DDT guideline = 14 µg/kg, Environment Canada (1997)

[b] CX = *Citharichthys xanthostigma* ; CSo = *Citharichthys sordidus* ; CSt = *Citharichthys stigmaeus* ; PC = *Paralichthys californicus* ; LE = *Lyopsetta exilis* .

POTW = Publicly owned treatment work monitoring areas.

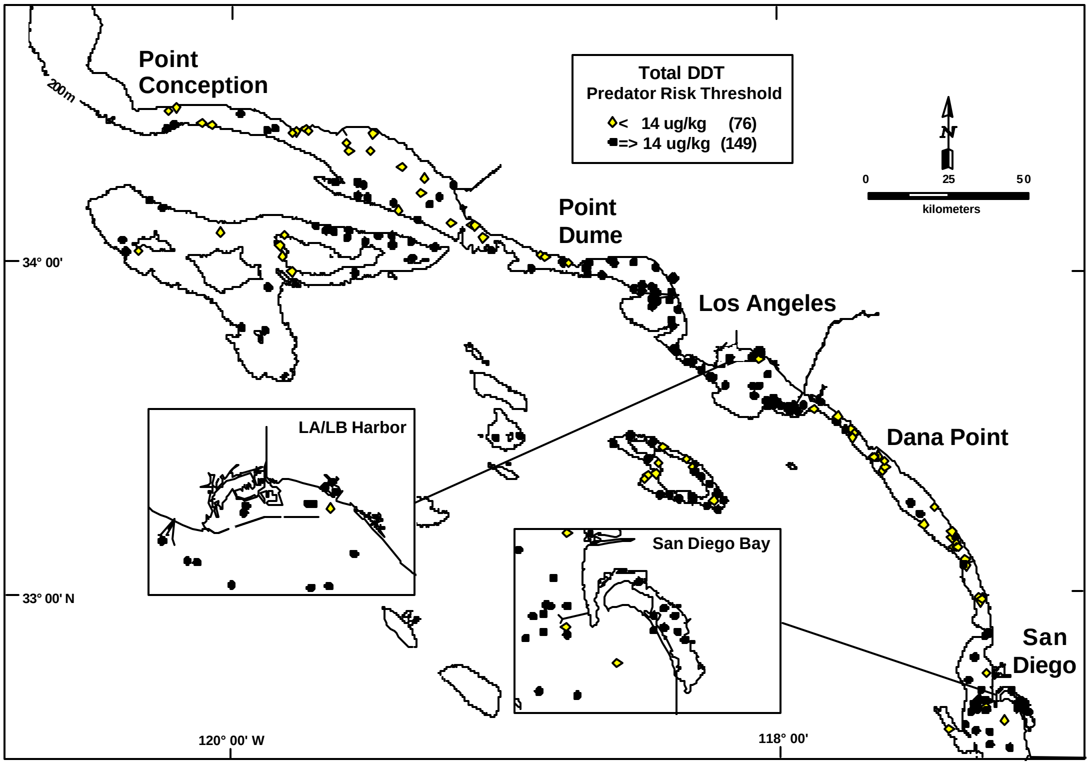


Figure 81. Distribution of sanddab guild fishes with concentrations of tDDT greater than predator-risk guideline on the southern California shelf at depths of 2-202 m, July-September 1998.

in ports and "other bays", and lowest on the island inner shelf (0%) and the middle shelf small POTWs (7%). The distribution of DDT above the guideline was centered around the central and southern mainland regions, southeast Channel Islands, and Santa Catalina Island (Figure 81). Within the area above threshold, highest DDT concentrations (>1,400 µg/kg) were on the Palos Verdes Shelf, followed by the Hyperion outfall area in Santa Monica Bay; with relatively high levels at the Orange County Sanitation District outfall (all in the range of 141-1,400 µg/kg) (Figure 80). The remaining areas above the threshold had lower concentrations (15-140 µg/kg).

Among sanddab guild species, detection rates were 100% for longfin sanddab, slender sole, and California halibut, and over 95% for Pacific sanddab and speckled sanddab (Appendices F5 through F9). The highest composite concentrations by species were as follows: Pacific sanddab, 10,462.0 µg/kg; longfin sanddab, 7,606.4 µg/kg; speckled sanddab, 768.7 µg/kg; California halibut, 234.7 µg/kg; and slender sole, 217.6 µg/kg. Slender sole had the highest percent of area (84%) of tDDT above the predator-risk guideline (all outer shelf zone, Table 59), followed by longfin sanddab with 77% (mostly mainland middle shelf zone), Pacific sanddab with 76% (mostly mainland and island middle shelf zone), California halibut with 62% (bays and harbors and inner shelf zone), and speckled sanddab with 48% (inner and middle shelf zones).

Chlordane. Total chlordane was analyzed in sanddab guild composites from 225 stations (Table 60, Appendix F1). Of these, 8% had detectable levels of chlordane, with concentrations ranging from 0.0 (nondetect) to 14.6 µg/kg (Table 60). The two isomers, α–chlordane and γ–chlordane (chlordane-a and chlordane-g), did not occur together in the same composite; α–chlordane was detected more frequently

Table 60. Summary of tChlordane (µg/kg) concentrations in sanddab guild composites by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	170	8	0.0	14.6	0.0	0.2	0.2
Northern	42	2	0.0	1.5	0.0	0.0	0.1
Central	71	18	0.0	14.6	0.0	0.6	0.4
Southern	57	0	0.0	0.0	0.0	0.0	0.0
Island	55	5	0.0	11.4	0.0	0.1	0.1
Cool (NW Channel Islands)	14	7	0.0	11.4	0.0	0.1	0.2
Warm	41	5	0.0	1.0	0.0	0.1	0.1
SE Channel Islands	15	7	0.0	0.6	0.0	0.1	0.1
Catalina Island	26	4	0.0	1.0	0.0	0.0	0.1
Shelf Zone							
Bays and Harbors (2-30 m)	18	17	0.0	5.2	0.0	0.6	0.7
Ports	3	0	0.0	0.0	0.0	0.0	0.0
Marinas	9	33	0.0	5.2	0.0	1.4	1.4
Other Bay	6	0	0.0	0.0	0.0	0.0	0.0
Inner Shelf (2-30 m)	46	2	0.0	11.4	0.0	0.2	0.3
Small POTWs	9	0	0.0	0.0	0.0	0.0	0.0
River Mouths	8	0	0.0	0.0	0.0	0.0	0.0
Other Mainland	25	0	0.0	0.0	0.0	0.0	0.0
Island	4	25	0.0	11.4	0.0	3.0	5.0
Middle Shelf (31-120 m)	119	8	0.0	14.6	0.0	0.2	0.2
Small POTWs	14	0	0.0	0.0	0.0	0.0	0.0
Large POTWs	32	19	0.0	14.6	0.0	1.5	1.2
Mainland Non-LPOTW	42	7	0.0	3.3	0.0	0.2	0.3
Island	31	3	0.0	0.6	0.0	0.0	0.0
Outer Shelf (121-202 m)	42	7	0.0	2.0	0.0	0.1	0.1
Mainland	22	9	0.0	2.0	0.0	0.2	0.2
Island	20	5	0.0	1.0	0.0	0.0	0.0
Total (all stations)	225	8	0.0	14.6	0.0	0.2	0.1

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

than γ–chlordane (Appendix F2). All samples had concentrations below the National Academy of Sciences (NAS) threshold of 50 µg/kg (NAS 1974). The highest values occurred near the Los Angeles County outfall (central mainland region middle shelf large POTW subpopulation) and on the west side of Santa Cruz Island (northwest Channel Islands) (Figure 82). The median concentration of chlordane was 0 µg/kg for all subpopulations and the overall mean concentration was 0.2 µg/kg (Table 60). Detection rates for individual species were similar to those for the guild, with values ranging from 6-12% (Appendices F10 through F14).

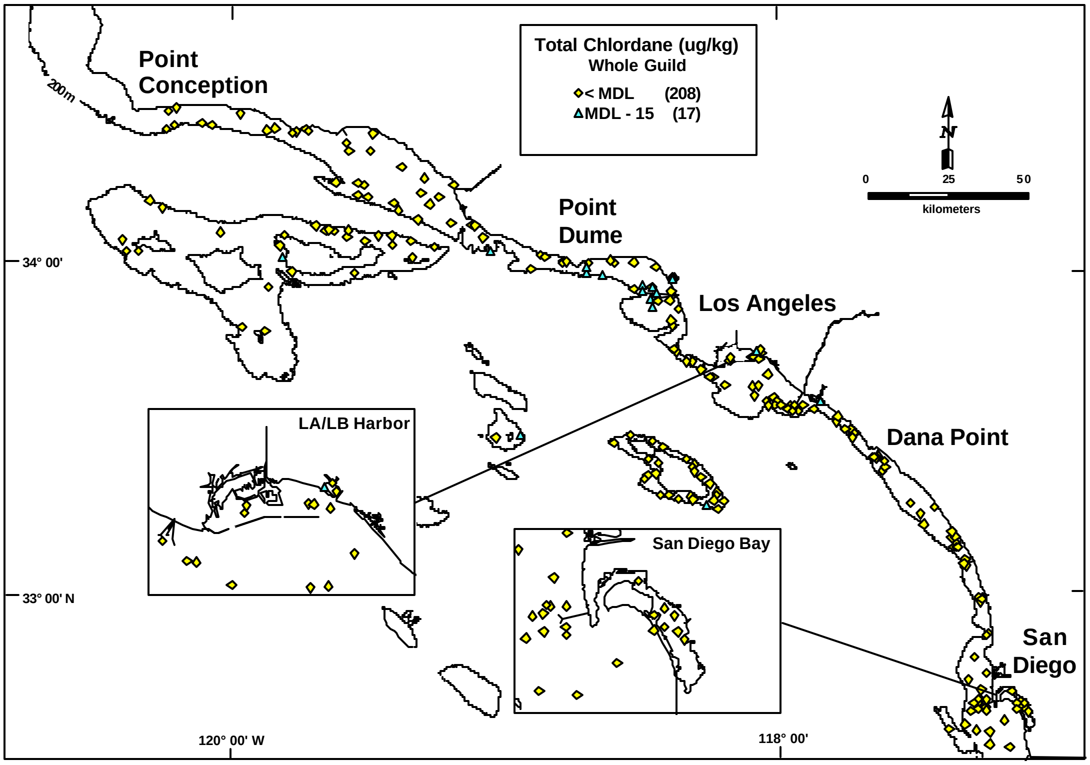


Figure 82. Distribution of tChlordane concentrations in sanddab guild fishes on the southern California shelf at depths of 2-202 m, July-September 1998.

Polychlorinated Biphenyls (PCBs)

Total PCB. PCBs were analyzed in sanddab guild composites from 225 stations (Table 61, Appendix F1). Of these, 44% had detectable levels of PCBs, with concentrations of total PCB ranging from 0.0 (nondetect) to 710.3 (µg/kg) (Table 61). The overall median and mean concentrations were 0.0 and 10.3 µg/kg, respectively. The highest values occurred in the central mainland region middle shelf large POTW subpopulation on the shelf off of Los Angeles (including the Palos Verdes Shelf), as well as in the bays and harbors (including LA/LB Harbor and San Diego Bay) (Table 61, Figure 83). These "ports" had a 100% detection rate. The lowest values occurred among the northern and southern mainland subpopulations and most of the Channel Islands. Most of the species had detection rates similar to that for the feeding guild, with values between 31 and 49% (Appendix F15 through F18). However, California halibut had a higher detection rate of 68% (Appendix F19), which reflects occurrence of this species primarily in bays and harbors, where PCB contamination was found to be high.

Mammal PCB Toxicity Equivalency Quotients (TEQs). Nine of the PCB congeners detected in this study had potential toxicity factors (TEFs) assigned to their concentrations (see Methods, Table 3). These congeners included PCB118, PCB105, PCB114, PCB77, PCB123, PCB156, PCB167, PCB81, and PCB169 (Appendix F20). Of the 225 samples collected, 26% had detectable levels of the PCB congeners that are toxic to marine mammals (Table 62). The PCB/TEQ concentrations toxic to mammals ranged from 0.0 (nondetect) to 30.9 ng/kg (pptr). The overall median concentration was 0.0 ng/kg; the overall mean concentration was 0.5 ng/kg. The samples with potential risk to mammals occurred in the central mainland region middle shelf large POTW subpopulation off of Los Angeles, including off Palos Verdes, near the Los Angeles County ocean outfall, and in bays and harbors, primarily San Diego Bay (Table 62, Figure 84).

Table 61. Summary of tPCB (µg/kg) concentrations in sanddab guild composites by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	170	43	0.0	710.3	0.0	15.1	6.9
Northern	42	21	0.0	19.4	0.0	1.8	1.9
Central	71	76	0.0	710.3	7.1	37.2	16.5
Southern	57	18	0.0	323.0	0.0	3.0	2.4
Island	55	49	0.0	69.8	0.0	3.3	3.2
Cool (NW Channel Islands)	14	36	0.0	9.3	0.0	0.6	0.8
Warm	41	54	0.0	69.8	3.0	8.2	8.2
SE Channel Islands	15	67	0.0	69.8	3.4	10.3	11.5
Santa Catalina Island	26	46	0.0	27.7	0.0	3.1	2.3
Shelf Zone							
Bays and Harbors (2-30 m)	18	78	0.0	323.0	19.9	86.7	50.4
Ports	3	100	62.8	254.0	155.6	188.4	100.5
Marinas	9	67	0.0	103.3	8.8	25.4	21.2
Other Bay	6	83	0.0	323.0	12.1	114.2	107.3
Inner Shelf (2-30 m)	46	26	0.0	36.6	0.0	3.4	3.7
Small POTWs	9	11	0.0	13.8	0.0	1.4	2.7
River Mouths	8	50	0.0	18.4	0.0	4.4	4.4
Other Mainland	25	20	0.0	36.6	0.0	3.4	4.0
Island	4	50	0.0	9.3	0.2	2.9	3.9
Middle Shelf (31-120 m)	119	46	0.0	710.3	0.0	13.0	6.7
Small POTWs	14	0	0.0	0.0	0.0	0.0	0.0
Large POTWs	32	72	0.0	710.3	28.4	114.9	58.2
Mainland non-LPOTW	42	40	0.0	105.4	0.5	13.1	10.3
Island	31	48	0.0	69.8	0.0	3.5	4.3
Outer Shelf (121-202 m)	42	45	0.0	48.4	0.0	3.6	2.5
Mainland	22	41	0.0	48.4	0.0	5.1	4.7
Island	20	50	0.0	27.7	0.0	2.4	2.0
Total (all stations)	225	44	0.0	710.3	0.0	10.3	4.5

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

For the Bight as a whole, 7% of the sanddab guild fish were estimated to be above the mammal predator-risk guideline for PCB/TEQs of 0.79 ng/kg TEQ (Table 62) (Environment Canada 1998). By region, 8% of the fish of this guild in the mainland region and 6% in the island region were above this guideline. The largest percentage of fish with PCB/TEQ levels above the guideline were from the central mainland region middle shelf large POTW subpopulation (37%) and in the bays and harbors (26%) (Table 62, Appendix F21). These subpopulations were also the ones with the highest levels of total PCB.

Similarly, 8% of the area of the southern California shelf had fish with PCB/TEQ levels above the mammal predator-risk guideline of 0.79 ng/kg TEQ (Table 63). The percent of area over the threshold was similar for

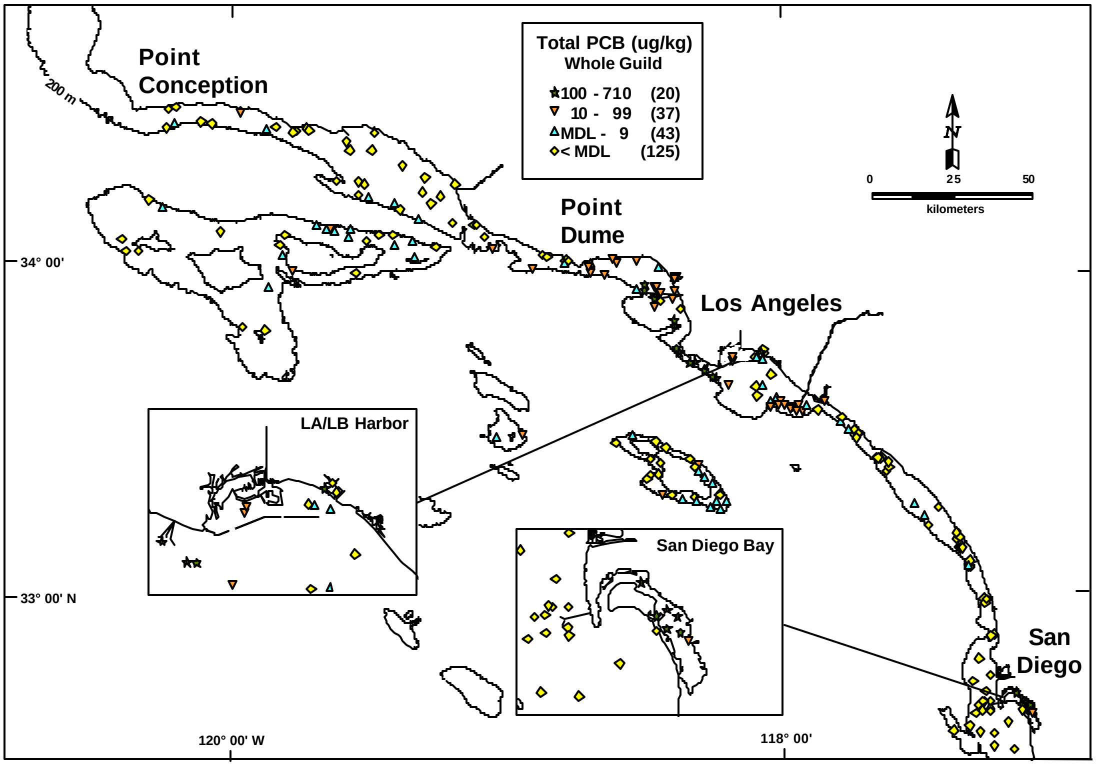


Figure 83. Distribution of tPCB concentrations in sanddab guild fishes on the southern California shelf at depths of 2-202 m, July-September 1998.

the mainland (10%) and island regions (6%) (Table 63, Appendix F22). In the mainland region, the area above the threshold was primarily in the central region and in the bays and harbors. At the islands, the area above the threshold for mammals was primarily the southeast Channel Islands subpopulation. For human-influence subpopulations, the percent of area above threshold was highest in the ports (67%), large POTWs (44%), and "other bays" (42%).

Detection of PCBs with potential toxicity to mammals was variable among sanddab guild species, with detection rates between 18 and 56% for Pacific sanddab and California halibut, respectively (Appendices F23 through F27). The PCB/TEQs were above the mammal predator-risk threshold in 13% of the area where longfin sanddabs were collected (mainland middle shelf zone), 10% for California halibut (bays and harbors and inner shelf zone), 9% for Pacific sanddab areas (mainland and island middle shelf zone), 3% for slender sole (mostly outer shelf zone), and 1% for speckled sanddab (inner and middle shelf zones) (Table 63).

Bird PCB TEQs. The same nine potentially toxic PCB congeners found in mammals (above) had TEFs assigned to their concentrations. However, the TEFs for birds were different from those of mammals (see Methods, Table 3). These congeners included PCB118, PCB105, PCB114, PCB77, PCB123, PCB156, PCB167, PCB81, and PCB169 (Appendix F20). Of the 225 samples collected, 26% had detectable levels of the PCB congeners that are toxic to birds (Table 64). The PCB/TEQ concentrations toxic to birds ranged from 0.0 (nondetect) to 466.7 ng/kg. The overall median concentration was 0.0 ng/kg; the overall mean concentration was 7.7 ng/kg. The majority of the samples with potential risk to birds occurred in the central mainland region middle shelf large POTW subpopulation off of Los Angeles, including Palos Verdes and near the Los Angeles County ocean outfall (Table 64, Figure 85). A few samples with levels higher than the

Table 62. Summary of PCB mTEQ (ng/kg) concentrations in sanddab guild composites by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998, July-September 1998. m = mammal.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI	% of Guild Above Threshold*
Region								
Mainland	170	28	0.00	30.89	0.00	0.83	1.10	8
Northern	42	7	0.00	0.22	0.00	0.00	0.00	0
Central	71	53	0.00	30.89	0.07	2.20	3.00	38
Southern	57	11	0.00	3.00	0.00	0.02	0.02	< 1
Island	55	22	0.00	1.80	0.00	0.10	0.09	6
Cool (NW Channel Islands)	14	14	0.00	0.16	0.00	0.01	0.02	0
Warm	41	24	0.00	1.80	0.00	0.26	0.22	22
SE Channel Islands	15	47	0.00	1.80	0.04	0.35	0.31	34
Santa Catalina Island	26	12	0.00	1.08	0.00	0.06	0.08	3
Shelf Zone								
Bays and Harbors (2-30 m)	18	72	0.00	3.00	0.19	1.00	0.55	26
Ports	3	67	0.00	2.80	1.20	1.70	1.40	25
Marinas	9	67	0.00	2.90	0.14	0.64	0.63	23
Other Bay	6	83	0.00	3.00	0.15	1.10	1.00	31
Inner Shelf (2-30 m)	46	13	0.00	0.74	0.00	0.03	0.03	0
River Mouths	8	25	0.00	0.74	0.00	0.12	0.16	0
Other Mainland	25	8	0.00	0.37	0.00	0.03	0.04	0
Island	4	25	0.00	0.16	0.00	0.04	0.07	0
Middle Shelf (31-120 m)	119	28	0.00	30.89	0.00	0.76	1.00	8
Small POTWs	14	0	0.00	0.00	0.00	0.00	0.00	0
Mainland non-LPOTW	42	21	0.00	30.90	0.00	1.30	2.00	12
Island	31	26	0.00	1.80	0.00	0.10	0.12	5
Outer Shelf (121-202 m)	42	17	0.00	0.82	0.00	0.07	0.06	5
Mainland	22	18	0.00	0.51	0.00	0.04	0.05	0
Island	20	15	0.00	0.82	0.00	0.09	0.09	10
Total (all stations)	225	26	0.00	30.89	0.00	0.53	0.69	7

* Threshold = 0.79 ng/kg, Environment Canada (1998).

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval;
POTW = Publicly owned treatment work monitoring areas.

threshold for birds were taken from the southeast Channel Islands and Santa Catalina Island. Note that samples from the bays and harbors subpopulation that had been over the threshold for mammals were not over the threshold for birds.

Overall, 5% of the sanddab guild fish in the SCB were above the Environment Canada (1998) bird predator-risk guideline of 0.79 ng/kg TEQ (Table 64). By region, 3% of the fish of this guild on the mainland and 6% at the islands were above this guideline. The largest percentages of fish with PCB/TEQ levels over the

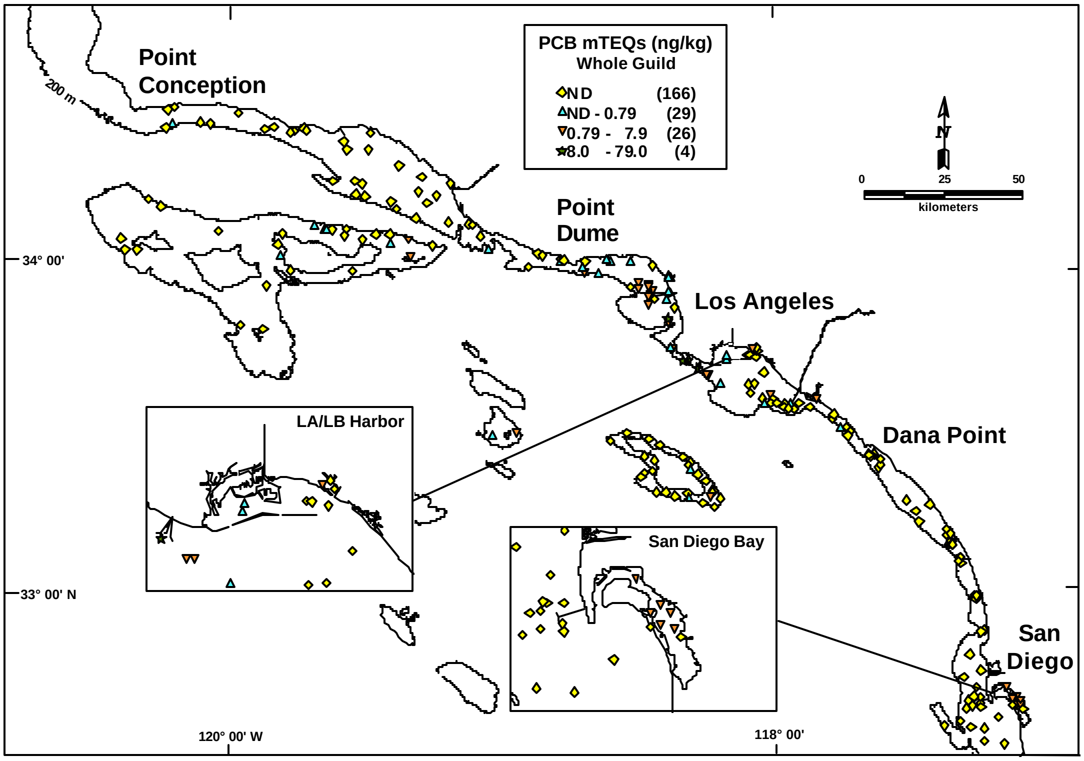


Figure 84. Distribution of PCB mTEQ concentrations in sanddab guild fishes on the southern California shelf at depths of 2-202 m, July-September 1998. m = Mammal.

threshold were from the central mainland region middle shelf large POTW subpopulation (34%) and in the inner shelf river mouth subpopulation (22%) (Table 64, Appendix F28).

Similarly, 5% of the southern California shelf had fish with PCB/TEQ levels above the bird predator-risk guideline of 0.79 ng/kg TEQ (Table 65). By region, 3% of the area was above the threshold for the mainland region and 10% for the island region. In the mainland region, the area above the threshold was primarily in the central region (Table 65, Appendix F29). At the islands, the area above the threshold for birds was primarily the southeast Channel Islands subpopulation. For subpopulations categorized by human influence, the percent of area above the threshold was highest in the middle shelf large POTW subpopulation (31%) and in the inner shelf river mouth subpopulation (13%).

Detection of PCBs with potential toxicity to birds was variable among sanddab guild species, with detection rates between 18% for Pacific sanddab and 56% for California halibut (Appendices F30 through F34). By species, 7% of the longfin sanddabs (mainland middle shelf zone) had levels above the bird predator-risk guideline; followed by 6% for Pacific sanddab (mainland and island middle shelf), 5% for slender sole (mostly outer shelf zone), and <1% for speckled sanddab (inner and middle shelf zones) (Table 65). None of the area with California halibut samples (bays and harbors and inner shelf zone) had values over the guideline for birds.

Tissue Contamination Relative to Sediments

The relationship between contaminant concentrations in whole fish samples of the feeding guild was compared to sediment contaminant concentrations taken at the same station for both total DDT and total PCBs.

Table 63. Percent of area by subpopulation on the southern California shelf with PCB mTEQ concentrations in sanddab guild species above the predator-risk guideline for mammals[a], July-September 1998. m = mammal

	Percent of Area					
	Species Name[b]					
Subpopulation	CX	CSo	CSt	PC	LE	Guild
Region						
Mainland	13	14	2	10	0	10
Northern	0	0	0	0	0	0
Central	28	97	4	13	0	27
Southern	0	0	0	10	0	1
Island	0	6	0	---	8	6
Cool (NW Channel Islands)	---	0	0	---	0	0
Warm	0	20	0	---	14	23
SE Channel Islands	---	25	0	---	25	21
Santa Catalina Island	0	6	0	---	0	4
Shelf Zone						
Bays and Harbors (2-30 m)	---	---	---	38	---	38
Ports	---	---	---	67	---	67
Marinas	---	---	---	23	---	23
Other Bay	---	---	---	42	---	42
Inner Shelf (2-30 m)	0	0	0	0	---	0
Small POTWs	0	---	0	0	---	0
River Mouths	---	---	0	0	---	0
Other Mainland	0	0	0	0	---	0
Island	---	---	0	---	---	0
Middle Shelf (31-120 m)	14	11	2	---	---	12
Small POTWs	0	---	---	---	---	0
Large POTWs	41	50	60	---	---	44
Mainland non-LPOTW	12	18	0	---	---	14
Island	0	7	0	---	---	7
Outer Shelf (121-202 m)	0	2	0	---	3	2
Mainland	0	0	---	---	0	0
Island	---	4	0	---	8	3
Total (all stations)	13	9	1	10	3	8

[a] PCB guideline = 0.79 ng/kg, Environment Canada (1998).

[b] CX = *Citharichthys xanthostigma*; CSo = *Citharichthys sordidus*; CSt = *Citharichthys stigmaeus*; PC = *Paralichthys californicus*; LE = *Lyopsetta exilis*.

POTW = Publicly owned treatment work monitoring areas.

Table 64. Summary of PCB bTEQ (ng/kg) concentrations in sanddab guild composites by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998. b = bird.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI	% of Guild Above Threshold*
Region								
Mainland	170	28	0.00	466.66	0.00	1.31	1.65	3
Northern	42	7	0.00	0.02	0.00	0.00	0.00	0
Central	71	54	0.00	466.66	0.12	3.53	4.53	12
Southern	57	11	0.00	0.30	0.00	0.00	0.00	0
Island	55	22	0.00	437.38	0.00	17.00	22.00	6
Cool (NW Channel Islands)	14	14	0.00	0.02	0.00	0.00	0.00	0
Warm	41	24	0.00	437.38	0.00	48.90	56.50	21
SE Channel Islands	15	47	0.00	437.38	0.00	68.30	78.40	33
Santa Catalina Island	26	12	0.00	74.09	0.00	2.85	5.50	3
Shelf Zone								
Bays and Harbors (2-30 m)	18	72	0.00	0.58	0.02	0.14	0.08	0
Ports	3	67	0.00	0.28	0.12	0.17	0.14	0
Marinas	9	67	0.00	0.58	0.01	0.15	0.13	0
Other Bay	6	83	0.00	0.30	0.01	0.11	0.10	0
Inner Shelf (2-30 m)	46	13	0.00	111.05	0.00	0.16	0.31	< 1
Small POTWs	9	11	0.00	0.02	0.00	0.00	0.00	0
River Mouths	8	25	0.00	111.05	0.00	13.90	25.40	22
Other Mainland	25	8	0.00	0.04	0.00	0.00	0.00	0
Island	4	25	0.00	0.02	0.00	0.00	0.00	0
Middle Shelf (31-120 m)	119	28	0.00	466.66	0.00	8.70	12.30	4
Small POTWs	14	0	0.00	0.00	0.00	0.00	0.00	0
Large POTWs	32	50	0.00	466.66	0.00	24.00	32.30	34
Mainland non-LPOTW	42	21	0.00	3.46	0.00	0.17	0.23	1
Island	31	26	0.00	437.38	0.00	16.60	26.90	4
Outer Shelf (121-202 m)	42	17	0.00	203.00	0.00	11.30	21.30	5
Mainland	22	18	0.00	0.05	0.00	0.00	0.00	0
Island	20	15	0.00	203.00	0.00	20.17	37.60	11
Total (all stations)	225	26	0.00	466.66	0.00	7.70	9.00	5

*Threshold = 0.79 ng/kg, Environment Canada (1998).

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

A strong, positive linear relationship was evident between fish and sediment concentrations for total DDT (r^2 = 0.63) (Figure 86). The relationship for PCBs was also strongly positive, but weaker than for total DDT (r^2 = 0.40) (Figure 86). Normalizing to lipid content did not improve the relationship between the whole fish and sediment concentrations (r^2 = 0.59 for tDDT, r^2 = 0.40 for tPCB).

Among the sanddab guild species, a strong, positive relationship was found between concentrations of tDDT in longfin sanddab and Pacific sanddab whole fish composites and sediment concentrations of tDDT (r^2 = 0.71 and 0.75, respectively) (Figure 87). A strong, positive relationship was also found between concentra-

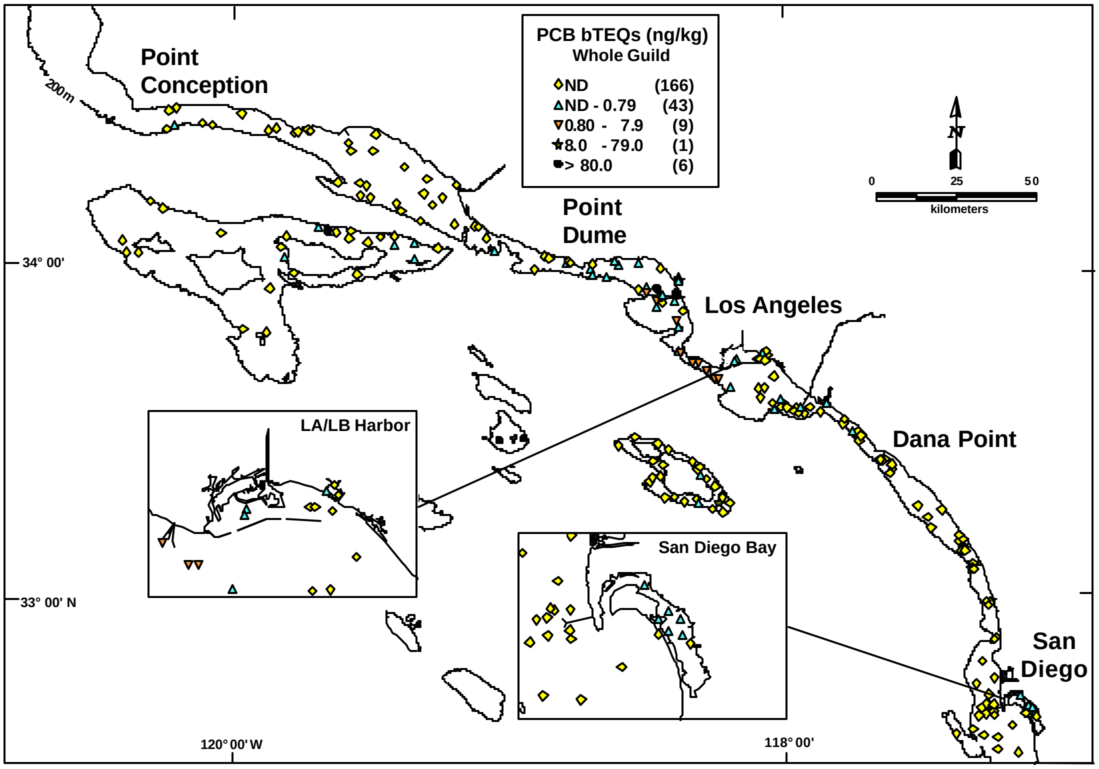


Figure 85. Distribution of PCB bTEQ concentrations in sanddab guild fishes on the southern California shelf at depths of 2-202 m, July-September 1998. b = Bird.

tions of tPCB in longfin sanddab and Pacific sanddab whole fish composites and sediment concentrations of tPCB (r^2 = 0.71, 0.97 respectively) (Figure 88). Trends were weak for speckled sanddab (Figures 87 and 88) and not evident for California halibut (Figure 89). Chemical analysis was conducted at only one site where slender sole composites were also analyzed; hence, no comparison between contaminant levels in slender sole and the sediment was made.

DISCUSSION

Extent of Contamination of Concern

The primary objective of this study was to determine the extent of area on the southern California shelf with contaminant levels of concern because this was the unanswered question from the 1994 survey (Allen *et al*. 1998). The study focused on whole fish composites of sanddab guild species and on DDT, PCBs, and chlordane. In addition to the primary objective of this study, secondary results were to describe the general distribution of fish tissue contamination in these species by region, shelf zone, and human influence subpopulations on the southern California mainland and island shelf, and in bays and harbors. The results of this study showed that fish with DDT concentrations above the predator-risk guideline used in this study (i.e., Environment Canada 1997) occurred in 71% of the area of the southern California shelf. In contrast, the area above the PCB predator risk guideline (Environment Canada 1998) was 8% for mammals and 5% for birds. None of the fish samples had chlordane concentrations above the predator-risk guideline of 50 µg/kg (NAS 1974). Although these guidelines have identified areas of potential concern, further studies are needed to determine concentrations that cause specific levels of impact.

Table 65. Percent of area by subpopulation on the southern California shelf with PCB bTEQ concentrations in sanddab guild species above the predator-risk guideline for birds[a], July-September 1998. b = bird.

	Percent of Area					
	Species Name[b]					
Subpopulation	CX	CSo	CSt	PC	LE	Guild
Region						
Mainland	8	2	1	0	8	3
Northern	0	0	0	0	17	0
Central	17	7	0	0	0	10
Southern	0	0	0	0	0	0
Island	0	8	0	---	0	7
Cool (NW Channel Islands)	---	0	0	---	0	0
Warm	0	26	0	---	0	21
SE Channel Islands	---	33	0	---	0	28
Santa Catalina Island	0	6	0	---	0	4
Shelf Zone						
Bays and Harbors (2-30 m)	---	---	---	0	---	0
Ports	---	---	---	0	---	0
Marinas	---	---	---	0	---	0
Other Bay	---	---	---	0	---	0
Inner Shelf (2-30 m)	0	0	< 1	0	---	< 1
Small POTWs	0	---	0	0	---	0
River Mouths	---	---	25	0	---	13
Other Mainland	0	0	0	0	---	0
Island	---	---	0	---	---	0
Middle Shelf (31-120 m)	8	5	1	---	---	6
Small POTWs	0	---	---	---	---	0
Large POTWs	30	50	20	---	---	31
Mainland non-LPOTW	6	0	0	---	---	3
Island	0	7	0	---	---	7
Outer Shelf (121-202 m)	0	8	0	---	5	6
Mainland	0	0	---	---	8	0
Island	---	13	0	---	0	10
Total (all stations)	7	6	< 1	0	5	5

[a] PCB guideline = 0.79 ngTEQ/kg, Environment Canada (1998).

[b] CX = *Citharichthys xanthostigma* ; CSo = *Citharichthys sordidus* ; CSt = *Citharichthys stigmaeus* ;PC = *Paralichthys californicus* ; LE = *Lyopsetta exilis* .

POTW = Publicly owned treatment work monitoring areas.

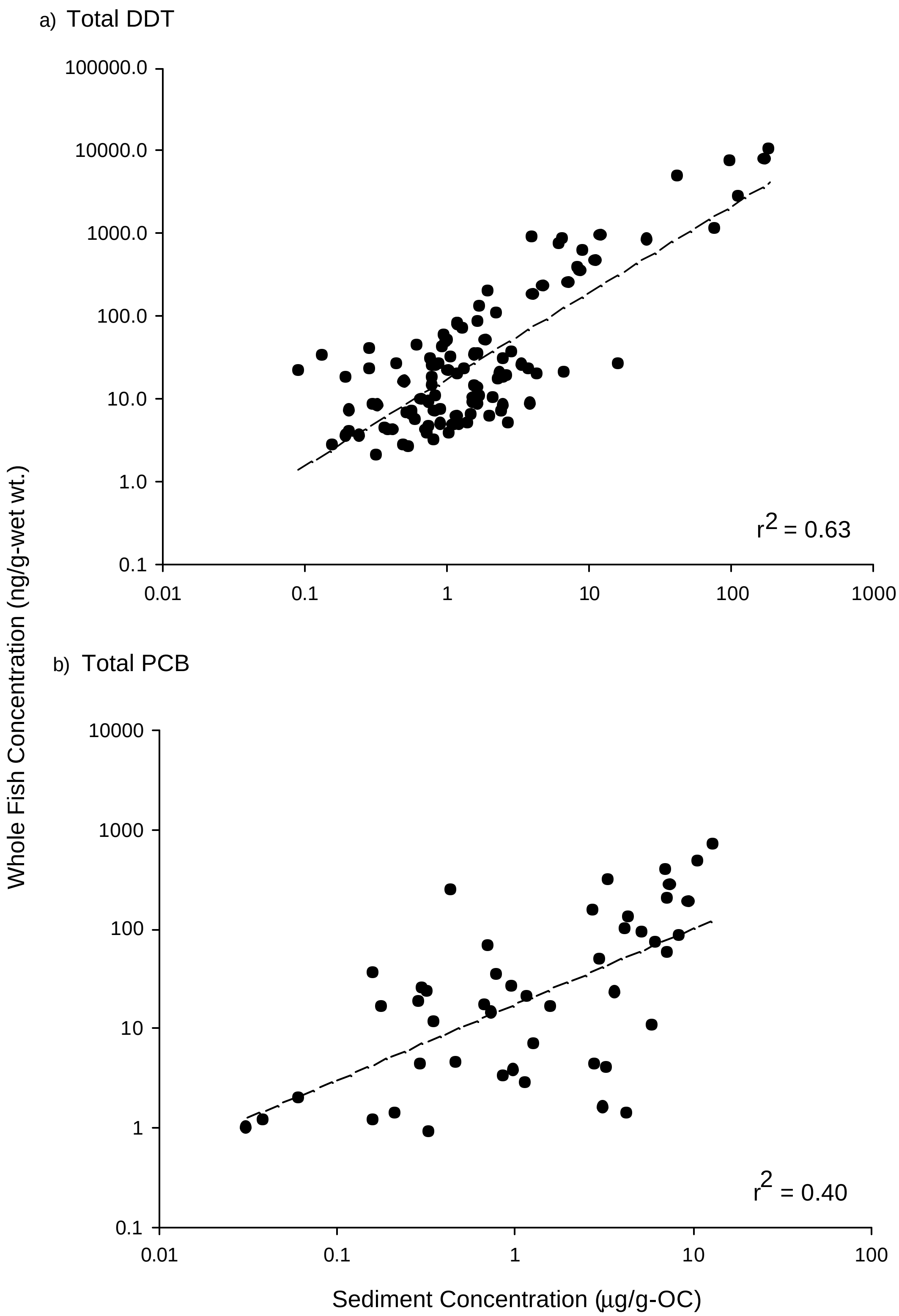


Figure 86. Relationships between a) total DDT and b) total PCB concentrations in whole fish composites of sanddab guild species and in sediments on the southern California shelf at depths of 3-187 m, July-September 1998. Dashed lines are best fit to the data from linear regression.

DDT

The distribution of DDT above the predator-risk guideline was centered around the central and southern mainland regions, southeast Channel Islands, and Santa Catalina Island (Figure 81), with the highest levels (>1,400 µg/kg) in the large POTW area on the Palos Verdes Shelf, followed by the large POTW areas in Santa Monica Bay and San Pedro Bay, with the remaining areas above threshold (e.g., San Diego Shelf, Santa Catalina Island, southeast Channel Islands) with levels of 15-140 µg/kg (Figure 80). The decreasing gradient, from the Palos Verdes Shelf sediments to the southeast Channel Islands in the north and to San Diego to the south, suggests that the source of this DDT is historical sediments on the Palos Verdes Shelf. Schiff and Gossett (1998) found a similar decrease in DDT levels extending north of the Palos Verdes Shelf in 1994. Another possible path is suggested by a series of above-guideline sites from the Santa Clara River to the southeast Channel Islands (Figure 81). In 1998, satellite imagery of the SCB showed a sediment plume of Santa Clara River runoff extending from the mouth of that river to Anacapa Island (Burt Jones, University of Southern California, Los Angeles, CA, personal communication). It is noteworthy that the only area around Santa Cruz Island with DDT levels below the predator-risk guideline was on the western end of the island, which is sheltered from easterly currents from both the central mainland and Santa Barbara Channel (Figure 81).

Since discharge of DDT was banned in 1972, most DDT in the southern California environment is assumed to originate from widespread historically deposited sediments, particularly on the Palos Verdes Shelf and in the Santa Monica Bay area (Mearns *et al*. 1991, Schiff and Gossett 1998), and perhaps from agricultural areas upstream of some rivers. During the past three decades, DDT levels have decreased more than an order of magnitude in fish muscle tissue at highly contaminated discharge sites (Allen and Cross 1994) and in liver tissue at reference sites (Allen *et al*. 1998, Schiff and Allen 2000). It is likely that predator risk has declined, as have tissue DDT levels over the past three decades, although no earlier whole fish data exist. Food web accumulation of DDT in southern California populations of brown pelican (*Pelecanus occidentalis*), bald eagle (*Haliaeetus leucocephalus*), and peregrine falcon (*Falco peregrinus*) in the 1970s and 1980s is well documented (Anderson and Hickey 1970, Risebrough *et al*. 1971, Andersen and Gress 1983, MBC 1993), as well as possible DDT effects on parturition in pinnipeds at the northwest Channel Islands (Hydroqual 1994). It is not known to what degree the levels found in whole sanddab guild samples actually pose a risk to southern California birds and mammals. Most of the sanddab guild species occur in relatively deep water and are generally cryptic (and difficult to see) or buried in the sediments. Nevertheless, as they are among the most common and abundant soft-bottom species, they may be eaten by pinnipeds, dolphins, diving birds, sharks and rays, and are likely eaten by larger predatory fishes.

Most previous studies in southern California have focused on contaminant levels in fish liver or muscle, with levels in whole fish seldom being determined (Mearns *et al*. 1991). Allen *et al*. (2002) found whole fish tDDT concentrations in sanddab guild species in southern California ranging from nondetect to 18,160 µg/kg (in Pacific sanddab from the Palos Verdes Shelf) in 1997. In 1998, values ranged from 0.0 (nondetect) to 10,462 µg/kg.

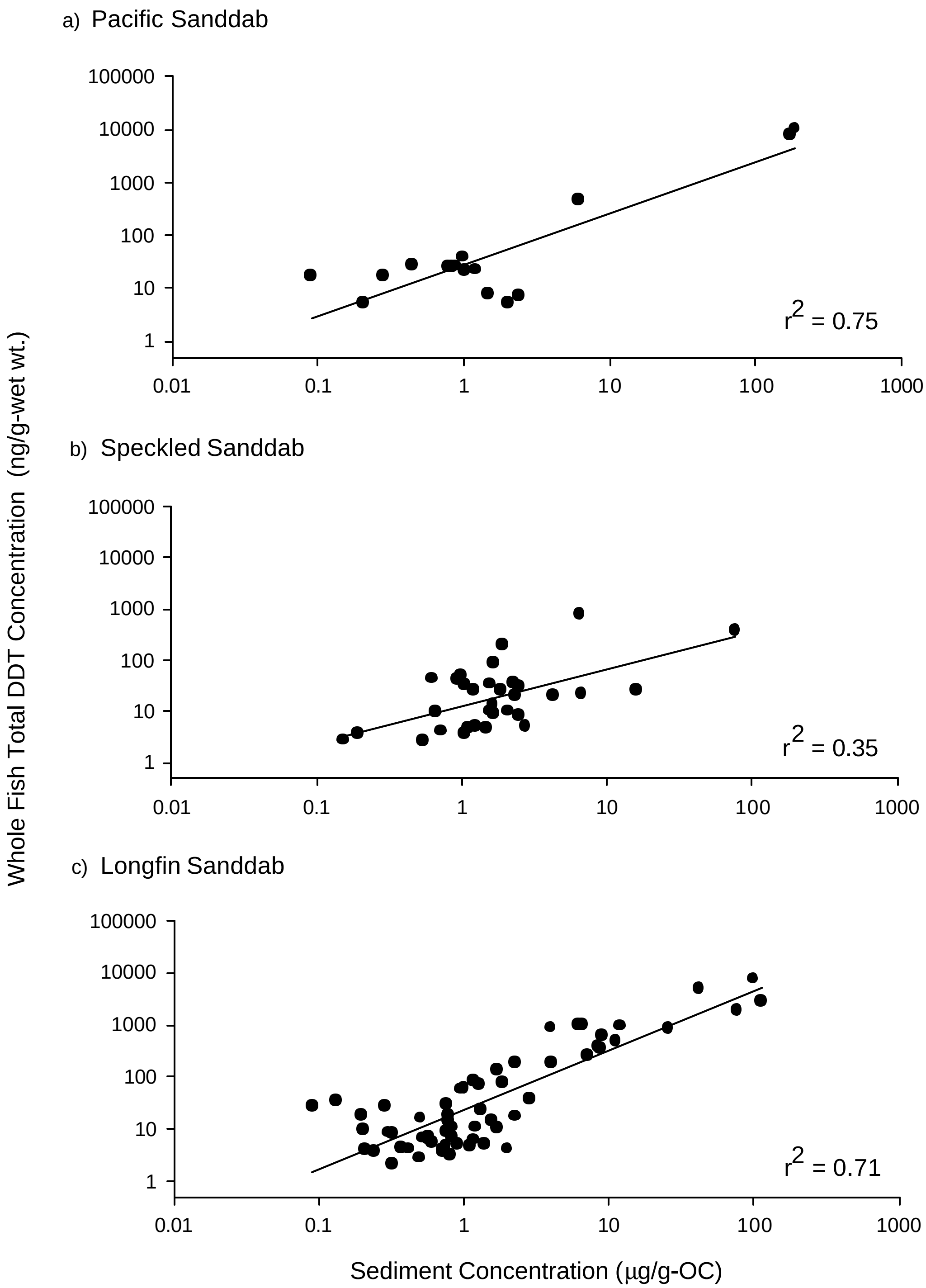


Figure 87. Relationships between total DDT concentrations in whole fish and sediment for three sanddab guild species, a) Pacific sanddab (*Citharichthys sordidus*), b) speckled sanddab (*Citharichthys stigmaeus*), and c) longfin sanddab (*Citharichthys xanthostigma*), collected from the southern California shelf at depths of 3-127 m, July-September 1998.

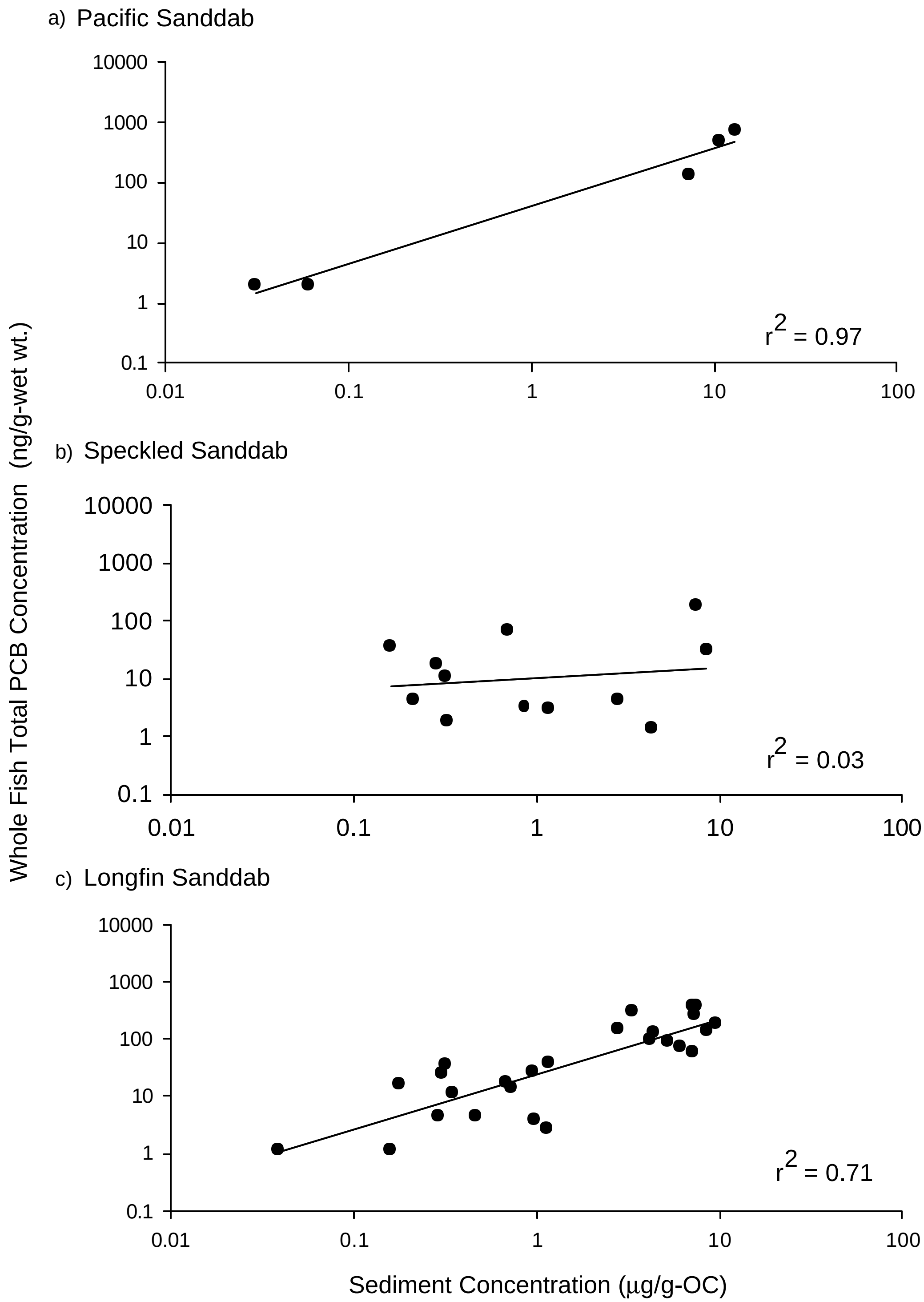
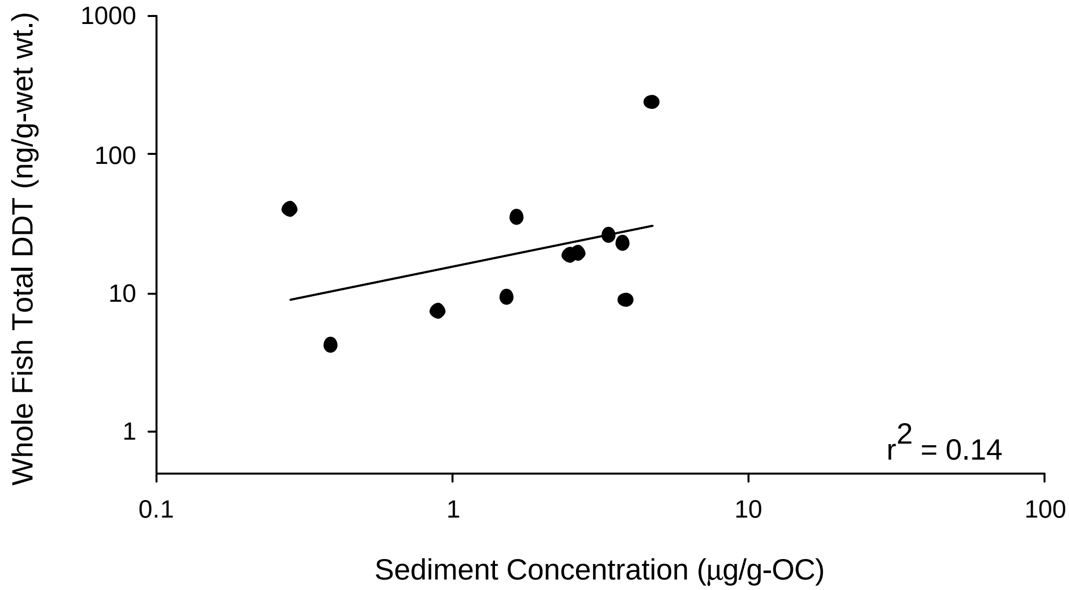


Figure 88. Relationships between total PCB concentrations in whole fish and sediment for three sanddab-guild species, a) Pacific sanddab (*Citharichthys sordidus*), b) speckled sanddab (*Citharichthys stigmaeus*), and c) longfin sanddab (*Citharichthys xanthostigma*), collected on the southern California shelf at depths of 3-127 m, July-September 1998.

a)



b)

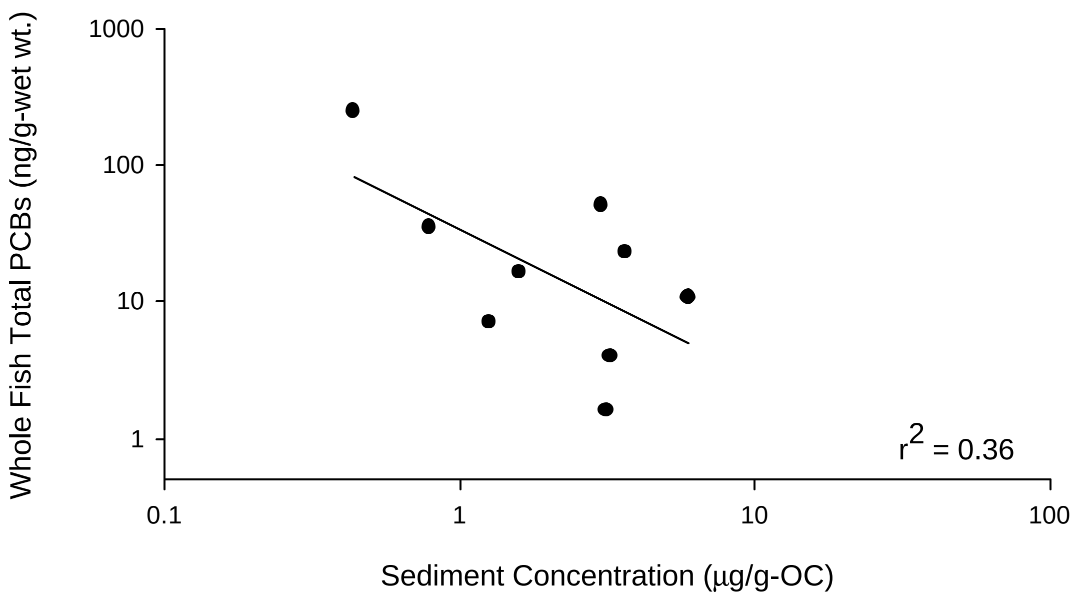


Figure 89. Relationships between a) total DDT and b) total PCB concentrations in whole fish samples of California halibut (*Paralichthys californicus*) and sediment collected in bays/harbors and on the southern California shelf at depths of 2-30 m, July-September 1998.

Chlordane

Chlordane was not widespread in sanddab-guild fishes in 1998, and none of the chlordane detected in sanddab-guild tissue was above the predator-risk guideline (Table 60, Figure 82). Although α–chlordane, trans-nonachlor, and heptachlor (all chlordane isomers or congeners) were examined in flatfish livers in the 1994 regional survey, none was detected (Allen *et al*. 1998, Schiff and Allen 2000). Chlordane was included in the 1998 survey because it was thought to be of potential concern to fishes living in bays and harbors. It did occur in a number of bays (e.g., Newport Bay, Alamitos Bay, Marina del Rey), as well as occasionally on islands (western Santa Cruz Island, Santa Barbara Island, and Santa Catalina Island) (Figure 82); these areas were not surveyed in 1994. However, while chlordane was not detected in flatfish livers from the mainland shelf in 1994, it did occur there in whole sanddab-guild tissue in 1998, particularly at a number of stations on the Palos Verdes Shelf, and in Santa Monica Bay (particularly near the Hyperion Treatment Plant outfall) (Figure 82).

Although historical records of chlordane in whole fish samples from the SCB are not available, chlordane has been measured in muscle and liver tissue (Mearns *et al*. 1991). In these tissues, chlordane was historically (1971-1985) high in Marina Del Rey, Long Beach Harbor (Seal Beach), and southern San Diego Harbor (Mearns *et al*. 1991). Chlordane in muscle and liver tissue from kelp bass (*Paralabrax clathratus*) collected on the Palos Verdes Shelf was 19 and 386 μg/kg, respectively, in 1985 (Risebrough 1987, Mearns *et al*. 1991). Whole fish samples of sanddab-guild fishes from this area in 1998 had 14.6 μg/kg (Table 60), which is comparable to 1985 levels in kelp bass muscle tissue. Chlordane was also found in kelp bass at the southeast Channel Islands (Anacapa Island), Santa Barbara Island, and Santa Catalina Island in 1985, and was found there in sanddab-guild fishes in 1998.

PCBs

The distribution of PCB TEQs above mammal and bird guidelines showed a different pattern, with risks to mammals being highest near large POTW outfalls (particularly on the Palos Verdes shelf and in Santa Monica Bay) and in San Diego Bay (Figure 84). A similar pattern follows for tPCB in sanddab guild composites (Figure 83). Although both PCB and DDT levels in fish have typically been high on the Palos Verdes Shelf, PCB levels have historically been high in San Diego Bay whereas DDT levels have not (Mearns *et al*. 1991). In contrast to values for mammals, PCB TEQs for birds were highest at locations in Santa Monica Bay, at both sites on Santa Barbara Island, and at a site north of Santa Cruz Island (Figure 85). This pattern differs greatly from that of tPCBs in fish samples. The differences between PCB TEQs for birds and for mammals were associated with differences in bird and mammal TEFs for different PCB congeners (Table 3) and the relative concentration of these congeners (Appendix F1).

Relationship of Tissue and Sediment Contaminant Levels

High levels of fish contamination are generally associated with high levels of sediment contamination (Smokler *et al*. 1979, Mearns *et al*. 1991, Allen and Cross 1994, Allen *et al*. 2002). In the 1994 survey (Allen *et al*. 1998), DDT and PCB levels in fish livers were highly correlated with sediment concentrations (Schiff and Allen 2001). In that study, lipid normalized DDT concentrations were highly correlated with organic carbon (OC) normalized sediment concentrations for longfin sanddab, Pacific sanddab, and Dover sole, and for lipid normalized PCBs for Pacific sanddab and longfin sanddab. Similarly in this study, whole fish composites of

Pacific sanddab and longfin sanddab were also highly correlated with sediment contamination for tDDT and tPCB (Figures 87 and 88). Lipid normalization did not improve the correlations. As this study focused on predator-risk assessment, wet weight whole fish samples were used rather than lipid-normalized samples because predators eat whole fish.

Relative to sediment concentrations, tDDT in California halibut and speckled sanddab did not show the same strong correlation as that found in Pacific and longfin sanddabs (Figures 87 and 89). However, speckled sanddab and California halibut samples were not collected from the Palos Verdes Shelf and hence samples of these species exposed to high levels of DDT were not available. A comparison of DDT levels of speckled sanddab and small California halibut at the same sites (including sites with high DDT levels) remains to be done.

As most studies of fish contamination in southern California have focused on either muscle or liver tissue (Mearns *et al*. 1991), estimates of whole fish concentrations are difficult to make. In longfin sanddab, liver concentrations of tDDT were 100 times higher than in muscle tissue of the same fish (Groce 2002). However, while liver and muscle samples can be analyzed from the same fish, whole fish analysis cannot be done. Hence, estimates of whole fish concentrations relative to liver and muscle concentrations can only be made from partial whole fish samples. The relationship between whole fish tissue concentrations and sediment concentrations suggests a possible way to estimate muscle or liver tissue levels based on whole fish concentrations. Sediment concentrations that result in whole fish concentrations at the predator-risk guideline in this study (Figures 87 and 88) might be used to determine liver concentrations (e.g., Schiff and Allen 2000) that correspond to whole fish predator-risk guidelines. Similarly, if the relationship of muscle tissue concentrations to sediment concentrations were known, then a similar determination of muscle concentrations that correspond to whole fish guidelines could be made. If the relationship between whole fish, muscle, and liver concentrations can be made relative to sediment concentrations, then historical data using liver or muscle concentrations could be used to assess changes in fish with DDT or PCB concentrations above the predator-risk guidelines.

Development of Approach Used

In the previous regional survey in 1994 (Allen *et al*. 1998, Schiff and Allen 2000), DDT was found in 100% of the Pacific and longfin sanddabs, and in 96% of the Dover sole. PCBs were found in 99% of the Pacific sanddab analyzed, 88% of longfin sanddab, and 16% of Dover sole. Even though the number of fish with detectable DDT and PCBs was high, this study was not able to assess the areal extent of fish with contaminant levels of concern. One reason was that none of the fish analyzed occurred over the entire area sampled (i.e., mainland shelf from Point Conception to the U.S.-Mexico international border at depths of 10-200 m). The second reason was that contaminants were analyzed in liver tissues in 1994, and there were no health risk guidelines associated with liver contaminant levels, at least not any that were relevant to the flatfishes examined. Although sanddabs and Dover sole are caught and consumed commercially outside of the area (central and northern California), the fish were not commonly sought and consumed in most of southern California at the time. Hence, the use of muscle fillets and human health-risk studies were not considered to be as meaningful for these fishes in this area as for other species that are consumed in southern California. Hence, because of these two reasons, the 1994 study was not able to answer the question of what is the extent of fish with contamination on the southern California shelf.

Selection of Target Species

As the question asked in 1994 was still important, steps were taken to remedy the problems posed by the past survey results. The first step was to determine how to get fish with better areal coverage of the shelf so that the extent of area affected in the SCB could be determined. Because the soft-bottom habitat is the most extensive habitat on the shelf and also the easiest to sample (by trawling), it was felt that soft-bottom fishes were still among the most desirable fishes to sample. Although many recreational fishes, such as white croaker, are more highly contaminated, their distribution over the shelf is patchy and not suitable for assessing extent of area questions. One possibility was to analyze contamination in a widespread guild (a group of ecologically similar species) of fishes. Foraging guilds of soft-bottom fishes have previously been described for the soft-bottom habitat of southern California (Allen 1982). Among the 18 guilds described there, one (benthic pelagobenthivores or the sanddab guild) was particularly widespread in the 1994 regional survey, occurring in approximately 96% of the samples from the shelf (Allen *et al*. 1998). This foraging guild consists of several species of small flatfishes with medium-sized mouths and generalized feeding habitats, feeding largely on small crustaceans (gammaridean amphipods, mysids) and other benthic organisms on or near the bottom (Allen 1982). Most of the species in this guild (speckled sanddab, Pacific sanddab, and slender sole), form a depth-displacing series with distinct inner shelf, middle shelf, and outer shelf species. Two additional species, longfin sanddab and gulf sanddab, were more southerly species that also occur in southern California. Although not abundant in the 1970s, the longfin sanddab became a dominant sanddab species on the southern mainland shelf of southern California during the past two decades. In combination, these five species occupy virtually the entire shelf except natural embayments.

Thus, there was the potential that species of this guild could be treated as a superspecies to assess the extent of areal effects on fishes. To assess whether fishes of this guild had similar contaminant uptake with similar exposures, Allen *et al*. (2002) examined levels of DDT in co-occurring sanddab guild species collected from the same sites at different locations along the southern California coast, including highly contaminated sites and less contaminated sites. This study showed that log-transformed DDT concentrations were highly correlated among all species pairs within the guild. All of the relationships were linear over the range observed, with slopes not statistically different from unity. The variability among sites was 60 times that of replicates at a site; the variability among species and among ages was 4 and 2 times, respectively, that of replicates.

The sanddab guild was chosen for the focus of fish tissue contamination studies in the 1998 survey. However, this study extended into the natural embayments, beyond the range of the species of the described sanddab guild. Natural embayments are important nursery grounds of juvenile California halibut, which although having a larger mouth, is the closest possible counterpart of the sanddab guild species in that habitat. Hence, small (< 20 cm) California halibut were included in the analysis to extend the guild distribution into these embayments. However, it was not possible to assess the contamination uptake of this species relative to a sanddab guild species from the same site prior to the survey. The only species that might occur with small California halibut is speckled sanddab, an inner shelf species that is seldom found in bays where almost all small California halibut are found. Speckled sanddab and small California halibut were not found at the same sites during this survey. Further study should determine the relative uptake of contaminants by similar sized individuals of these two species at sites where they occur together.

In Allen *et al*. (2002) contaminant levels of sanddab guild species of the same age from the same site were compared. In that study, size at age and maturity at age information was estimated for longfin sanddab. Age 1 fish were 9-13 cm in length and Age 2 fish were 14-16 cm in length. Fish were thought to be immature through Age 2. Since that study, Groce (2002) examined age, growth, and maturity in longfin sanddab and found that males and females mature at 10-11 cm and at about 2 yr. Hence, ranges given in that study should be adjusted to Age 0 (5-7 cm), Age 1 (8-10 cm), and Age 2 (11-12 cm). Ages 0 and 1 were immature fish. The Age 1 class of longfin sanddab used in this study is likely to include Age 1 and 2 fish, and thus would include mature and immature fish. In future studies, these size-class adjustments should be made for sample selection.

Choice of Risk Guidelines

Bioaccumulation (i.e., the amount of contaminants accumulated by an organism) is an indicator of an organism's exposure to environmental contamination. It results from both the dietary accumulation of contaminants and the bioconcentration of contaminants from the water via gills or epithelial tissue (Connell 1988, Cardwell 1991, Groce 2002). Biomagnification is the increase in tissue contaminant concentrations up a food chain, with predators having higher concentrations than their prey (Mearns *et al*. 1991). Because a predator consumes many prey organisms during its lifetime, low concentrations of a contaminant in its prey would magnify in a predator if the contaminant is not metabolized or excreted. Because of this, relatively low levels of tissue contamination in prey organisms may pose a health risk to predators. Hence, predator-risk guidelines are typically lower than those for human-health risks.

The 1994 survey (Allen *et al.* 1998, Schiff and Allen 2000) examined contaminant concentrations in fish livers. Although biological effects of liver contaminant concentrations are known for some particular species (e.g., white croaker) (Cross and Hose 1988, Hose *et al*. 1989, AMS and IE 1994), biological effects of contaminants in livers are not known for sanddab guild species. Fish health guidelines based on liver contaminant levels have not been established. Further, although human-health risk guidelines, such as those of the California Office of Environmental Health Hazard Assessment (OEHHA) (Pollock *et al*. 1991) and the United States Environmental Protection Agency (USEPA 1995), are appropriate for assessing contamination of edible tissue (e.g., muscle tissue) in fish consumed by humans, the lack of interest in sanddab guild species as a food source in southern California at the time of this study (1998) prompted us to focus on health risk to predators of sanddabs.

The OEHHA human health-risk screening level for tDDT carcinogenicity in fish muscle tissue is 100 μg/kg (Pollock *et al*. 1991). In contrast to carcinogenicity guidelines, predator-risk guidelines concern toxic effects of DDT on bird and mammal populations (e.g., reduced survival, growth rates, fecundity, eggshell thickness, etc.) (Environment Canada 1997). NAS predator-risk guidelines (NAS 1974) for marine wildlife were 50 μg/kg for tDDT and tChlordane and 500 μg/kg tPCB (sum of Aroclors). More recently, aquatic and marine predator-risk guidelines have been developed for DDT and PCBs by Environment Canada (1997, 1998). The tDDT guideline of 14 μg/kg (Environment Canada 1997) was based on a review of toxicological literature on DDT effects on birds and mammals and determining the most sensitive lowest-observable adverse effects level and the no-observed adverse effect level. The lowest reference concentration was adopted as the Canadian tissue residue guideline. The Environment Canada (1998) PCB guidelines focus on the ability of PCB congeners to produce a response in the cytochrome enzyme system relative to its most potent inducer — 2, 3,7,8-TCDD (tetrachlorodibenzo-p-dioxin). Coplaner PCB congeners are the most toxic, and these typically cause reduced fecundity and impaired growth (Environment

Canada 1998). Congeners were assigned TEFs to this response and these varied between birds and mammals. In this study, PCB congener TEFs for birds and mammals used by the World Health Organization were used (Van den Berg *et al.* 1998). The sum of these TEFs, the TEQ for the PCB congeners, was then used in the guideline of 0.79 PCB TEQ/kg. This gives the toxicity of the sum of toxic PCB congeners relative to that of dioxin. While this guideline assesses toxicity of PCBs due to the 12 most dioxin-like congeners, there is more potential toxicity in total PCB than is measured using the TEFs for the 12 most dioxin-like congeners. As with DDT, the lowest reference concentration was adopted, but in this case, it was the lowest of either birds or mammals. Environment of Canada guidelines were chosen for this study for DDT and PCBs because they were based on a more recent consideration of information that results in government (Canadian) guidelines for screening tissue contamination for potential risks to bird and mammal predators. Research since the 1970s has resulted in lower predator-risk guidelines for tDDT and PCBs (Environment Canada 1997, 1998). The NAS (1974) predator-risk guideline was not adopted as a federal regulatory standard, but has been cited in state studies (Mearns *et al.* 1991).

BIOMARKERS AND SUBLETHAL EFFECTS

INTRODUCTION

Biomarkers and sublethal effects are measures of an organism's response to contaminants. Biomarkers are biochemical compounds and histological effects produced in response to contaminant exposure. Whereas DDT and PCBs accumulate in fish tissue, other potentially harmful contaminants do not. Polycyclic aromatic hydrocarbons (PAHs) are one such class of potentially harmful contaminants to fishes that do not accumulate in fish tissues. High concentrations of PAHs (along with metals and pesticides) are found in southern California bays and harbors (Fairey *et al.* 1996, Anderson *et al.* 1998, Phillips *et al.* 1998), important habitats for a variety of fish species. Many PAHs are toxic and exposure to this group of compounds has been identified as a risk factor that influences the development of liver lesions in fish (Myers *et al.* 1998). However, exposure to PAHs cannot be assessed by conventional tissue analysis because these compounds are rapidly metabolized by the liver and secreted into the bile. One biomarker that has been used to quantify the exposure to PAHs in fish is fluorescent aromatic compounds (FACs) in fish bile. Bile FAC concentrations have shown a strong correlation with sediment PAH concentrations (Collier *et al.* 1993). Bile FAC concentrations have been measured as an indication of PAH exposure in fish from southern California (Brown and Bay 1999) and other locations, including Puget Sound, Washington (Varanasi *et al.* 1988); Galveston Bay, Texas (Willett *et al.* 1997); and Tampa Bay, Florida (McCain *et al.* 1996). Hence, assessment of bile FAC levels in a fish is a potentially useful biomarker indicating exposure to PAHs.

Although biomarkers are used to assess exposure to contaminants, they do not always indicate a biological effect in an organism. One important indicator of contaminant-induced biological effect is DNA damage. Damage to DNA can be caused by a variety of environmental contaminants including PAHs (Shugart 1988), and has been associated with growth and reproductive effects. This sublethal effect has been successfully measured in a variety of species, including marine fish (Di Giulio *et al.* 1993). The DNA damage is measured by quantifying the amount of strand breaks in the stained DNA of fish blood cells. Although PAHs are important contaminants of bays and harbors of southern California, there has been no assessment of the level of PAH exposure in demersal fishes off southern California or of potential sublethal effects resulting from this exposure.

The goal of this study is to assess exposure of southern California demersal fishes to PAH contamination and to determine if sublethal effects result from this exposure. This project had three objectives: 1) to characterize exposure of PAHs in fish from bays and harbors (environments often contaminated with PAHs) by measuring bile FACs and by characterizing the extent of DNA damage by location and fish species in coastal southern California; 2) to compare these indicators in fish to concentrations of contaminants in sediments; and 3) to examine the relationship between PAH exposure and a measure of biological effect by comparing concentrations of FACs and DNA single-strand breaks in individual fish.

The study was focused particularly in bays and harbors of southern California, as these provide habitats for a variety of fish species and nurseries for juvenile fishes. However, because bays and harbors are important sites of human activity, they are good habitats for examining exposure to contaminants. Samples were also collected from the Channel Islands to provide insight into fish responses in a different area and habitat.

RESULTS

Variability by Location and Species

FAC Concentrations by Location

FAC concentrations in California halibut varied among bay and harbor locations (Figure 90). Concentrations varied by a factor of three, with the lowest average concentration occurring at Ventura Harbor (1,424 ng BaP equivalents/mL bile) and the highest concentration at King Harbor (4,133 ng BaP equivalents/mL bile).

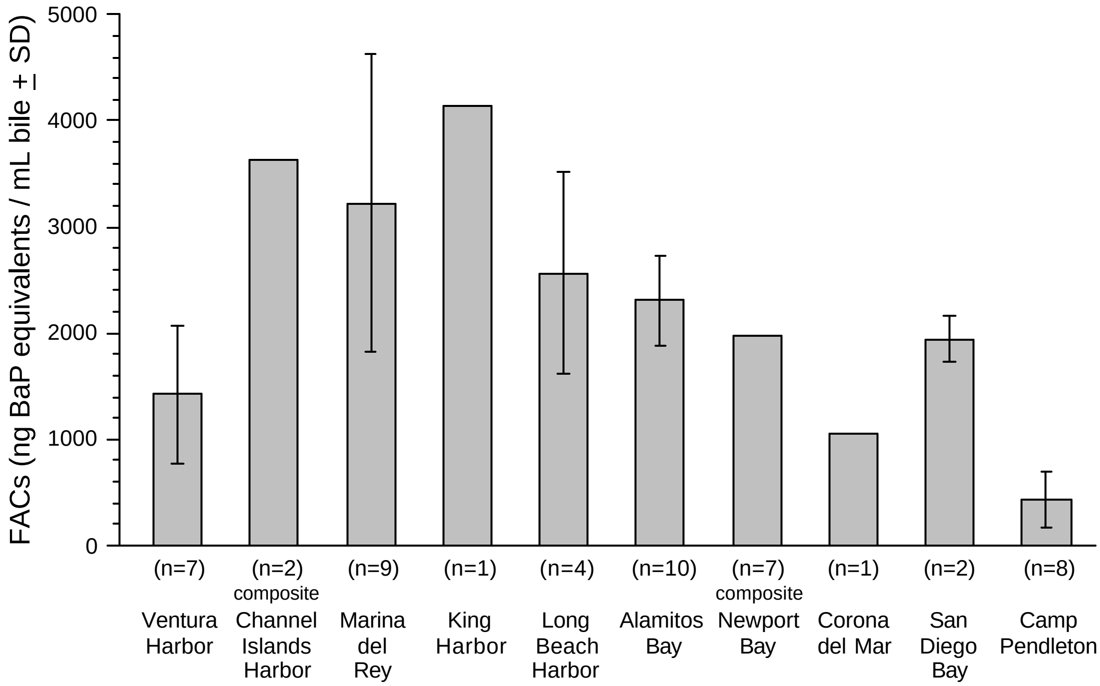


Figure 90. Concentration of fluorescent aromatic compounds (FACs) in California halibut (*Paralichthys californicus*) sampled from southern California bays and harbors, and from a reference site (Camp Pendleton, California), July-September 1998. The fish from Corona del Mar were caught offshore at a station of opportunity. The fish from the Camp Pendleton reference site were collected in 1999. n = Number of fish sampled.

FAC concentrations in California halibut from bays and harbors were elevated compared to fish from the Camp Pendleton reference site. Mean concentrations among locations ranged from 3-10 times the reference value. Among the locations that had data for more than one fish, there were significant differences in the concentrations of FACs ($p < 0.001$, Kruskal-Wallis). Fish from Marina del Rey, LA /LB Harbor, and Alamitos Bay had significantly greater FAC values than fish from the Camp Pendleton reference site (Dunn's Method for Multiple Comparisons), while fish from Ventura Harbor and San Diego Bay were not significantly different from the reference site fish.

FAC concentrations were more consistent among Pacific sanddabs from the Channel Islands, varying by less than a factor of two. Average concentrations ranged from 356 ng BaP equivalents/mL bile in fish from the northwest Channel Islands outer shelf subpopulation to 629 ng BaP equivalents/mL bile in fish on the southeast Channel Islands middle shelf (Figure 91). The differences in concentrations among the Channel Islands were not statistically significant (p = 0.18, ANOVA).

Average FAC concentrations in Pacific sanddab from the Channel Islands were comparable to the concentration in California halibut from the Camp Pendleton reference site, and much lower than average concentrations in California halibut from any of the bays and harbors stations (Figures 90 and 91).

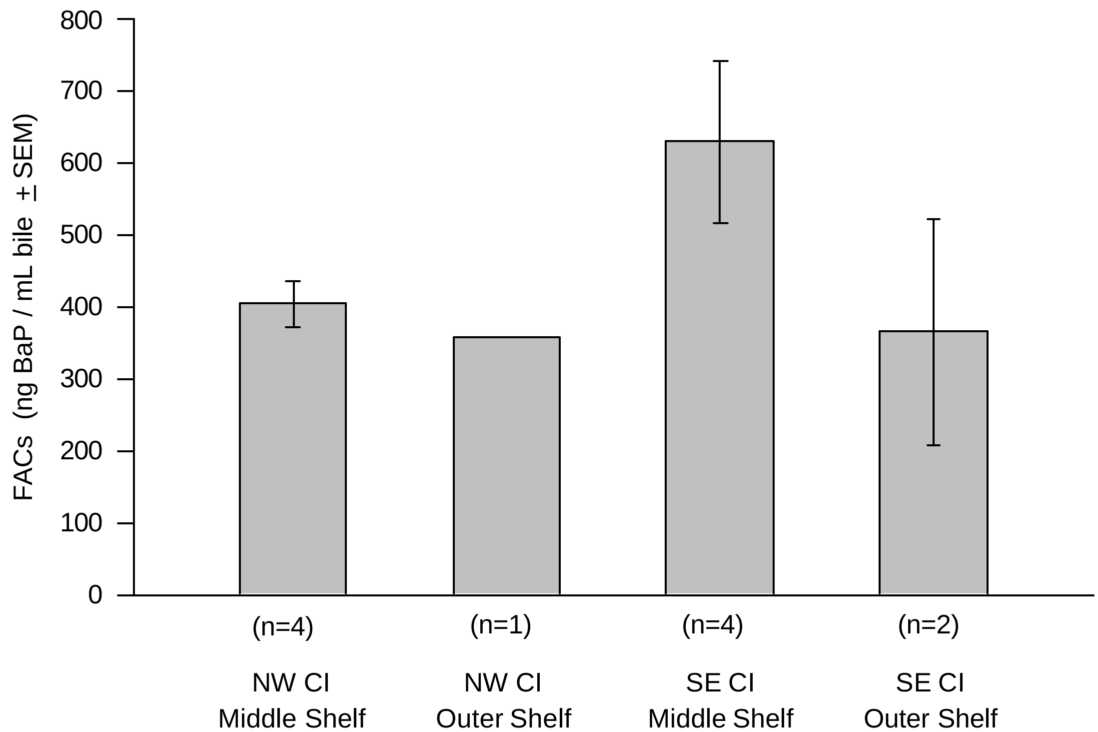


Figure 91. Concentration of bile FACs in Pacific sanddab (*Citharichthys sordidus*) from the southern California Channel Islands shelf at depths of 31-202 m, July-September 1998. n = Number of stations in each subpopulation. CI = Channel Islands; NW = northwest; SE = southeast.

DNA Damage by Location

Bays/Harbors. At only a limited number of the bay and harbor stations (48%) were 3 or more fish sampled. Statistical comparisons were only performed on stations where 3 or more samples of the same species were analyzed. Fish from 12 of the 13 stations (92%) had equivalent levels of DNA damage (Figure 92). Station 2298 in LA/LB Harbor had significantly higher DNA damage than all but one of the stations, Station 2593 from Alamitos Bay. Station 2593 had an intermediate level of damage equivalent to Station 2298 and all other stations.

To examine whether fish from different geographical regions had significantly elevated DNA damage, individual DNA damage values from fish at all stations in a geographic area were pooled for comparison. Although the apparent range of mean damage levels appeared significantly different for some locations, no statistically significant differences were resolved because of the non-normal distribution and broad variability of the data (Figure 93).

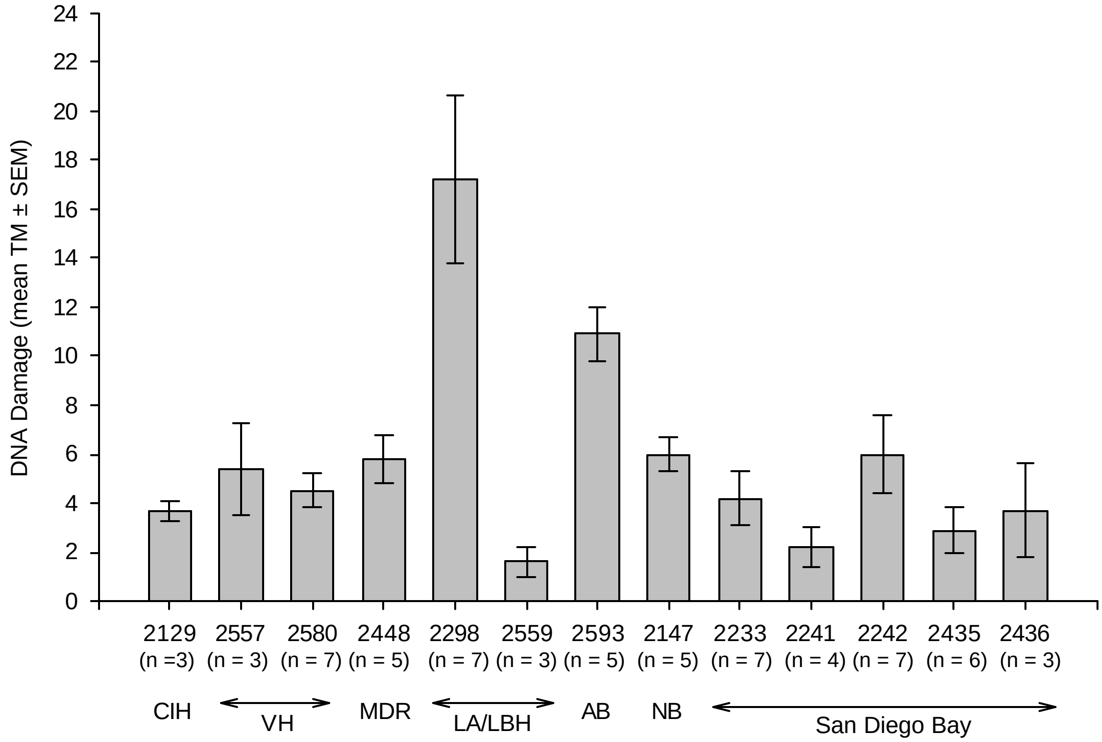


Figure 92. DNA damage levels in California halibut (*Paralichthys californicus*) sampled from southern California bay and harbor stations where three or more individuals were collected, July-September 1998. TM (or tail moment) = (% DNA in tail) x (tail length/100). SEM = Standard error of mean; CIH = Channel Islands Harbor; VH = Ventura Harbor; MDR = Marina del Rey; LA/LBH = Los Angeles/Long Beach Harbor; AB = Alamitos Bay; NB = Newport Bay.

Channel Islands. The Pacific sanddab was the predominant species caught and sampled at the Channel Islands stations. The DNA damage samples were collected at 13 of 18 stations. Of those 13 stations, 3 or more Pacific sanddabs were sampled at 8 stations. Levels of DNA damage were significantly greater at Stations 2491 and 2493 compared to Station 2523 (Figure 94). Samples were analyzed from four of the six subpopulations: northwest Channel Islands middle shelf; northwest Channel Islands outer shelf; southeast Channel Islands middle shelf; and southeast Channel Islands outer shelf. There was no significant difference in the DNA damage levels in fish from these four subpopulations. It should be noted, however, that damage levels in fish from the northwest Channel Islands middle shelf were barely below the threshold for statistical significance when compared to levels found from the southeast Channel Islands outer shelf (Figure 95).

1999 Samples. Of the five stations sampled in 1999, only three yielded three or more fish: Station 2700, Camp Pendleton; Station 2449, Marina del Rey; and Station 2593, Alamitos Bay (Table 66). White blood cell DNA damage in Alamitos Bay samples was significantly higher than in the Camp Pendleton samples ($p<0.01$).

DNA Damage Among Species

As mentioned previously, DNA damage was determined to have occurred in samples from 8 species of flatfish. Mean damage values were combined for all species except longfin sanddab (Figure 96), of which

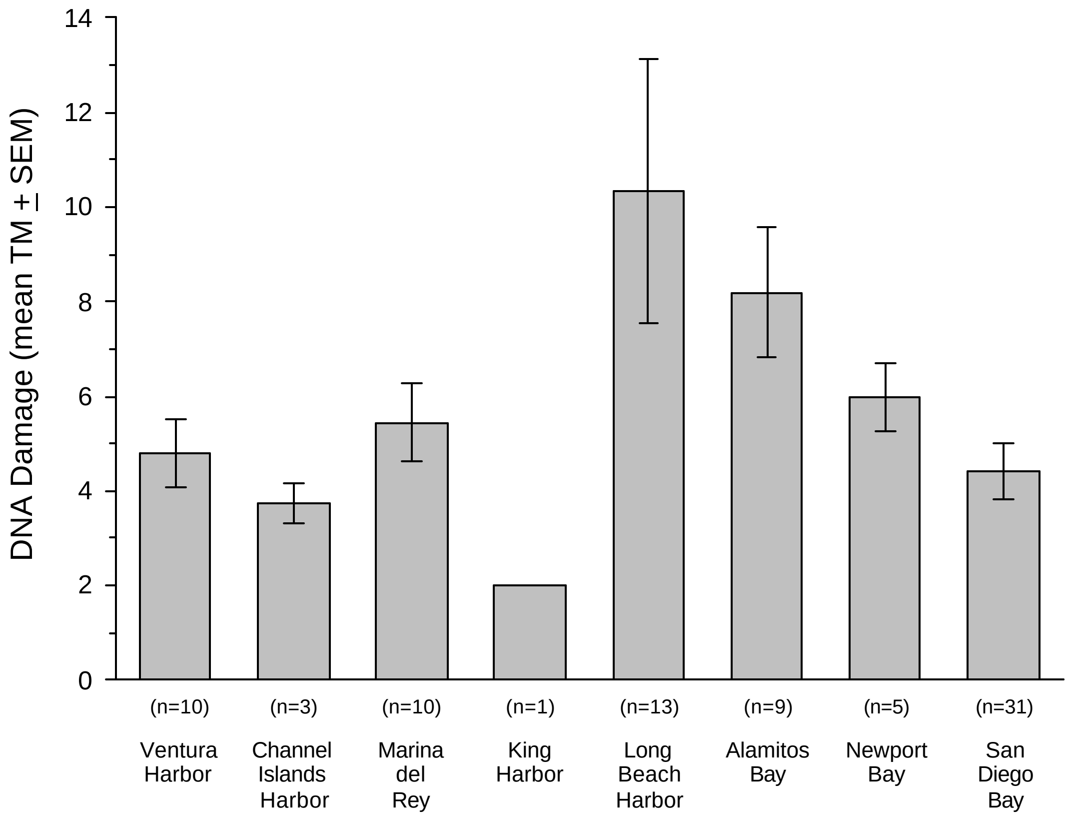


Figure 93. DNA damage in blood cells of California halibut (*Paralichthys californicus*) collected from southern California bays and harbors, July-September 1998. n = Number of fish sampled. TM (or tail moment) = (% DNA in tail) x (tail length/100). SEM = Standard error of mean.

only two individuals were sampled (Table 11). The Channel Islands species appeared to have higher levels of damage relative to the bays and harbors species. The speckled sanddab levels were significantly higher than all species sampled from bays and harbors ($p<0.01$). Damage has been observed in speckled sanddab held in the laboratory at levels of TM = ~2.0 (S. A. Steinert, Computer Sciences Corporation Biomarker Laboratory, San Diego, CA, unpublished data). Increases of this magnitude have not been observed in the blood of other species collected since this study. The high percentage of dead specimens sampled, and the equally high percentage of nondetectable samples found with the Channel Islands species suggests that these high values might be the result of poor sample handling or an extreme sensitivity of Channel Islands species to the collection methods used for this study.

Relationship to Sediment Concentrations

FAC Concentrations

Seven locations had both FAC and sediment PAH data: Ventura Harbor, Channel Islands Harbor, Marina del Rey, LA/LB Harbor, Newport Bay, and San Diego Bay, and off Corona del Mar. Sediments from Alamitos Bay and King Harbor were not analyzed for contaminants. While FAC concentrations were elevated in fish from bays and harbors, there was no significant relationship between the concentration of FACs in fish bile

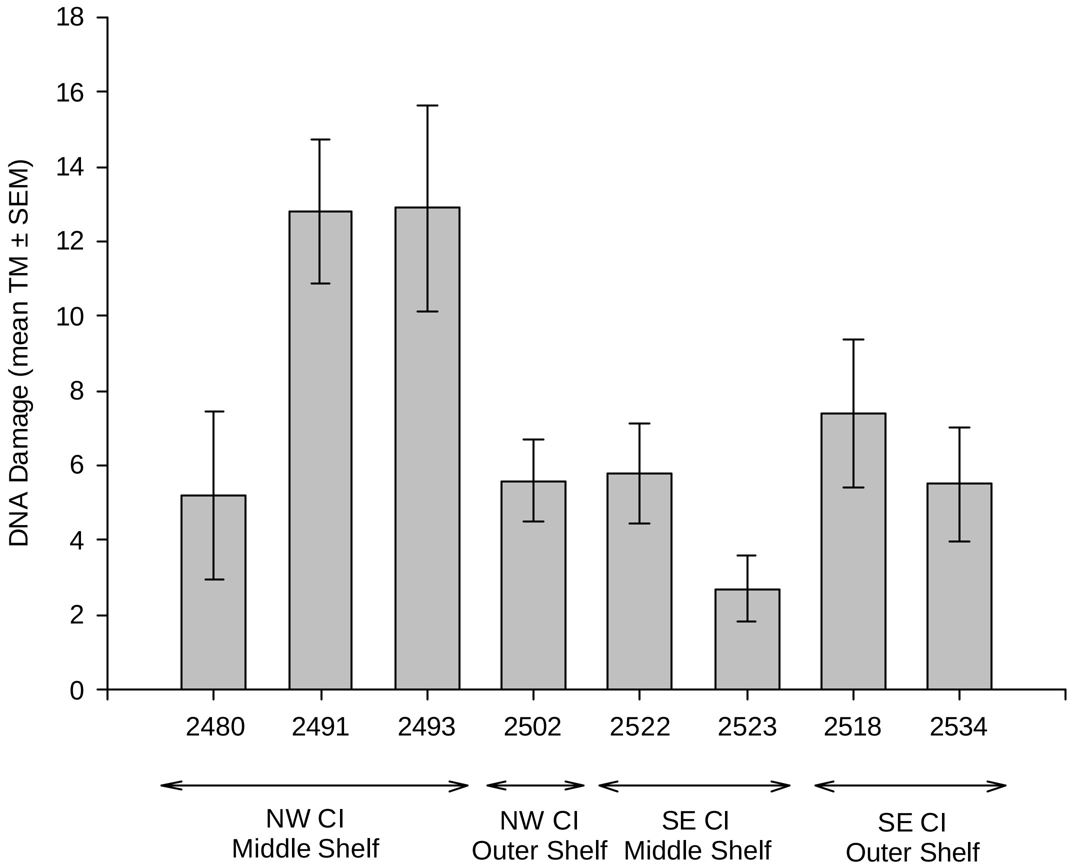


Figure 94. DNA damage levels in Pacific sanddab (*Citharichthys sordidus*) collected from each the southern California Channel Islands shelf (31-202 m) at stations where three or more individuals were collected, July-September 1998. TM (or tail moment) = (% DNA in tail) x (tail length/100); SEM = Standard error of mean; CI = Channel Islands; NW = north-west; SE = southeast.

and the concentration of high molecular weight PAHs in sediments (r^2 = 0.03) (Figure 97), or the total organic carbon normalized concentration of high molecular weight PAHs in sediments (r^2 = 0.03).

Sediments from the Channel Islands were not analyzed for contaminants during this survey; therefore, the relationship between the concentration of PAHs in sediment and FACs in Pacific sanddab could not be characterized.

DNA Damage

There was no significant association between DNA damage in fish and total concentration of selected metals (the sum of Ag, Cd, Cr, Cu, and Pb) (r^2<0.01), total PCBs (r^2 = 0.11), high molecular weight PAHs (r^2 = 0.50, p = 0.11), or total PAHs (r^2 = 0.50, p =0.12) in sediments. This was not unexpected for two reasons: 1) sediment contaminant profiles are highly variable; and 2) fish mobility makes it difficult to correlate biomarker responses to the chemistry confined within a few square meters of sediment. Unfortunately, fish tissues were not analyzed for metals or PAHs, two major classes of contaminants that could influence DNA damage.

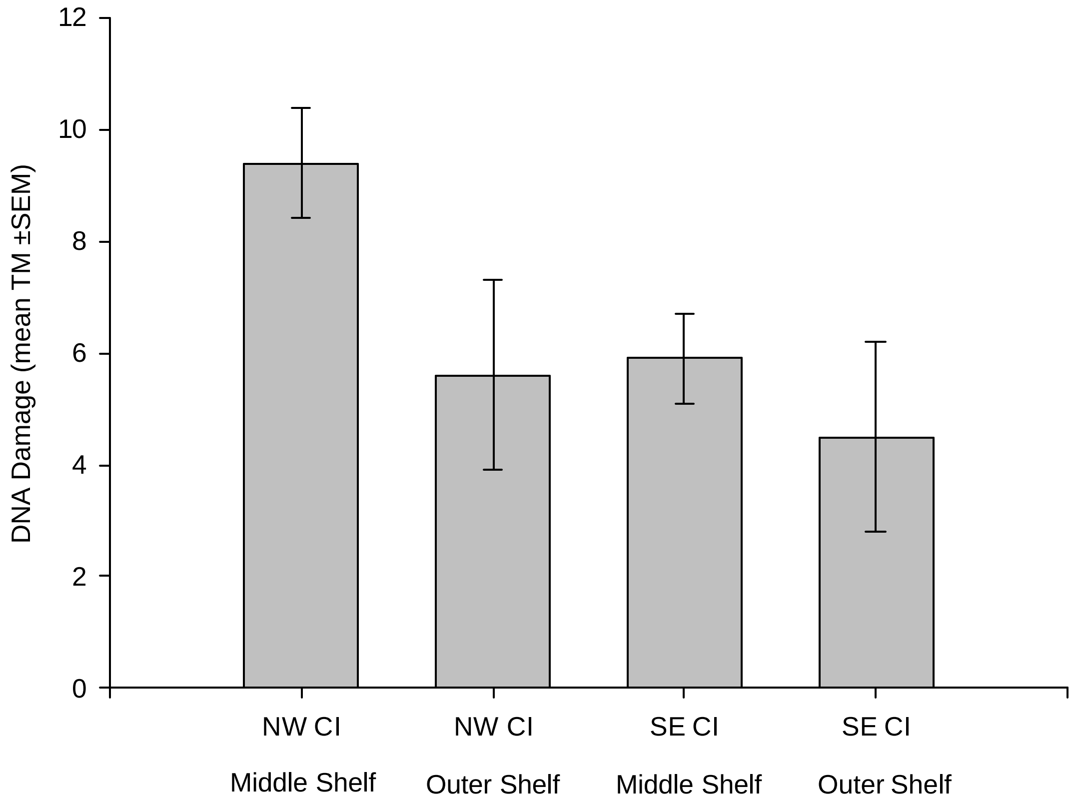


Figure 95. DNA damage levels in Pacific sanddab (*Citharichthys sordidus*) collected from the southern California Channel Islands shelf at depths of 31-202 m, July-September 1998. TM (or tail moment) = (% DNA in tail) x (tail length/100); SEM = Standard error of mean; CI = Channel Islands; NW = northwest; SE = southeast.

DNA Damage Relative to FAC Concentrations

There was no significant relationship between DNA damage and FAC concentration when indicators in fish from all bay and harbor locations were compared (r^2 = 0.06) (Figure 98). However, the relationship was stronger between indicators for some locations when data from individual locations were compared. The incidence of DNA damage showed a significant relationship with concentrations of bile FACs in fish from Marina Del Rey (r^2 = 0.49, p = 0.04) and Ventura Harbor (r^2 = 0.56, p = 0.05) (Figure 99). The relationship was not significant in fish from Alamitos Bay (r^2 = 0.30, p = 0.13), or LA/LB Harbor (r^2 = 0.02, p = 0.85).

DISCUSSION

Fluorescent Aromatic Compounds

The results of this study show that California halibut are exposed to elevated levels of PAHs at most bays and harbors in southern California. The concentration of FACs in California halibut from most bay and harbor locations were elevated compared to fish collected off Camp Pendleton, an area containing lower concentrations of sediment PAHs. This pattern is consistent with findings of the National Oceanic

Table 66. DNA damage in California halibut (*Paralichthys californicus*) blood samples collected off Camp Pendleton, California in August 1999.

			Comet Results (TM)								
Location	Station	Sample	Overall	Mean	SD	WBC	Mean	SD	RBC	Mean	SD
Camp Pendleton	2700	1002	16.3	16.2	3.8	11.2	4.6	3	19.5	25.5	3
Camp Pendleton	2700	1003	17.9	-	-	4.9	-	-	26.6	-	-
Camp Pendleton	2700	1004	19.2	-	-	3	-	-	31.9	-	-
Camp Pendleton	2700	1005	16.4	-	-	5.3	-	-	29.4	-	-
Camp Pendleton	2700	1006	8.8	-	-	3.9	-	-	22.7	-	-
Camp Pendleton	2700	1007	12.8	-	-	1.2	-	-	18.2	-	-
Camp Pendleton	2700	1022	17.5	-	-	3.3	-	-	27	-	-
Camp Pendleton	2700	1102	20.7	-	-	3.9	-	-	28.6	-	-
Marina del Rey, back	2444	1103	24.4	22.5	2.7	13.6	13.9	0.4	26	31.6	0.4
Marina del Rey, back	2444	1104	20.6	-	-	14.2	-	-	37.1	-	-
Marina del Rey, mouth	2449	1105	17.3	22.5	5.5	9.2	6.9	2.3	24	31.2	2.3
Marina del Rey, mouth	2449	1106	23.4	-	-	3.2	-	-	33	-	-
Marina del Rey, mouth	2449	1107	30.1	-	-	6.4	-	-	32.7	-	-
Marina del Rey, mouth	2449	1108	24.8	-	-	8.3	-	-	30.6	-	-
Marina del Rey, mouth	2449	1109	17.1	-	-	7.5	-	-	35.7	-	-
Alamitos Bay	2593	1110	30.4	30.6	7.7	12.3	19.3	6.8	35.4	37.8	6.8
Alamitos Bay	2593	1111	30.6	-	-	19.7	-	-	39.8	-	-
Alamitos Bay	2593	1112	30.8	-	-	19.2	-	-	38.5	-	-
Alamitos Bay	2593	1113	33.7	-	-	25.8	-	-	35.6	-	-
Alamitos Bay	2593	1114	34	-	-	21.4	-	-	38.5	-	-
Alamitos Bay	2593	1115	39.6	-	-	27.8	-	-	44.7	-	-
Alamitos Bay	2593	1116	14.8	-	-	8.7	-	-	32.3	-	-
LB Harbor, SE basin	2180	1117	6.2	19.4	18.7	2.1	12.3	14.4	36.3	36	14.4
LB Harbor, SE basin	2180	1118	32.6	-	-	22.5	-	-	35.7	-	-

TM = Tail Moment (% DNA in tail) x (tail length/100); SD = Standard deviation;
WBC = White blood cell (DNA damage); RBC = Red blood cell (DNA damage); LB = Long Beach;
SE = Southeast.

and Atmospheric Administration's (NOAA) National Benthic Surveillance Project, which found elevated FAC levels in fish collected from the urban areas of Puget Sound, San Francisco Bay, LA/LB Harbor, and San Diego Bay (Varanasi *et al*. 1989). For example, the mean concentrations of FACs in white croaker collected from LA/LB Harbor and San Diego Bay in the mid-1980s were 2 and 31 times higher, respectively, than the concentration in white croaker from a reference site off Dana Point. That study also found the mean concentration of FACs in barred sand bass (*Paralabrax nebulifer*) collected at a San Diego Bay station to be over 100 times higher than the concentration in barred sand bass from Dana Point. In the present study, the mean concentration of FACs in California halibut from San Diego Bay was elevated compared to the reference value, but was not found to be significantly different. The statistical power for the current data, however, may be insufficient to detect a significant difference, since the FAC data from the San Diego station were collected as the result of sampling two fish. Moreover, because the FAC data are for a single site within San Diego Bay, they may not be representative of the PAH exposure in other parts of the Bay.

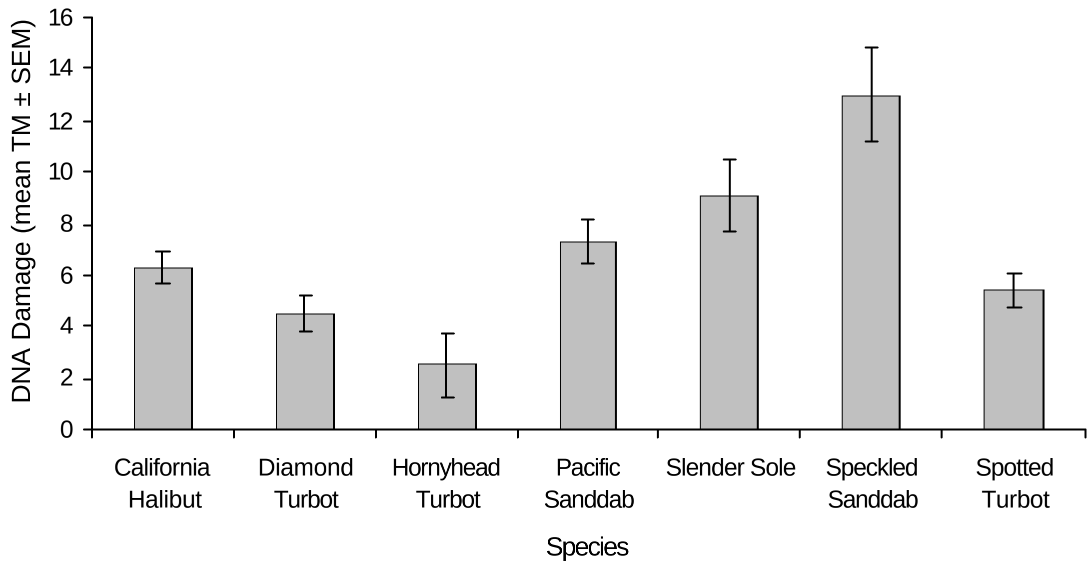


Figure 96. DNA damage levels in seven species of flatfishes collected in southern California bays and harbors and the Channel Islands shelf, July-September 1998. TM (or tail moment) = (% DNA in tail) x (tail length/100). SEM = Standard error of mean. California halibut (*Paralichthys californicus*); diamond turbot (*Pleuronichthys guttulatus*); hornyhead turbot (*Pleuronichthys verticalis*); Pacific sanddab (*Citharichthys sordidus*); slender sole (*Lyopsetta exilis*); speckled sanddab (*Citharichthys stigmaeus*); spotted turbot (*Pleuronichthys ritteri*).

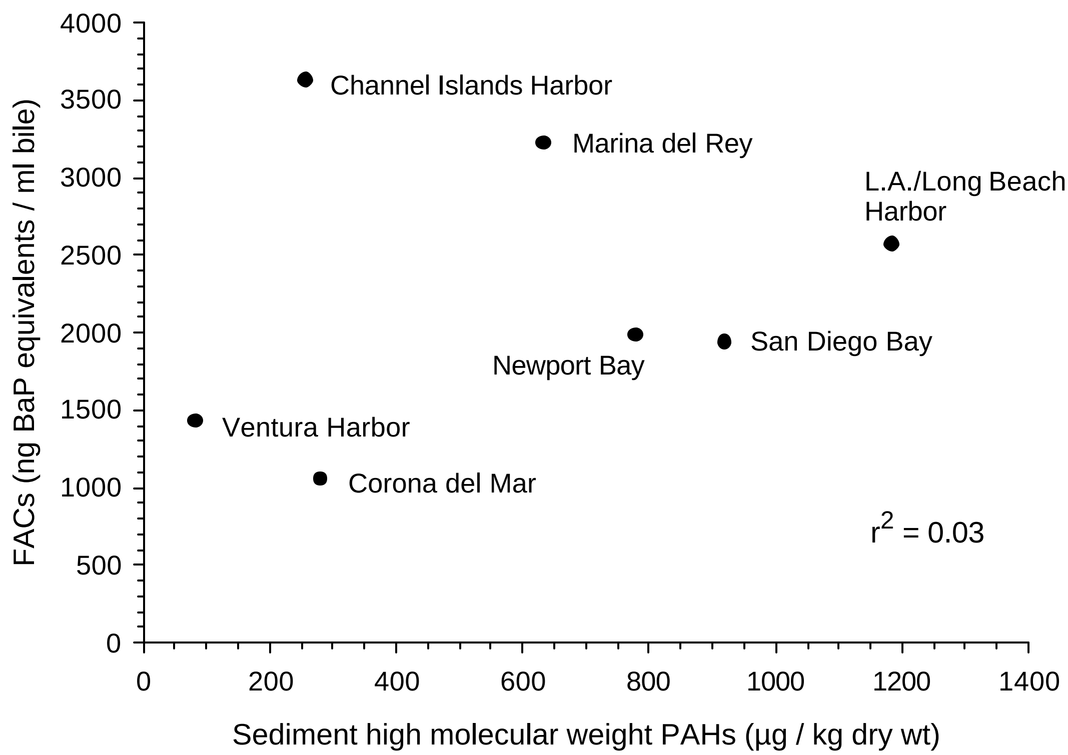


Figure 97. Relationship between high molecular weight PAHs in sediments and FACs in bile of California halibut (*Paralichthys californicus*) collected from southern California bays and harbors, July-September 1998. Sediment and FAC concentrations are reported as mean values for all sites sampled. Sediment chemistry was not analyzed for King Harbor or Alamitos Bay.

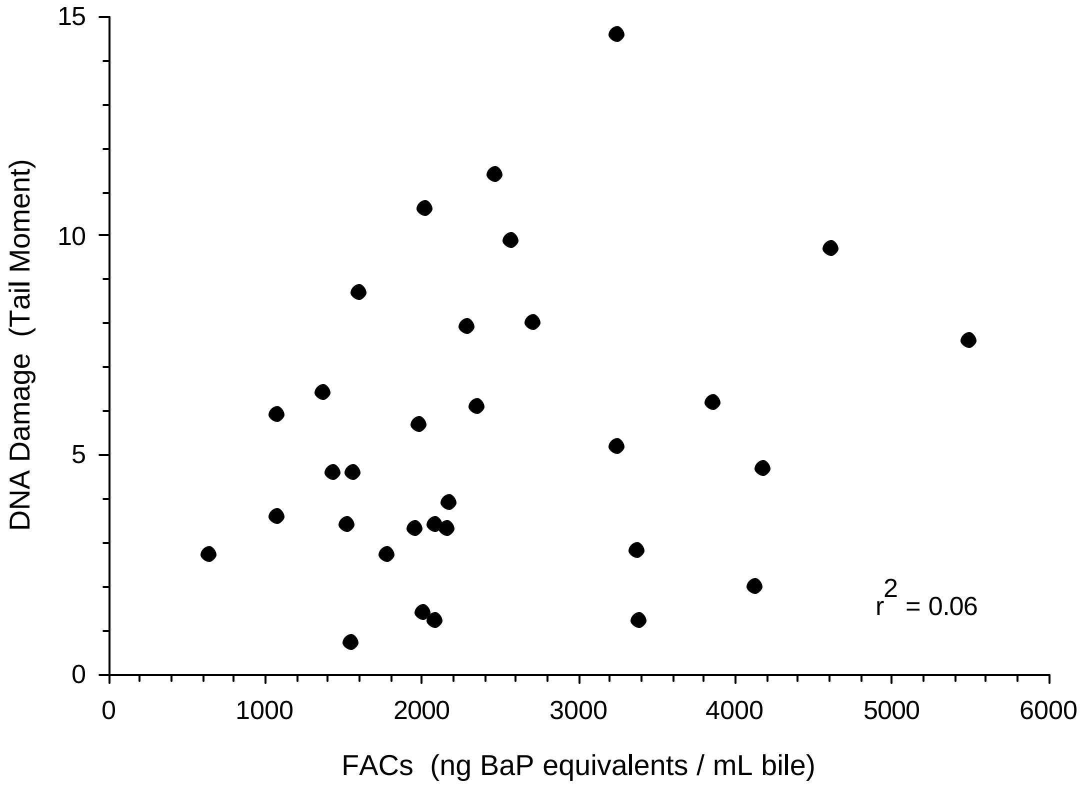


Figure 98. Relationship between bile FACs and DNA damage in California halibut (*Paralichthys californicus*) collected from southern California bays and harbors, July-September 1998. Data are for all individual fish analyzed for both types of biomarkers.

There are indications that PAH exposure in Pacific sanddab from the Channel Islands is low. The FAC concentrations were equivalent to those in California halibut from the Camp Pendleton reference site, and less than half of the concentrations in California halibut from bays and harbors locations. However, potential differences between species in the uptake, metabolism, and excretion of PAHs preclude interspecies comparisons (Stein *et al.* 1995). Sediments from the Channel Islands were not analyzed for contaminants. These areas are remote from discrete sources of contamination, and PAH concentrations are expected to be low.

Previous unpublished SCCWRP data also suggest that the fish from the Channel Islands are not exposed to elevated levels of high molecular weight PAHs. The FAC values in this study (356-629 ng BaP equivalents/mL bile) are comparable to those found in Pacific sanddab from a Dana Point reference site in 1997 (741 ng BaP equivalents/mL bile), and lower than the mean concentration in fish captured near the City of Los Angeles' wastewater outfall in Santa Monica Bay (1021 ng BaP equivalents/mL bile).

While FACs were elevated in fish from bays and harbors, FAC concentrations were not related to the concentrations of PAHs in sediments. This is not unexpected for areas that have a high variability in concentrations of sediment contaminants. Because fish move around within each location, their exposure is variable and not necessarily correlated with contaminant concentrations at discrete sites. Sediment data for Marina del Rey demonstrate how variable PAH concentrations can be over small distances. Concentrations of high molecular weight PAHs in sediments varied by a factor of eight in this marina, ranging from 196-1623 µg/kg dry wt. The results in the present study illustrate the importance of measuring the

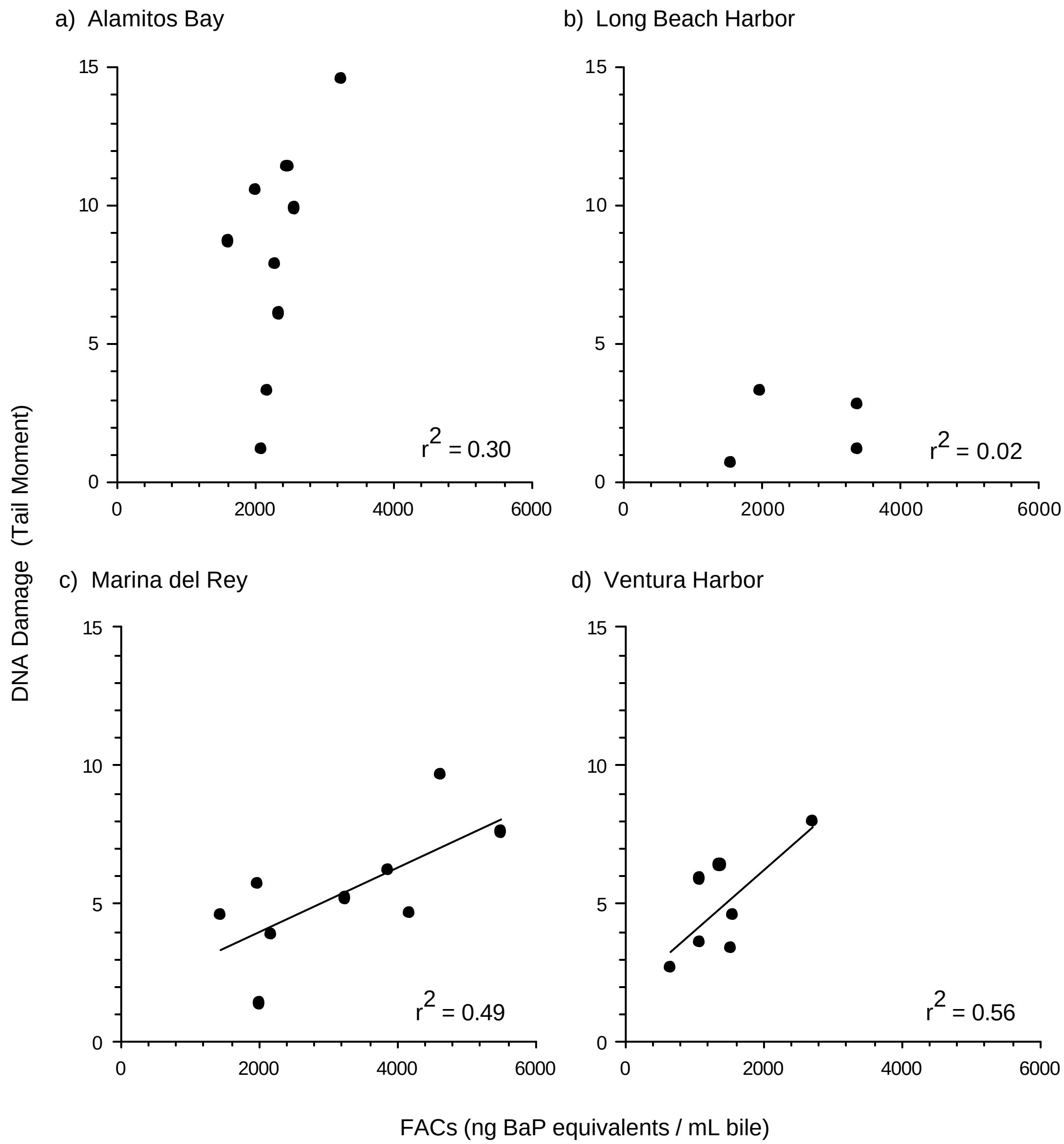


Figure 99. DNA damage and bile FACs in individual California halibut (*Paralichthys californicus*) sampled from southern California bays and harbors where more than two fish were collected, July-September 1998.

actual exposure in fish, rather than inferring the exposure from concentrations of PAHs in sediments. Previous studies using laboratory exposures have found agreement between PAH exposure and FACs in fish bile. For example, Varanasi *et al.* (1985) found elevated concentrations of FACs in fish exposed to PAH-contaminated sediments, compared to fish exposed to reference sediments, and Collier and Varanasi (1991) found excellent dose responses in fish injected with either BaP or a solvent extract of PAH-contaminated sediment.

This study focused on characterizing fish exposure to high molecular weight PAHs (products of combustion) because these compounds have been identified as a risk factor influencing the development of liver lesions in fish (Myers *et al.* 1998). However, exposure to low molecular weight PAHs (components of petroleum) may also be an important risk factor to fish health, particularly for fish from the Channel Islands, where oil seeps are common. Future studies may benefit by measuring both high and low molecular weight PAHs in order to characterize the overall exposure to this class of compound.

Relationship of DNA Damage to FACs

There was no consistent relationship between FAC concentrations and DNA damage among bay and harbor locations. There was a significant association between indicators at Marina del Rey and Ventura Harbor, but not at other locations. Differences in the relationship between indicators at the various locations are also evident in the slopes of the regression lines (Figure 99). This variation in slopes may reflect differences in the types and amounts of contaminants that fish are exposed to at each location, since DNA damage can be caused by a variety of environmental contaminants, in addition to PAHs. Alternatively, the differences in slopes may indicate that the relationship between PAH exposure and DNA damage was variable. Exposure of bluegill (*Lepomis macrochirus*, a sunfish) to BaP in a laboratory experiment leads to an increase in DNA damage initially, but a similar level of damage to control fish was observed after 30 d of exposure (Shugart 1988). Theodorakis *et al.* (1992) found consistent FAC concentrations in bluegill over a 40 wk exposure to contaminated sediments, but fluctuations in DNA damage over this same period. Di Giulio *et al.* (1993) found significant damage in channel catfish (*Ictalurus punctatus*) exposed in the laboratory to contaminated sediments after 28 d, but the damage was much less than it was after 14 d.

The relative lack of correlation between DNA damage and FACs was not unexpected since each biomarker is sensitive to different stressors. The FACs are sensitive to PAHs and DNA damage is sensitive to a broad spectrum of contaminants, including PAHs, metals, pesticides, and more. This study was limited to DNA damage in fish blood samples. Preliminary studies examining DNA damage in flatfish that preceded this study indicated that, under chronic exposure conditions, both blood and liver tissue might be appropriate tissues to sample (Stransky and Ford 1998). The focus was on obtaining the maximum number of samples for DNA damage analysis. Due to protocol in the study plan for the survey, liver samples were limited to individual fish remaining after assemblage data and bioaccumulation samples had been taken. Since blood samples could be collected from any fish, assessing DNA damage in blood cells became the focus of this aspect of the study. Subsequent studies have shown that, under chronic exposures, liver cells and possibly germ cells might be more appropriate indicator tissues (Steinert *et al.*, in press). Nonetheless, significant elevation of DNA damage in the blood cells of the Alamitos Bay fish in the 1999 samples indicates that fish in that location are encountering significant stresses. It is unfortunate that circumstances did not allow a direct comparison of the 1999 Camp Pendleton samples with the 1998 regional survey samples since the Camp Pendleton site may represent a minimal contaminant exposure station.

DNA Damage

Importance, Types, and Implications of DNA Damage

Of central importance to an organism is its survival and reproductive success. Neither is attainable if an organism does not maintain the integrity of its genetic material, DNA. At the molecular level, the corruption of the information encoded in DNA may not pass beyond the boundary of an affected single cell. Yet there exists the potential for a cascade of effects adversely affecting the functioning and survival of cell populations, organs, and the organism as a whole. Furthermore, damage sustained in reproductive cells has the potential to adversely affect fertilization success, development, and the ultimate survival of offspring, thereby causing a net negative effect at the population and community levels (Shugart *et al.* 1992).

Of the many pathological conditions initiated by an increased incidence of DNA damage, the most common is the initiation of carcinogenesis as a result of DNA damage-induced mutations. The DNA damage may be manifested in the form of base alterations, adduct formation, strand breaks, and cross linkages (Bernstein and Bernstein 1991). Strand breaks may be introduced directly by genotoxic compounds through the induction of apoptosis or necrosis and, secondarily, through the interaction with oxygen radicals or other reactive intermediates; or as a consequence of excision repair enzymes (Park *et al.* 1991, Eastman and Barry 1992, Speit and Hartmann 1995). In addition to a linkage with cancer, studies have demonstrated that increases in cellular DNA damage precede or correspond with reduced growth, abnormal development, and reduced survival of adults, embryos, and larvae (Shugart *et al.* 1992, Lee *et al.* 1999, Steinert 1999).

The most prevalent type of genetic damage is the DNA single-strand break. Tens of thousands occur daily in individual cells (Bernstein and Bernstein 1991), and many toxicants have been shown to cause strand breaks in a dose-dependent manner (Tice 1996). Many methods are available for measuring DNA strand breaks; most rely on the denaturation of cellular DNA followed by some means of enumerating broken strands. Many early methods relied on rates of unwinding as determined by the incorporation of a fluorescent dye in double-stranded DNA or the separation of reannealed double-stranded DNA from break-produced single-stranded DNA by centrifugation or filtration (Shugart *et al.* 1992, Mitchelmore and Chipman 1998). These and similar methods have been used to demonstrate the dose relationship of DNA strand breakage to applied toxicological effects *in vitro, in vivo*, and in field collected organisms (Shugart 1988; Everaarts *et al.* 1993; Sugg *et al.* 1995, 1996; Mitchelmore and Chipman 1998).

Merits of the Comet Assay in Assessing DNA Damage

In this study, DNA single-strand break levels were determined in the blood cells of wild trawl-captured flatfish throughout the SCB using the Comet assay. The Comet assay has been used to determine oxidative DNA lesions as well as single-strand breaks, double-strand breaks, DNA repair activity, frequency of apoptosis, and pyrimidine dimer lesions, in single cells (Gedik *et al.* 1992, Collins *et al.* 1993, McKelvey-Martin 1993, Tice 1996). An extension of earlier DNA denaturation methods, it utilizes the electrophoretic mobility of relaxed or broken strands of DNA following denaturation to detect damage. The assay has the added advantages of measuring strand breaks in individual cells, requiring small sample sizes of ~10,000 cells, and not requiring DNA extraction and purification from tissues. Because the method requires such small numbers of cells per sample, it has been used to screen the genotoxicity of various compounds on isolated fish cells *in vitro* (Tiano *et al.* 2000), as well as the dose-dependent anti-oxidant (protective) properties of various compounds (Villarini *et al.* 1998). Belpaeme *et al.* (1998) conducted systematic *in vivo* genomic damage studies on marine flatfish using the Comet assay. It was concluded that the method was indeed simple and sensitive, but that due care must be taken in the choice of protocols and experimental conditions. Significantly elevated levels of DNA damage have been reported in cells from fish collected at polluted sites compared to those from reference sites using this method (Pandrangi *et al.* 1995).
Modifications to the Comet assay can specifically express single or double-strand damage, specific lesions, DNA repair activity, and the cellular presence of photoactive contaminants (Gedik *et al.* 1992, Collins *et al.* 1993, McKelvey-Martin 1993, Tice 1996, Steinert *et al.* 1998b). These attributes, coupled with the method's

capability to distinguish germ and somatic cells by DNA content, and to identify apoptotic cells, enable the development of protocols to identify patterns of damage characteristic of specific damage-inducing agent(s) (Tice 1996, Steinert *et al.* 1998a).

Updates and Future Prospects

No additional data have been collected for California halibut since this study. However, hornyhead turbot blood DNA damage values were determined in a flatfish survey in the vicinity of the Orange County Sanitation District (OCSD) wastewater outfall (OCSD 2001). These samples showed elevated blood DNA damage at a reference location of TM = 0.34±0.1 (mean ± standard deviation) and overall at 8 stations throughout the region of TM = 0.67±0.5, as compared to the combined average for all hornyhead turbots sampled in 1998 of TM = 2.9±2.9. In the OCSD study, DNA damage increased in samples collected closer to shore, going from 60-18 meters in depth and approximately 6-1.5 miles off shore. The fish closest to shore had damage levels of TM = 1.46±0.5. The hornyhead turbots in the present study were collected in much shallower water closer to shore. These levels fall within the range of those observed in a subsequent study; but they follow the observed trend of higher levels of DNA damage at inshore locations, which may be the result of increased exposure to anthropogenic contaminants closer to shore in the bays and harbors. The California halibut in the present study were all collected within marinas, bays and harbors. It is not certain whether any individuals representative of a nonstressed population were sampled.

This was the first study in which widespread DNA damage monitoring of fish had been attempted. Several areas were identified for future improvement relative to the collection/handling of samples and the analysis of blood cells. Since 1998, the protocols for DNA damage sampling and analysis have been refined and guidelines have been written that are currently under review by the American Society for Testing and Materials. Similar guidelines will be published in the 2002 edition of *Standard Methods for Water and Wastewater Testing.* The database of DNA damage in flatfish tissues has expanded as a result of subsequent coastal ocean monitoring efforts with the OCSD in the summers of 2000 and 2001 and additional laboratory exposure experiments. The DNA damage monitoring and other biomarker determinations are important tools for assessing contaminant exposure and sublethal effects in future fish population and contaminant bioaccumulation studies.

DEBRIS

INTRODUCTION

Many studies have documented the types and amounts of marine debris that aesthetically impair coastal recreation areas and threaten marine organisms through ingestion and entanglement (Fowler 1987, Ryan 1987, Bjorndal *et al.* 1994, Moore *et al.* 2001). Many organizations have been and are currently collecting and analyzing debris data to inform the public of this growing worldwide problem (Ribic *et al.* 1997). Although marine debris is of increasing concern, most studies have focused only on the types and amounts of large debris found on coastal beaches (MBC 1988, Ribic *et al.* 1997, SMBRP 1998). In southern California, the Los Angeles Regional Water Control Board has set a total maximum daily load of zero trash for several area watersheds based on the amounts of trash flowing from rivers and storm drains; however, few studies have documented the amount of trash that remains in the ocean versus that transported to beaches. A recent study (Moore *et al*., in press) documented a density of 8 pieces of plastic per cubic meter in the neuston and a baseline study conducted in 1994 documented the types and amounts of benthic debris in the SCB (Allen *et al*. 1998, Moore and Allen 2000).

This chapter presents the second study of debris on the seafloor of the SCB. The objectives of this chapter are 1) to assess the distribution, type, and amount of anthropogenic and natural marine debris on the seafloor of the mainland shelf of the SCB in 1998, and 2) to compare these findings to those of a 1994 baseline study (Allen *et al.*1998).

RESULTS

Debris (natural and/or anthropogenic) was found in 259 of 314 (82%) trawl stations representing an area of 5,541 km^2 (85% of the area) on the southern California shelf. Natural debris occurred in 88% of the area of the shelf, whereas anthropogenic debris occurred in 23% of the area (Table 67). Although natural debris covered a much larger percent of area than anthropogenic debris in all subpopulations in the SCB, both were nearly equal in area in the Santa Catalina Island subpopulation. Southwest Santa Catalina Island had the largest uniform area without any debris (Figure 100).

Natural Debris

Natural debris varied in areal coverage by subpopulation (Figures 101, 102). Regionally, the percent of areal coverage of natural debris varied little among the northern (86%), central (83%), and southern (86%) regions (Table 67). However, among the island subpopulations there was more variation in percent of areal coverage of natural debris, with the cool islands (northwest Channel Islands) having the highest percent of area (100%) and Santa Catalina Island the lowest (42%). Bathymetrically, natural debris had the highest percent of area on the middle shelf (91%), followed by the inner shelf (85%), outer shelf (80%), and finally the bays and harbors (72%). Within the middle shelf, small POTWs (100%) had the highest percent of area of natural debris followed by the islands (93%), non-LPOTW (91%), and LPOTWs (69%) (Figure 102, Table 67). Inner shelf natural debris occurred in the highest percent of area in the island (100%), river (90%), mainland (84%), and small POTW (78%) subpopulations. On the outer shelf, the percent of area of natural debris was highest in the island areas (87%) and lowest in the mainland (72%) areas. The percent of

Table 67. Percent of area by subpopulation of debris types on the southern California shelf at depths of 2-202 m, July-September 1998.

	Natural Debris					Anthropogenic Debris									
Subpopulation	M.Veg	T.Veg	Ben.D	Rocks	Total	Plast	Metal	Cans	Other	Lumb	FshGr	GlaBo	Tires	Total	Overall
Region															
Mainland	72.6	41.9	3.0	3.6	85.0	8.3	2.4	6.1	3.9	0.3	2.6	0.1	0.2	17.3	85.5
Northern	72.3	62.9	3.7	2.4	86.0	3.3	-	3.8	3.7	-	-	-	-	10.8	-
Central	65.0	36.9	3.4	5.2	83.0	14.8	0.2	4.0	0.3	0.4	2.7	0.4	0.4	20.7	-
Southern	85.5	8.6	0.8	3.1	86.3	7.5	10.4	13.9	10.2	0.6	7.8	-	0.1	24.4	-
Island	80.9	22.7	73.9	37.0	91.6	14.1	7.9	1.1	3.5	9.6	2.5	5.4	-	33.3	93.7
Cool (NW Channel Isl.)	89.5	17.7	83.9	43.4	100.0	21.7	10.5	-	-	10.5	-	4.9	-	37.1	100.0
Warm	64.9	32.1	55.6	24.9	76.1	-	3.2	3.2	10.1	7.9	7.2	6.4	-	26.6	-
SE Channel Islands	78.0	41.5	69.5	33.0	89.0	-	-	-	11.0	11.0	8.5	-	-	22.0	91.5
Santa Catalina Island	30.8	7.7	19.2	3.8	42.3	-	11.5	11.5	7.7	-	3.8	23.1	-	38.5	57.7
Shelf Zone															
Bays and Harbors	48.6	24.3	16.5	6.0	71.8	22.2	4.0	12.0	6.0	4.7	6.1	-	1.3	33.8	78.1
Ports	54.2	30.4	29.6	12.7	74.4	41.5	6.8	27.1	19.5	13.7	14.4	-	5.1	54.2	74.4
Marinas	39.8	37.1	5.5	-	66.2	27.0	5.5	10.4	-	5.2	10.8	-	-	43.3	82.5
Other Bay	49.6	16.0	14.6	5.3	72.8	10.6	2.0	5.3	2.0	-	-	-	-	19.9	78.2
Inner Shelf	75.6	40.4	2.9	3.1	84.6	7.8	-	5.8	-	-	0.2	-	-	11.0	84.6
Small POTWs	77.8	-	-	-	77.8	-	-	-	-	-	-	-	-	-	77.8
River Mouths	87.0	64.2	-	-	90.2	28.6	-	-	-	-	6.5	-	-	35.1	90.2
Other Mainland	74.1	38.8	-	-	83.9	6.4	-	6.4	-	-	-	-	-	9.7	83.9
Island	100.0	80.0	73.3	80.0	100.0	26.7	-	-	-	-	-	-	-	26.7	100.0
Middle Shelf	77.9	30.6	35.4	18.4	90.8	12.3	6.0	3.9	4.9	5.5	3.4	0.8	0.1	27.7	91.6
Small POTWs	90.0	62.3	-	-	100.0	6.3	-	-	-	-	-	-	-	6.3	100.0
LPOTW	56.3	28.1	9.4	6.3	68.8	18.8	3.1	6.3	-	3.1	6.3	3.1	3.1	37.5	75.0
Mnld. non-LPOTW	75.0	40.8	3.1	3.1	90.6	6.4	3.1	6.3	6.2	-	3.2	-	-	18.9	90.7
Island	83.2	18.6	75.7	37.5	93.0	18.5	9.8	1.0	4.0	12.2	3.5	1.5	-	37.3	94.0
Outer Shelf	70.6	44.1	38.8	22.8	80.1	5.5	3.5	2.6	3.3	1.4	1.8	9.3	-	19.5	83.1
Mainland	68.2	59.9	4.0	11.9	72.2	11.9	4.0	4.0	4.3	-	4.0	-	-	16.2	72.2
Island	72.7	30.5	68.7	32.0	86.9	-	3.0	1.5	2.5	2.5	-	17.2	-	22.3	92.5
Total	75.7	34.6	29.8	16.2	87.5	10.5	4.5	4.2	3.8	3.8	2.6	2.1	0.1	23.4	88.6

POTW = Publicly owned treatment work monitoring areas; M.Veg = Marine vegetation; T.Veg = Terrestrial vegetation; Ben.D = Benthic debris; Plast = Plastic; Metal = Metal debris; Lumb = Lumber; FshGr = Fishing gear; GlaBo = Glass & Bottles; Isl. = Islands; Mnld. = Mainland.

area for natural debris in the bays and harbors was consistently around 70% for all areas. Ports (74%) were the highest followed by other bays (73%) and marinas (66%).

On the mainland shelf of southern California, marine vegetation was the most commonly occurring natural debris, followed by terrestrial vegetation, benthic debris, and rocks (Table 67). All types of natural debris were most commonly found in low numerical densities (2-10 items per haul) and low weight densities (0.2-1.0 kg), except for marine vegetation, which was more common at trace weight densities (0.0-0.1 kg) (Table 68).

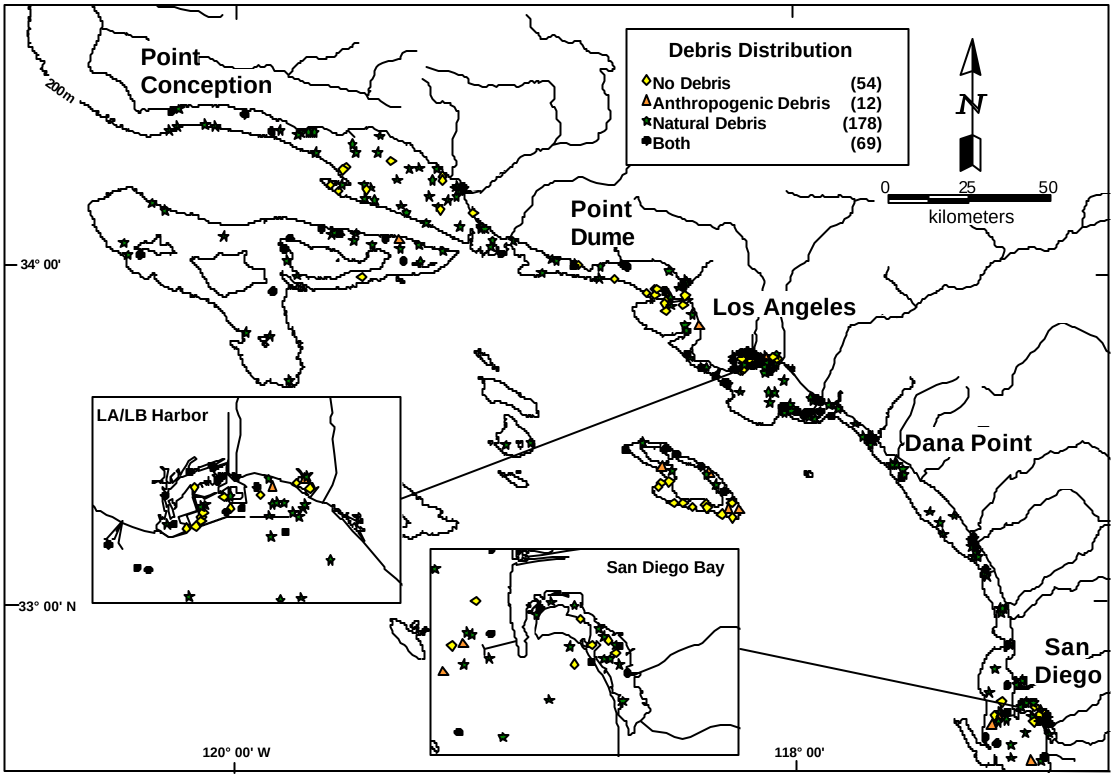


Figure 100. Distribution of natural and anthropogenic debris on the mainland shelf of southern California at depths of 2-202 m, July-September 1998.

Different types of natural debris also varied by subpopulation (Table 67). Marine vegetation was most widely distributed on the inner shelf of the islands (100%) and least distributed on Santa Catalina Island (31%). Terrestrial vegetation occurred most commonly on the inner shelf island areas (80%) and was absent in inner shelf small POTW areas. Benthic debris was widely distributed in the cool island (northwest Channel Islands) areas (84%) and absent in the inner shelf small POTW, river, and mainland areas. Rocks were most widely distributed on the inner shelf island areas (80%) and were absent in the inner shelf small POTW, river, and mainland areas, as well as in marinas.

Anthropogenic Debris

Anthropogenic debris also varied by subpopulation, but the pattern of variation differed from that of natural debris (Figures 101, 102). Regionally, Santa Catalina Island (39%) had the highest areal coverage of anthropogenic debris and the northern mainland region the lowest (11%) (Table 67). Along the mainland, the southern and central regions had similar areal coverage (24 and 21%, respectively) (11%). At the Channel Islands, the northwestern islands had more coverage than the southeast Channel Islands (37 and 22%, respectively). Bathymetrically, anthropogenic debris occurred most commonly in the bays and harbors (34%), followed by the middle shelf (28%), outer shelf (20%), and inner shelf (11%) zones. Within bays and harbors, ports had the highest areal coverage (54%) and other bays the least (20%) (Figure 102, Table 67). The highest occurrence (35%) of anthropogenic debris on the inner shelf occurred at river mouths, while small POTW areas had no anthropogenic debris. On the middle shelf, large POTW and island areas had the highest areal coverage (38 and 37%, respectively) of anthropogenic debris, whereas middle shelf small POTWs had the least (6%). On the outer shelf, island areas had the highest occurrence (22%) and mainland areas the least (16%).

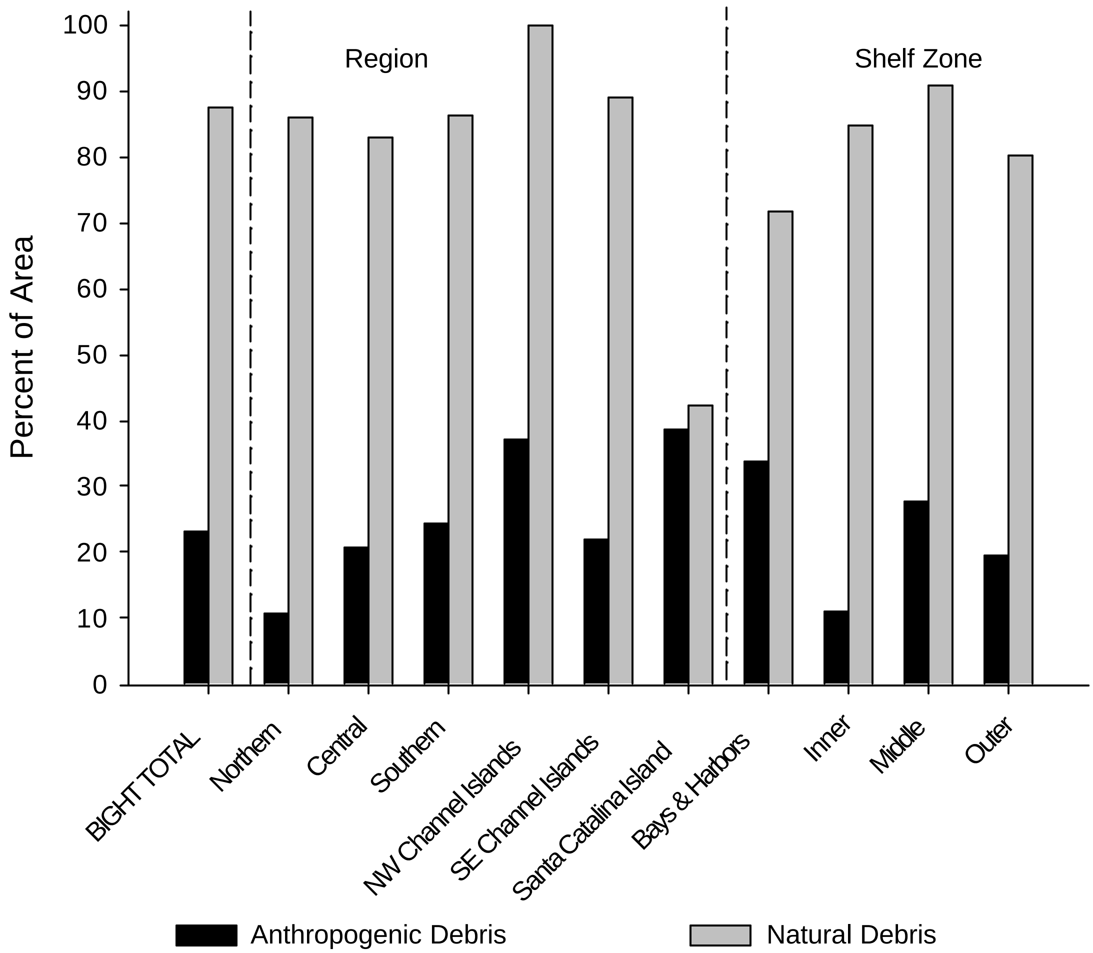


Figure 101. Percent of area with natural and anthropogenic debris by region and depth on the southern California shelf at depths of 2-202 m, July-September 1998.

Anthropogenic debris consisted of cans, glass bottles, fishing gear, metal, plastic, lumber, tires, and "other" anthropogenic debris. On the mainland shelf of the SCB, plastic occurred most commonly, followed by metal and cans, with tires occurring the least. Anthropogenic debris occurred primarily in the trace abundance and weight categories (Table 68). However, metal occurred most commonly at low numerical densities and tires at moderate weight densities.

Anthropogenic debris types were found to vary by location and subpopulation along the southern California shelf (Figure 103, Table 67). Regionally, all types of anthropogenic debris occurred in the central region, with plastic occurring most commonly (15%). In the southern region, cans occurred commonly (14%) but glass bottles were completely absent. In the northern region only cans, "other" anthropogenic debris, and plastic occurred. Among the island subpopulations, glass bottles (23%), metal (12%), and cans (12%) occurred most frequently at Santa Catalina Island, whereas lumber (11%), "other" anthropogenic debris (11%), and fishing gear (9%) occurred most frequently at the southeast Channel Islands. At the cool northwest Channel Islands, plastic was the most common. Regionally, ports had the highest occurrence of plastic (42%), cans (27%), "other" anthropogenic debris (20%), lumber (14%) and tires (5%). Metal, "other" anthropogenic debris, lumber, glass bottles, and tires did not occur on the inner shelf. On the middle shelf, plastic

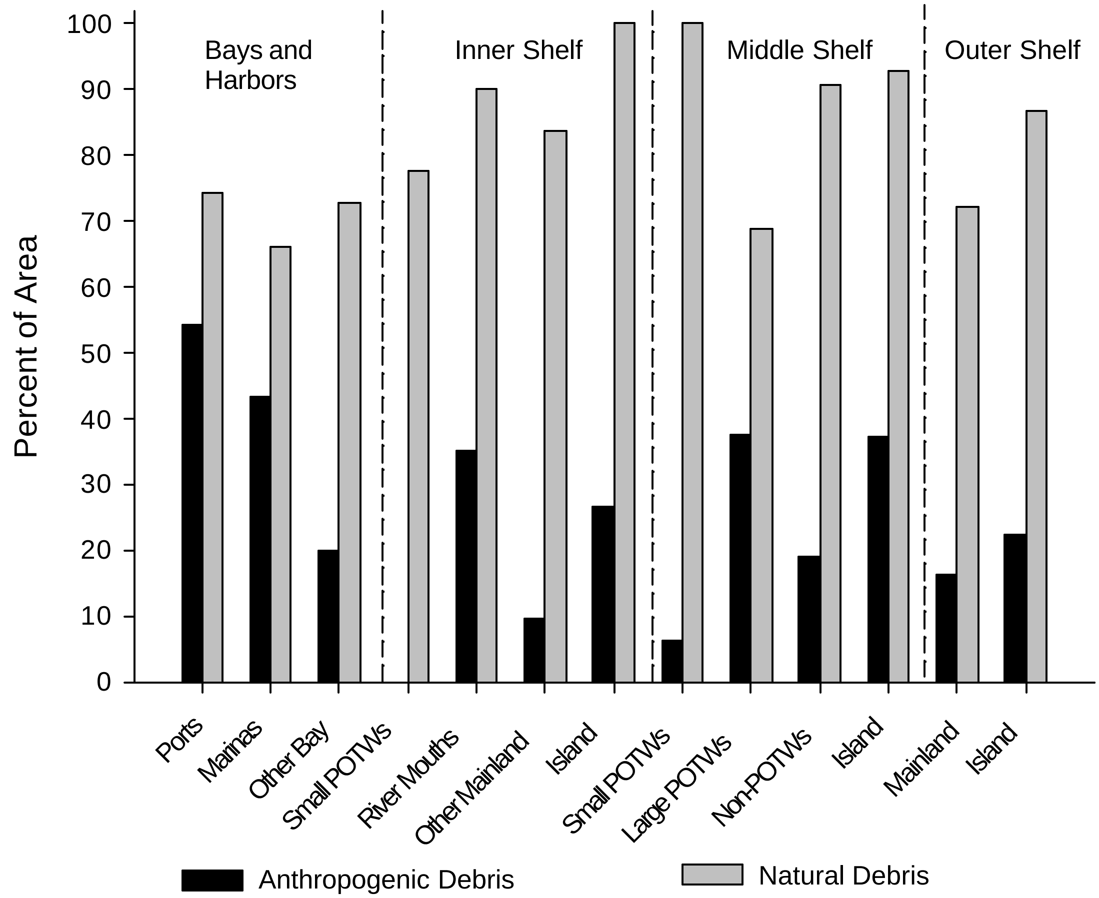


Figure 102. Percent of area with natural and anthropogenic debris by subpopulation within shelf zones on the southern California shelf at depths of 2-202 m, July-September 1998.

occurred most frequently near large POTWs (19%) and islands (19%). Plastic, cans, fishing gear, glass bottles, and tires occurred more frequently in middle shelf large POTW subpopulations; metal, lumber, and "other" anthropogenic debris occurred most frequently in middle shelf non-POTW subpopulations (Figure 104). On the outer shelf, plastic (12%) occurred most commonly on the mainland shelf and glass bottles (17%) on the islands (Table 67).

DISCUSSION

Natural and anthropogenic debris was widespread on the mainland shelf of southern California (Figure 100) but was generally found in small amounts at any given site. Natural debris occupied the same amount of area in the northern, central, and southern regions and, bathymetrically, was most common in the middle shelf zone. Terrestrial debris was most common in the northern region (Table 67), reflecting its greater availability in this less developed region. Although the middle shelf zone had the most areal coverage of natural debris, the middle shelf large POTW subpopulation had low areal coverage of natural debris, which may be due to the greater width of the middle shelf in large POTW areas (excluding the Palos Verdes Shelf area). The outer shelf, which is more distant from shore and thus may more closely reflect a middle shelf POTW area, had the lowest occurrence of natural debris on the mainland shelf. The low occurrence of natural debris in bays and

Table 68. Percent of area of quantification categories of debris types collected on the southern California shelf at depths of 2-202 m, July-September 1998.

DebrisType	No. of Stations	Abundance[a] T	Abundance[a] L	Abundance[a] M	Abundance[a] H	Weight[b] T	Weight[b] L	Weight[b] M	Weight[b] H	Total
Natural Debris										
Marine Vegetation	210	14.0	42.0	15.5	4.1	33.0	28.6	12.9	1.1	75.7
Terrestrial Vegetation	116	7.2	19.9	5.8	1.5	13.3	15.3	5.7	0.2	34.6
Benthic Debris	42	0.5	15.9	13.1	0.3	4.5	20.3	5.1	-	29.8
Rocks	24	5.1	9.3	1.9	-	2.8	7.9	1.3	4.3	16.2
Total	247	38.1	60.3	25.3	5.9	54.7	55.8	21.7	5.5	87.5
Anthropogenic Debris										
Plastic	43	9.7	0.8	0.0	-	8.2	2.3	-	0.0	10.5
Metal Debris	10	1.3	3.2	-	-	2.8	0.3	1.3	0.0	4.5
Cans	19	2.7	1.2	0.3	-	2.6	1.3	0.3	-	4.2
Lumber	7	3.0	0.8	-	-	2.9	0.9	0.0	-	3.8
Other	11	3.2	0.4	0.0	0.0	3.2	0.1	0.4	0.0	3.8
Fishing Gear	12	1.9	0.3	0.0	-	1.2	0.1	1.0	-	2.6
Glass Bottles	8	2.0	0.1	-	-	1.2	0.8	0.1	-	2.1
Tires	2	0.1	0.0	-	-	-	-	0.1	0.0	0.1
Total	81	21.6	15.4	10.8	2.8	21.0	16.3	10.9	1.4	22.3
Overall	259	39.1	60.4	25.3	5.9	55.2	56.2	21.9	5.6	88.6

[a]T = Trace (1 item)
L = Low (2-10 items)
M = Moderate (11-100 items)
H = High (>100 items)

[b]T = Trace (0.0-0.1 kg)
L = Low (0.2-1.0 kg)
M = Moderate (1.1-10.0 kg)
H = High (>10.0 kg)

harbors may be due to the greater proximity of these areas to highly populated, industrially developed areas and perhaps to dredging activities in these areas. Natural debris occurred around all of the islands, with the exception of the exposed southwestern area of Santa Catalina Island where no debris was collected.

In contrast to natural debris, anthropogenic debris was highest in the southern and central regions and in bays and harbors. The higher occurrence in the southern and central regions is due to the proximity of large populations to these areas (near Los Angeles and San Diego metropolitan areas). The high occurrence of anthropogenic debris in bays and harbors is likely from land-based and marine vessel sources. The next highest occurrence on the middle shelf is more likely from a combination of recreational fishing and boating sources, and less from land-based sources. Anthropogenic debris was most frequent on the mainland (leeward) side of all island subpopulations, reflecting the greater recreational use of the more protected waters. For Santa Catalina Island, the mainland side is also the most populated area. Plastic was the most commonly occurring debris item in all subpopulations, except for the outer shelf island areas, where glass bottles were the most common.

Most of the plastic debris may come from terrestrial sources. In 1998, a study of Orange County beach debris estimated that approximately 80% of the debris items were plastic (excluding preproduction plastic pellets) (Moore *et al*. 2001). The high occurrence of plastic on beaches, in bays and harbors, and in river areas, as

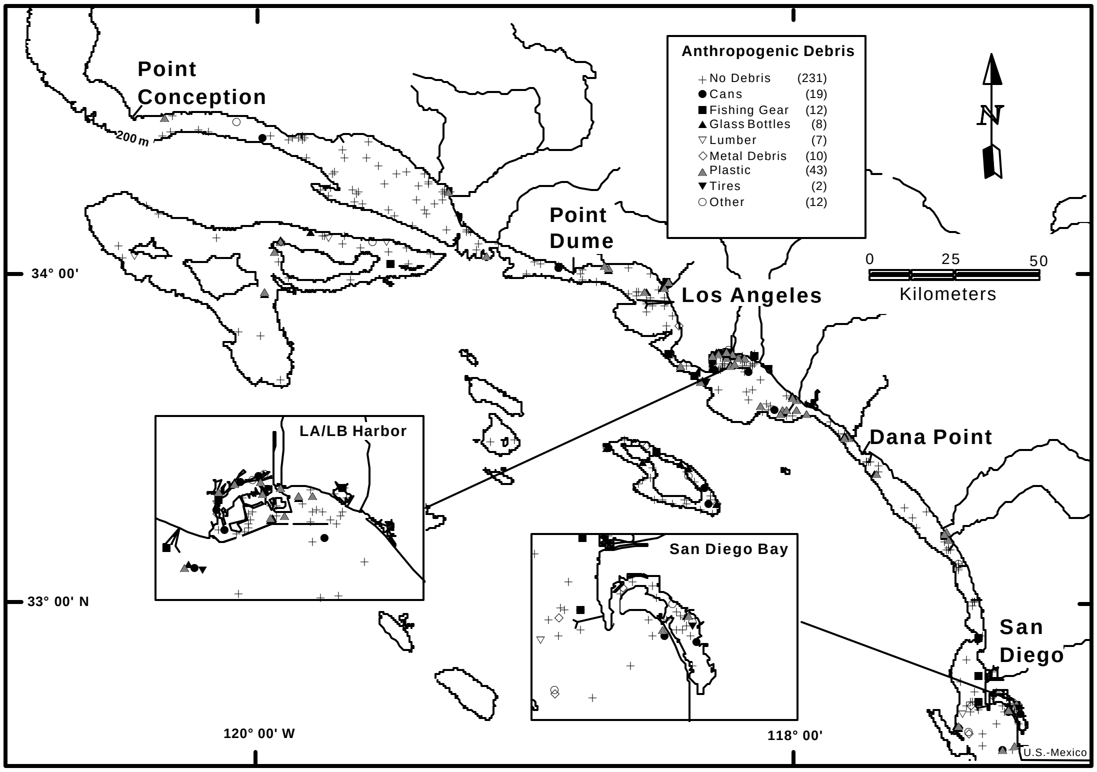


Figure 103. Distribution of anthropogenic debris types on the southern California shelf at depths of 2-202 m, July-September 1998.

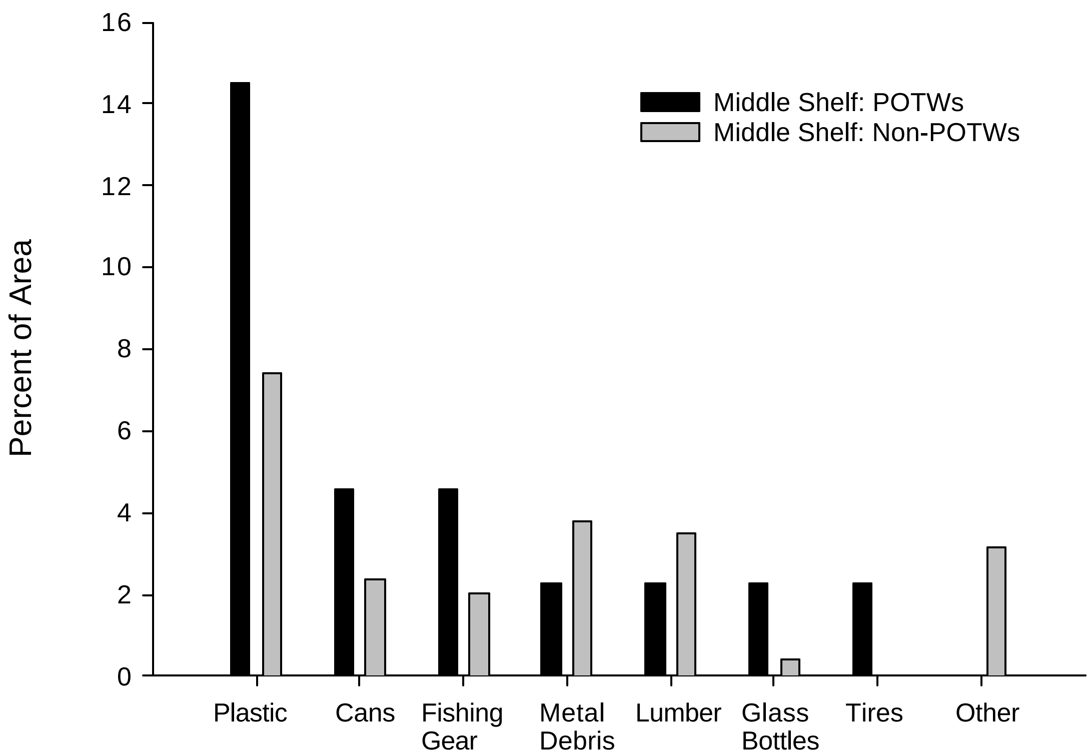


Figure 104. Percent of area of anthropogenic debris types on the mainland middle shelf (31-120 m) in publicly owned treatment work (POTWs) and non-POTW subpopulations of southern California, July-September 1998.

well as the possibility that beach currents and tides may move plastic seaward, may account for the low occurrence of plastics in the inner shelf regions.

The present study (1998) was part of the second region-wide monitoring effort of the SCB. The first study, in 1994 (Allen *et al*. 1998, Moore and Allen 2000), provides a baseline for comparing the amounts of debris to those found in 1998. In 1994 about 14% of the SCB had anthropogenic debris, whereas in 1998 this number increased to 23%. This may be due in part to a more extensive survey in 1998 (314 stations in 1998 compared to 114 for 1994) and to the inclusion of bays, harbors, and islands. Trends for both studies were similar in that most of the debris occurred in low abundance and low biomass. Also similar was the higher occurrence of anthropogenic debris in the southern and central regions (the most populated) and the middle shelf areas. Plastic, metal debris, and glass bottles occurred over a much larger area at LPOTW areas in 1994 than in 1998; the glass bottles were most likely from recreational boat uses (Figure 105). Although natural debris as a whole was more evenly distributed throughout the northern, central, and southern regions in 1998 than in 1994, terrestrial vegetation showed a similar trend for both years, reflected in the fact that terrestrial debris was most commonly found in the northern region.

Most of the debris occurred in low abundance and low biomass, indicating that while anthropogenic debris occurred in about 23% of the SCB, it was not present in large quantities. As marine debris becomes of greater concern to the public, not only for aesthetic reasons, but also in regard to marine organism health, studies such as this one will provide valuable information on the types, amounts, and location of debris in the marine benthic habitat.

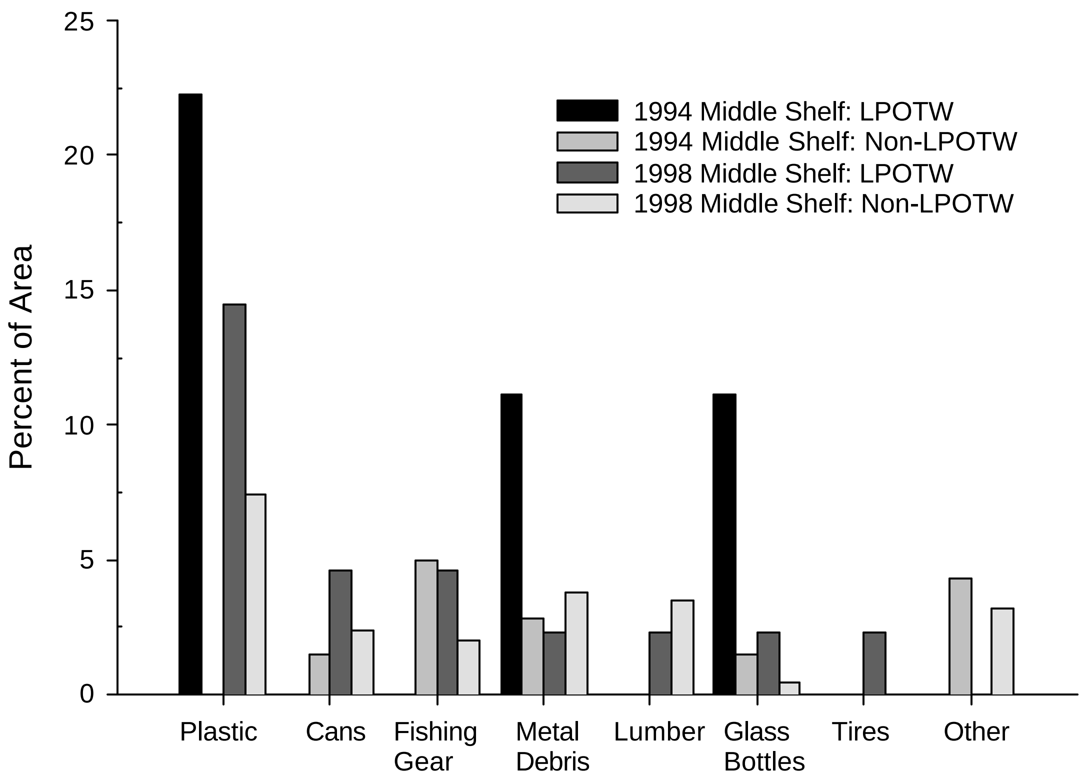


Figure 105. Percent of area of anthropogenic debris categories in large publicly owned treatment work (LPOTW) and non-LPOTW subpopulations on the mainland middle shelf (31-120m) of southern California in 1994 and 1998. NOTE: 1994 data has been reclassified into 1998 subpopulations and hence may differ from Allen *et al.* (1998) and Moore and Allen (2000).

DISCUSSION

ASSESSMENT OF HUMAN IMPACT

Assemblages

Demersal fish and invertebrate populations and assemblages on the southern California shelf were healthy in 1998. A fish biointegrity index (fish response index, FRI) (Allen *et al*. 2001a) identified 97% of the southern California shelf as reference (normal), with a few nonreference sites in some nearshore areas that receive runoff from nonurban watersheds (Figure 64). This was the first application of a biointegrity index to regional trawl data, and hence provides the first objective assessment of the extent of reference assemblages in the SCB. None of the nonreference sites were located near POTWs.

The findings of the 1998 study differ dramatically from conditions in the 1970s, where populations and assemblages were clearly altered in the most contaminated areas (SCCWRP 1973; Mearns *et al*. 1976; Allen 1977, 1982; Cross *et al.* 1985; Stull 1995; Stull and Tang 1996, Allen *et al*. 2001b). However, the FRI did identify nonreference sites in historical data from the Palos Verdes Shelf, the only area with substantial effects, and showed that index values there shifted from nonreference in the 1970s to reference in the 1980s (Allen *et al*. 2001a). As this index is based on the relative abundance of fish species along a pollution gradient, it is expected to be most responsive to contaminated conditions.

Earlier studies (SCCWRP 1973; Mearns *et al*. 1976; Allen 1977, 1982; Cross *et al.* 1985; Stull 1995; Stull and Tang 1996) showed identifiable local effects on fish abundance and diversity, and enhanced or depressed occurrence of specific species. Species feeding on polychaetes and plankton were more abundant, and those feeding on small epibenthic crustaceans were frequently absent (Allen 1977). Cross *et al*. (1985) also noted that the latter fishes were depressed on the Palos Verdes Shelf, possibly due to the effects of DDT on their prey. During the 1970s, when contamination levels were high on the Palos Verdes Shelf, the abundance of planktivorous rockfishes, shiner perch, white croaker, and polychaete-feeding flatfishes was significantly higher near the outfall than at control sites. In contrast, species feeding on epibenthic or hypoplanktonic prey (e.g., sanddabs and bigmouth sole) were significantly lower near the outfall (Allen *et al*. 2001a). Thus, high organic sediments with high polychaete populations and low epibenthic crustacean populations are likely to result in high abundance of polychaete-feeding flatfishes and low abundance of epibenthic crustacean feeders. The high abundance of planktivorous rockfishes and shiner perch near the outfall suggests that plankton populations were enhanced, perhaps due to suspended wastewater particulates. Some of these conditions might occur off the Santa Clara River, which had high runoff during the El Niño storms of 1997-1998. Such conditions might create the nonreference conditions detected there by the FRI. Indeed, white croaker and shiner perch, both abundant in contaminated areas on the Palos Verdes shelf in the 1970s, were also abundant in some stations in the nonreference river mouth areas in 1998.

Current wastewater discharge does not adversely affect the demersal fish and invertebrate assemblages and populations. Some minor population and assemblage differences were found between POTW and non-POTW areas. Although one invertebrate recurrent group (California blade barnacle and yellow sea twig) was associated with outfall areas, unique POTW assemblages were generally not identified in 1998. In addition, there were some differences in areal distribution of fish biomass and invertebrate diversity (higher in 1994) and invertebrate abundance and biomass (higher in 1998) at POTW areas. However, in general, wastewater discharge appears to have had little effect on local demersal fish and invertebrate assemblages in the 1990s.

Fish, invertebrate, and combined fish/invertebrate assemblages were primarily organized by depth, with distinct assemblages also in bay and harbor areas. In addition, three different analytical methods (recurrent group analysis, cladistic analysis, and cluster analysis) also described similar assemblages, although the details were often quite different. Each of the analyses provided a different perspective to the assemblages. However, whereas cluster analysis and cladistic analysis defined site and species assemblages, recurrent group analysis only defined species groups. As in 1994 (Allen *et al*. 1998), assemblages of the shelf were generally associated with one or more of the three predefined depth zones: inner shelf, middle shelf, and outer shelf. Assemblages in San Diego Bay (a natural embayment) differed in species composition from those in LA/LB Harbor (an artificially enclosed area of the open coast). Although these harbors both have been developed for shipping and boating, they are ecologically different. The LA/LB Harbor assemblage is affected by human activities (e.g., the artificial enclosure of a portion of the coastal zone). However, the high abundances of white croaker, queenfish, and other species suggest that, at least for these species, the harbor has had a positive impact on their populations (presumably providing a good spawning and nursery area). Although San Diego Bay is similar to LA/LB Harbor in the development of ports and marinas, it differs in having a large shallow inner bay. Hence, it is populated by species adapted to natural embayments. These species can tolerate greater temperature and salinity variation, as well as greater tidal influence, than most coastal species.

Diseases and Anomalies

Fish populations had background levels of anomalies and parasites, with the prevalence of anomalies significantly lower since the 1970s. Anomaly prevalence in 1998 was 0.5%, slightly down from 1.0% in 1994 (Allen *et al.* 1998). These rates were similar to background anomaly rates in mid-Atlantic (0.5%) and Gulf Coast (0.7%) estuaries (Fournie *et al.* 1996). In contrast, anomaly prevalence for the SCB from 1969-1976 was 5.0% (Mearns and Sherwood 1977).

In 1998, there was no incidence of fin erosion, an important fish response to contaminated sediments in the past. From 1972-1976, fin erosion was the most frequently observed anomaly of southern California demersal fishes, being found in 33 species, with most being flatfishes (Mearns and Sherwood 1977). It occurred primarily on the Palos Verdes Shelf, but occasionally at other outfall areas. In the 1970s, 39% of the Dover sole on the Palos Verdes Shelf had fin erosion. However, fin erosion decreased on the Palos Verdes Shelf as sediment contamination decreased between the early 1970s and the mid-1980s, when it was virtually absent (Stull 1995). Although the disease appeared to be related to sediment contamination, its cause was never determined.

Epidermal tumors were another common disease in the 1970s. In 1972-1975, epidermal tumors were found in 1.4% of the Dover sole (Mearns and Sherwood 1977), and this decreased to 1% in 1994 (Allen *et al*. 1998) and 0.7% in 1998. This rate of occurrence probably represents the background prevalence for this disease in the SCB. Epidermal tumors occur predominantly in Dover sole less than 12 cm in length (Mearns and Sherwood 1977). Although the tumors occurred frequently on the Palos Verdes Shelf in the 1970s, they were also found in Dover sole from other areas throughout the SCB, from Point Arguello, California, to Cedros Island, Baja California Sur, Mexico (Mearns and Sherwood 1976). The prevalence of epidermal tumors in Dover sole on the Palos Verdes Shelf decreased with increasing distance from the outfall and also with time from 1971-1983 (Cross 1988). In 1998, epidermal tumors occurred in small Dover sole from the Palos Verdes Shelf to the southeast Channel Islands (Figure 22). Epidermal tumors are x-cell lesions thought to be caused by an amoebic parasite (Dawe *et al.* 1979).

Bioaccumulation

The contaminant DDT was prevalent in fish tissue on the southern California shelf. Of the whole fish sanddab-guild composites examined, 99% had detectable levels of DDT; 100% of the composites at the Channel Islands (a marine protected area) had detectable levels of DDT. In 1994, 100% of Pacific sanddab and longfin sanddab, and 81% of Dover sole liver composites from the southern California shelf, had detectable levels of DDT (Allen *et al*. 1998, Schiff and Allen 2000). The DDT concentrations in these liver composites from reference areas were more than an order of magnitude lower in 1994 for all three species than in 1977-1985. Similarly, DDT in muscle tissue composites of recreationally caught fishes at contaminated sites was more than an order of magnitude lower in the 1990s compared to the 1970s (Allen and Cross 1994). Hence, although DDT in whole-fish sanddab guild samples was widespread in 1998, concentrations were likely to be at least an order of magnitude lower than they might have been two decades earlier.

The DDT in the Southern California Bight is a remnant of historical discharges and dumping. Although it has not been discharged to the SCB for 30 years (Mearns *et al*. 1991), DDT is still widespread in sediments throughout the SCB, with highest concentrations on the Palos Verdes Shelf and in Santa Monica Bay (Schiff and Gossett 1998, Noblet *et al*. 2002).

In addition to detectable levels being widespread, 71% of the southern California shelf had fish with DDT concentrations above a predator-risk guideline (Environment Canada 1997). All fish samples from the southeast Channel Islands were above the predator-risk guideline. This guideline of 14 µg/kg ww DDT was developed following the protocol for deriving Canadian tissue residue guidelines, which identified the most sensitive lowest observed adverse effect levels and no observed adverse effect levels for DDT in birds and mammals (Environment Canada 1997). When applied to the appropriate trophic level, concentrations of DDT below this guideline in prey organisms should not produce adverse effects in predators. Thus, the guideline identified areas of potential concern, but not actual impact on predator health or populations. Further studies of DDT effects on predators are needed to determine concentrations that cause specific levels of impact.

Contamination of predator-risk concern was restricted primarily to DDT. However, PCB was detected in 44% of the sanddab-guild samples in 1998. PCB was above the predator-risk guideline (Environment Canada 1998) in 8% of the southern California shelf area for mammals and 5% for birds. The predator-risk guideline was 0.79 TEQ ng/kg ww (Environment Canada 1998). The toxicity equivalent quotient (TEQ) is the product of the concentration of a PCB congener times the toxicity equivalent factor (TEF) of a PBC congener relative to dioxin (see Chapter 2). The TEF of a congener differs for birds and mammals (Table 3).

In 1994, DDT and PCB were the only chlorinated hydrocarbons of 14 targeted analytes that were detected in fish tissue on the southern California shelf (Allen *et al*. 1998). Although chlordane was one of the undetected contaminants in 1994, some chlordane was detected in this survey; however, all values were below the NAS (1974) predator-risk guideline.

Biomarkers

Bile FACS (a biomarker of PAH exposure) and DNA damage were both present in fishes from coastal bays and harbors. Both were most elevated in the LA/LB Harbor area. Fish from Marina del Rey and Ventura Harbor with elevated bile FACs had DNA damage. The focus of this pilot study was to evaluate the potential for assessing biomarkers and sublethal effects in coastal fishes. The results showed promise but will be more valuable in the future if applied more broadly in the SCB.

Debris

Anthropogenic debris (mostly plastic, metal, and cans) was found on 23% of the area of the southern California shelf and was most common in areas frequented by boats such as ports, marinas, and Santa Catalina Island. In 1994, anthropogenic debris was found in 14% of the area (Allen *et al*. 1998, Moore and Allen 2000). As the 1994 survey only sampled the mainland shelf, and the 1998 survey sampled the shelf and bays and islands, the increase in areal extent of debris appears to be related to the inclusion of bays and islands.

EFFECTS OF EL NIÑO AND OCEAN WARMING

By chance, the 1998 survey occurred following the 1997-1998 El Niño, one of the strongest El Niño events of the past century (Hayward 2000). El Niño/Southern Oscillation (ENSO) events occur aperiodically, and can dramatically change the ocean environment off southern California. During an El Niño event, waters of the SCB become warmer, more saline, and more oligotrophic than during normal oceanic conditions (Graham and White 1988). These conditions may extend to a depth of 100 m, and may persist for months. Because the 1998 survey was conducted during extremely unusual conditions, it provided a rare opportunity to determine the effect of an El Niño event on the demersal fish and invertebrate communities.

Some effects of the 1997-1998 El Niño were apparent in fish and invertebrate populations and assemblages. Relative to 1994, coldwater fish species (e.g., Pacific sanddab, plainfin midshipman, and Dover sole) were less widespread on the mainland shelf in 1998 and warm water species (e.g., California lizardfish, longfin sanddab, and California tonguefish) occurred more widely (Table 33). Part of the change of area for the coldwater species may be a shift in their depth of occurrence to deeper water. Movement to the outer shelf zone, which has less area than the middle shelf zone, might cause a decrease in areal occurrence. Changes in areal occurrence between 1994 and 1998 also occurred among foraging guilds (Table 57).

Examination of depth displacement patterns in a model of the functional structure of the fish communities allowed an assessment of changes in community organization during three oceanic periods: a cold regime (1972-1973); a warm regime (1994); and El Niño conditions (1998) (Figures 78 and 79) (Allen 1982, Allen *et al*. 1998). Overall, many foraging guilds have decreased their occurrence since the cold regimen, with some guilds being affected more than others (Figure 78). Different guilds showed different responses to ocean warming and to the El Niño event, particularly with regard to the depth displacement patterns of dominant guild members (Figure 79). Some guilds retreated from shallower depths into deeper water. Guild dominants also sometimes retreated to deeper water but some expanded their depth range without retreating; others were partially displaced by more southerly guild members.

In addition to changes at the population and community level, two fish species (Allen and Groce 2001b, Groce *et al*. 2001b) and three invertebrate species (Montagne and Cadien 2001) collected in the 1998 survey had never been recorded off California prior to 1998. Previous records of these species were off southern Baja California. However, it is likely that unreported populations of these species had gradually moved north during warming that occurred during the previous two decades (Smith 1995, Allen and Groce 2001b, Montagne and Cadien 2001).

Possible effects of El Niño conditions in demersal fish and megabenthic invertebrate assemblages are the following: 1) movement of subadult and adult organisms into the area from the south (as evidenced by the appearance of larger individuals capable of such a movement); 2) transport of larvae into the area from the south (as evidenced by recruitment or settlement of small juveniles of southern species); 2) movement of subadult and adult organisms out of the area to the north (as evidenced by the disappearance of larger mobile individuals in the SCB and their appearance to the north); 3) reduction of larval transport from the north (reduction or absence of recruitment or settlement of small juveniles); 4) changes in depth ranges (by expanding range to deeper water, shifting depth range deeper while moving out of shallow areas); 5) replacements of normal guild dominants; and 6) death of individuals in a given depth zone.

Of these alternatives, there was little evidence from this study to support movement of subadults and adults of demersal fishes collected in this survey into or out of the area. The presence of new species from the south which appeared as small juveniles near the end of the El Niño (Allen and Groce 2001b, Groce *et al*. 2001b, Montagne and Cadien 2001) indicates that transport of southerly larvae was occurring. Reduction of northern larvae to the area requires more detailed investigation of the data, as some recruitment of northern species was occurring at the islands. Although some species appeared to disappear from shallow areas, probably due to increased water temperatures, it cannot be determined if this was due to death of organisms or to movements out of the area. However, there was considerable evidence that movements of subadults and adults to deeper depths did occur, along with replacements of expected dominant guild species at a depth by more southerly species (Figures 78 and 79). Further analysis of these data with a focus on determining El Niño effects may better define responses of the demersal fish and invertebrate fauna to this oceanic event.

CONCLUSIONS

1. Demersal fish and invertebrate populations and assemblages on the southern California shelf were healthy in 1998.

    - A fish biointegrity index identified 97% of the southern California shelf as reference, with a few nonreference (atypical) sites near runoff areas.

    - Fish populations had background levels of anomalies and parasites. The prevalence of anomalies had decreased significantly since the 1970s, and there was no incidence of fin erosion, an important fish response to contaminated sediments in the past.

2. DDT was prevalent in fish tissue on the southern California shelf.

    - Of the sanddab-guild fish examined, 99% had detectable levels of DDT; 100% of the fish at the Channel Islands (a protected marine area) had detectable levels of DDT.

    - DDT levels of concern were also widespread in the fish examined; 71% of the southern California shelf had fish with DDT concentrations above the predator-risk guideline. This guideline identified areas of potential concern; further studies are needed to determine specific levels of impact.

    - DDT in the Southern California Bight is a remnant of historical discharges. Although it has not been discharged to the SCB for 30 years, DDT is still widespread in historically deposited sediments on the Palos Verdes Shelf and in Santa Monica Bay. Although the specific risk to local predators is not known, it is probably less than that of two or three decades earlier. DDT concentrations in southern California fishes have decreased more than an order of magnitude during the past three decades.

    - Contamination of predator-risk concern was restricted primarily to DDT. PCB was above the predator-risk guideline in less than 10% of the southern California shelf area. In 1994, DDT and PCB were the only chlorinated hydrocarbons detected in fish tissue on the southern California shelf. Chlordane was detected in this survey but all values were below predator-risk levels.

3. Fish and invertebrate assemblages were generally associated with major depth zones on the shelf, with distinct assemblages also in bay and harbor areas.

    - Assemblages in San Diego Bay (a natural embayment) differed from those in Los Angeles/ Long Beach Harbor (an artificially enclosed area of the open coast) by having distinctive inner bay species.

    - Assemblages in the island region differed only slightly from those of the mainland region.

4. Anthropogenic debris (mostly plastic, metal, and cans) was found in 23% of the southern California shelf. It was most common in areas frequented by boats, such as ports, marinas, and Santa Catalina Island.

5. Some effects of the 1997-1998 El Niño were apparent in fish and invertebrate populations and assemblages.

    - Relative to 1994, coldwater species were less widespread on the mainland shelf in 1998 and warm water species occurred more widely.

    - Many important community members expanded or shifted their distributions to deeper parts of the shelf in 1998.

    - Two fish species and three invertebrate species collected in the 1998 survey had never been recorded off California prior to 1998; all normally occurred from southern Baja California to the south.

RECOMMENDATIONS

1. Determine the spatial extent of DDT above a predator-risk guideline in pelagic fishes (e.g., northern anchovy).

More than two-thirds of the southern California shelf had benthic fish with tissue DDT levels above the predator-risk guideline. While this indicates a potential risk to predators, benthic fish are not the predominant prey for most marine birds and mammals. Most upper level predators preferentially feed on pelagic (free-swimming) fishes, such as northern anchovy. This recommendation is intended to assess whether the DDT predator-risk concern identified in this study extends to the pelagic food web.

2. Define the route of DDT transport to sanddabs in the Channel Islands National Marine Sanctuary.

Nearly all of the Channel Islands sea floor had benthic fish with tissue DDT levels above the predator-risk guideline. This finding is of particular concern because the Channel Islands National Marine Sanctuary (CINMS) is a protected bird and mammal resource; meeting this management objective requires an understanding of how the fish became contaminated. Some possible routes of DDT from coastal sources that can be examined include the transport of suspended sediments by currents from historically contaminated sediments near Los Angeles, transport of suspended sediments in the Santa Clara River runoff plume, movement of contaminated fish prey to the islands, or movement of the contaminated fish from the mainland region to the island region across deepwater barriers.

3. Apply the Fish Response Index to assess the biointegrity of demersal fish assemblages in other southern California monitoring surveys.

Fish communities are routinely surveyed as part of site-specific monitoring programs, but are typically used for assessing trends rather than determining present status. The difficulty with status assessment is that unless the impact is severe, it is difficult to distinguish site effects from natural background variability. The fish biointegrity index (fish response index, FRI) developed during this study provides new opportunities for objective assessment of responses in southern California demersal fishes. This tool is applicable to, and has the potential to improve the interpretation of, data from other fish monitoring surveys in southern California.

4. Assess the regional extent of sublethal effects in southern California fishes.

Fish contamination was found to be widespread in the Southern California Bight, but there were few observed effects at the fish community level. Fish contamination effects, though, are more likely to manifest themselves at the sublethal level. The focus of this study was to assess the potential occurrence of sublethal effects in fish populations and the potential applicability of using bile fluorescent aromatic compounds (FACs) and DNA damage in regional assessments. While the results of this study suggested the presence of sublethal effects, the study was not applied sufficiently broadly to provide a regional assessment of sublethal effects. However, the methods were found to be applicable and their use should be expanded in future surveys.

5. Conduct periodic regional surveys of southern California demersal fishes and invertebrates to assess trends in human effects, populations, and baseline communities.

Demersal fish and invertebrate assemblages have been monitored locally for three decades to assess effects of wastewater discharge and other human activities. Local effects are identified by comparing local assemblages to background or baseline communities. While a single large-scale survey could provide an adequate baseline description of the communities in an unchanging world, regional surveys conducted in 1994 and 1998 showed that this baseline varies with changing oceanic conditions. These and earlier studies have also shown decreasing prevalence of fish diseases and increasing or decreasing population trends related to changing environmental conditions. Periodic assessment of the demersal fish and invertebrate populations on the southern California shelf will establish the appropriate baselines for assessing local effects and determining long-term trends in populations. We recommend that regional surveys of southern California demersal fishes and invertebrates be conducted periodically to assess trends in human effects, populations, and baseline communities.

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APPENDICES

APPENDIX A

APPENDIX A. MATERIALS AND METHODS

Appendix A1. Trawl station locations and characteristics in the Southern California Bight 1998 Regional Survey, July-September 1998.

				Station Coordinates[a]								Tow Characteristics						
				Nominal Trawl				Trawl Start										
	Date												Depth	Dur.	Speed	Dist.	Trawl	
Station	(1998)	Ag.[b]	Ve.[c]	Lat N (dm)		Long W (dm)		Lat N (dm)		Long W (dm)		Time	(m)	(min)	(m/sec)	(m)	Type[d]	FC[e]
2065	7/21	WI	SW	33	29.49	118	34.71	33	29.45	118	35.57	7:44	201	9.00	1.37	741	A T	-
2066	7/21	WI	SW	33	28.63	118	35.77	-	-	-	-	-	-	-	-	-	N	RB
2067	7/21	WI	SW	33	27.72	118	39.15	33	27.87	118	39.29	11:24	190	10.00	1.15	692	A T	-
2068	7/21	WI	SW	33	28.48	118	33.79	-	-	-	-	-	-	-	-	-	N	RB
2069	7/20	WI	SW	33	28.49	118	30.79	33	28.36	118	30.60	16:28	106	10.00	1.17	703	A T	-
2070	7/20	WI	SW	33	27.24	118	28.83	33	27.30	118	28.33	13:21	98	10.00	0.89	536	A T	-
2071	7/21	WI	SW	33	25.18	118	31.66	33	25.14	118	31.55	14:45	88	12.00	0.89	644	A T	-
2072	7/25	WI	SW	33	24.36	118	29.32	33	24.46	118	29.35	11:10	23	10.00	1.14	686	A T	-
2073	7/22	WI	SW	33	25.17	118	22.91	33	25.21	118	23.03	6:41	86	9.00	1.65	891	A T	-
2074	7/25	WI	SW	33	22.07	118	31.66	33	22.12	118	31.59	8:41	121	10.00	1.07	644	A T	-
2075	7/25	WI	SW	33	22.42	118	29.86	33	22.38	118	29.87	10:15	66	10.00	0.96	575	A T	-
2076	7/22	WI	SW	33	24.01	118	20.77	33	24.24	118	21.29	11:48	153	10.00	-[f]	-[f]	A T	-
2077	7/22	WI	SW	33	23.75	118	21.83	33	23.75	118	21.82	9:40	49	10.00	0.98	585	A T	-
2078	7/25	WI	SW	33	21.46	118	32.17	33	21.40	118	32.21	7:35	111	9.00	2.35	1268	A T	-
2079	7/22	WI	SW	33	22.98	118	21.33	33	22.91	118	21.28	13:44	53	8.00	-	-	A T	-
2080	7/24	WI	SW	33	20.83	118	31.16	-	-	-	-	-	-	-	-	-	N	RB
2081	7/24	WI	SW	33	20.56	118	31.12	-	-	-	-	-	-	-	-	-	N	RB
2082	7/22	WI	SW	33	22.12	118	19.86	33	21.99	118	19.74	14:37	81	10.00	1.02	611	A T	-
2083	7/24	WI	SW	33	20.05	118	30.08	-	-	-	-	-	-	-	-	-	N	RB
2084	7/23	WI	SW	33	20.76	118	17.90	33	20.74	118	17.90	10:48	88	11.00	1.08	716	A T	-
2085	7/24	WI	SW	33	18.40	118	28.91	33	18.51	118	28.76	13:25	177	10.00	0.91	544	A T	-
2086	7/24	WI	SW	33	18.57	118	26.78	33	18.54	118	26.65	11:36	76	10.00	-	-	N	RB
2087	7/24	WI	SW	33	18.57	118	25.74	33	18.57	118	26.79	10:30	69	10.00	3.62	2170	A T	-
2088	7/24	WI	SW	33	18.41	118	22.10	33	18.34	118	21.91	6:48	42	10.00	1.01	606	A T	-
2089	7/24	WI	SW	33	17.80	118	24.49	33	17.83	118	24.65	8:25	91	10.00	1.00	602	A T	-
2090	7/22	WI	SW	33	19.27	118	16.38	33	19.11	118	16.24	16:28	172	10.00	1.03	618	A T	-
2091	7/23	WI	SW	33	17.72	118	21.49	33	17.71	118	21.48	16:44	71	10.00	0.98	585	A T	-
2092	7/23	WI	SW	33	18.36	118	16.19	33	18.69	118	16.29	9:55	164	11.00	0.88	580	A T	-
2093	7/22	WI	SW	33	17.89	118	17.09	33	17.68	118	17.00	7:46	97	10.00	1.14	685	A T	-
2094	7/23	WI	SW	33	17.68	118	14.77	33	17.64	118	14.70	12:26	195	10.00	1.03	620	A T	-
2095	7/23	WI	SW	33	16.63	118	18.30	33	16.64	118	18.41	15:42	131	11.00	0.96	635	A T	-
2096	7/23	WI	SW	33	16.12	118	16.01	33	15.98	118	16.01	14:33	179	11.00	0.95	627	A T	-
2097	8/17	M E	S	34	24.44	120	18.75	34	24.43	120	18.92	13:05	174	10.00	0.98	587	A T	-
2098	8/17	M E	S	34	23.68	120	20.45	34	23.66	120	20.53	14:23	181	10.00	0.93	558	A T	-
2099	8/17	M E	S	34	24.95	120	12.85	34	24.93	120	12.82	8:05	174	10.00	1.02	615	A T	-
2100	8/17	M E	S	34	24.69	120	10.57	34	24.69	120	10.56	11:30	165	10.00	0.83	499	A T	-
2101	8/28	A B	H	34	19.93	119	48.37	34	20.42	119	48.40	9:20	202	10.00	1.34	804	A T	-
2102	8/27	A B	H	34	17.93	119	41.90	34	17.95	119	41.75	12:49	145	10.00	1.25	747	A T	-
2103	8/27	A B	H	34	17.04	119	42.87	34	17.49	119	42.24	15:24	199	10.00	1.11	667	A T	-
2104	8/28	A B	H	34	14.57	119	44.39	34	14.61	119	44.87	12:25	200	10.00	1.06	637	A T	-
2105	8/19	M E	S	34	14.85	119	42.59	34	14.85	119	42.48	8:06	184	10.00	1.03	619	A T	-
2106	8/28	A B	H	34	13.30	119	42.65	34	13.58	119	43.11	13:25	196	10.00	-	-	A T	-
2107	8/28	A B	H	34	13.43	119	40.61	-	-	-	-	-	-	-	-	-	N	RB
2108	8/27	A B	H	34	13.85	119	36.91	34	13.99	119	36.97	9:36	152	10.00	0.92	552	A T	-
2109	8/27	A B	H	34	12.93	119	37.81	34	13.04	119	38.88	10:29	160	10.00	-	-	A T	NC

Appendix A1 (continued)

Station	Date (1998)	Ag.[b]	Ve.[c]	Station Coordinates[a]: Nominal Trawl Lat N (dm)		Nominal Trawl Long W (dm)		Trawl Start Lat N (dm)		Trawl Start Long W (dm)		Tow Characteristics: Time	Depth (m)	Dur. (min)	Speed (m/sec)	Dist. (m)	Trawl Type[d]	Trawl FC[e]
2110	8/19	MEC	S	34	12.16	119	35.14	34	12.20	119	35.20	13:43	154	10.00	1.06	638	A T	-
2111	8/19	MEC	S	34	9.96	119	28.15	34	9.97	119	28.19	15:45	167	10.00	1.03	621	A T	-
2112	8/19	MEC	S	34	8.40	119	23.98	34	8.31	119	23.87	17:06	179	10.00	0.94	566	A T	-
2113	8/20	M E	S	34	3.03	119	7.35	34	3.05	119	7.35	10:32	130	10.00	1.00	597	A T	-
2114	8/20	M E	S	33	59.79	118	58.32	33	59.81	118	58.38	8:35	165	10.00	1.01	604	A T	-
2115	8/14	M E	S	33	58.90	118	45.44	33	59.11	118	45.84	9:02	75	10.00	1.60	961	A T	-
2116	8/19	HY	LM	33	58.88	118	42.53	33	58.91	118	42.55	10:38	186	10.00	0.71	427	A T	-
2117	8/13	M E	S	33	56.58	118	35.58	33	56.56	118	35.50	16:21	184	10.00	0.93	559	A T	-
2118	8/12	LA	OS	33	49.88	118	26.62	33	49.82	118	26.70	11:38	82	10.02	0.87	526	A T	-
2119	8/7	M E	SW	33	34.74	117	55.18	33	34.72	117	55.11	8:37	193	10.00	1.06	638	A T	-
2120	8/10	M E	E	33	32.51	117	50.15	33	32.51	117	50.05	9:06	141	5.00	0.87	261	A T	Ob
2121	7/28	M E	E	33	30.35	117	47.82	-	-	-	-	-	-	-	-	-	N	IB
2122	7/29	M E	E	33	13.64	117	30.63	33	13.65	117	30.60	11:17	121	10.00	1.05	632	A T	-
2129	7/31	AB	H	34	10.38	119	13.65	34	10.27	119	13.70	7:58	3	5.00	0.10	29	ATBD	-
2137	8/5	M E	SW	33	36.77	117	55.46	33	36.86	117	55.48	7:25	3	5.00	1.00	300	A	-
2147	8/5	M E	SW	33	36.03	117	53.60	33	36.14	117	53.68	8:26	4	10.00	1.05	632	ATBD	-
2152	8/18	NV	Ec	33	45.58	118	9.76	33	45.55	118	9.63	14:33	7	5.00	0.89	267	A	-
2153	8/19	NV	Ec	33	45.22	118	9.47	33	45.13	118	9.36	12:49	9	5.00	0.96	287	ADT	-
2154	8/18	NV	Ec	33	44.93	118	9.36	-	-	-	-	-	-	-	-	-	N	Ab
2155	8/18	NV	Ec	33	44.60	118	10.07	33	44.61	118	10.13	13:30	12	5.00	0.80	241	A	-
2158	8/18	NV	Ec	33	43.70	118	12.52	33	43.67	118	12.40	10:07	24	5.00	0.65	194	A	-
2162	8/6	HY	Sur	33	42.81	118	14.50	33	42.83	118	14.44	12:12	21	5.12	1.01	310	A	-
2165	9/8	M E	E	33	38.61	117	53.11	-	-	-	-	-	-	-	-	-	N	Ob
2167	8/18	NV	Ec	33	44.14	118	9.46	33	44.16	118	9.35	13:30	15	5.00	0.84	253	A	-
2168	8/6	HY	Sur	33	42.71	118	15.05	33	42.70	118	15.02	9:35	27	5.00	0.76	228	A T	-
2174	8/12	M E	E	33	44.06	118	16.00	33	44.12	118	15.11	13:59	-	-	-	-	N	Ob
2180	8/12	M E	E	33	44.42	118	12.14	33	44.54	118	12.15	10:54	19	5.00	0.95	284	ABD	-
2184	8/19	NV	Ec	33	43.28	118	16.14	-	-	-	-	-	-	-	-	-	N	Ob
2186	8/18	NV	Ec	33	43.88	118	11.58	33	43.88	118	11.39	11:10	17	5.00	0.85	255	A T	-
2189	8/13	M E	E	33	57.18	118	33.62	33	57.22	118	33.61	15:14	64	10.00	1.05	628	A T	-
2190	8/13	M E	E	33	56.88	118	31.72	33	56.92	118	31.53	14:22	50	10.00	1.03	620	A T	-
2191	7/29	HY	LM	33	56.20	118	33.66	33	56.15	118	33.62	10:48	99	10.07	0.80	481	A T	-
2192	7/29	HY	LM	33	56.62	118	31.19	33	56.72	118	31.23	9:24	49	10.10	0.98	596	A T	-
2193	7/29	HY	LM	33	55.38	118	33.20	-	-	-	-	-	-	-	-	-	N	Ob
2194	8/4	HY	LM	33	55.23	118	31.29	33	55.20	118	31.13	12:53	57	10.02	0.86	519	A T	-
2195	7/29	HY	LM	33	54.62	118	31.47	33	54.66	118	31.49	13:38	61	10.30	0.78	482	A T	-
2196	7/9	HY	LM	33	54.17	118	33.19	-	-	-	-	-	-	-	-	-	N	Ob
2197	8/13	M E	E	33	54.23	118	30.05	33	54.33	118	30.10	13:06	53	9.00	0.70	380	A T	-
2198	8/4	HY	LM	33	53.27	118	31.46	33	53.29	118	31.31	11:15	58	10.72	0.76	489	A T	-
2199	8/13	M E	E	33	52.94	118	32.12	-	-	-	-	-	-	-	-	-	N	RB
2200	8/12	LA	OS	33	44.87	118	25.75	33	44.99	118	25.83	12:51	53	10.03	0.89	536	A T	-
2201	8/12	LA	OS	33	43.23	118	23.56	33	43.16	118	23.39	13:45	89	10.10	0.83	505	A T	-
2202	8/13	LA	OS	33	43.32	118	22.35	33	43.25	118	22.21	8:36	48	10.08	0.86	522	A T	-
2203	8/13	LA	OS	33	43.41	118	20.87	-	-	-	-	-	-	-	-	-	N	RB
2204	8/13	LA	OS	33	41.81	118	20.34	33	41.73	118	20.21	9:39	74	10.03	0.78	468	A T	-
2205	8/13	LA	OS	33	40.61	118	18.35	33	40.47	118	18.27	10:54	65	10.12	0.88	532	A T	-

Appendix A1 (continued)

Station	Date (1998)	Ag.[b]	Ve.[c]	Station Coordinates[a]: Nominal Trawl Lat N (dm)		Nominal Trawl Long W (dm)		Trawl Start Lat N (dm)		Trawl Start Long W (dm)		Tow Characteristics: Time	Depth (m)	Dur. (min)	Speed (m/sec)	Dist. (m)	Trawl Type[d]	FC[e]
2206	8/13	LA	OS	33	40.51	118	17.60	33	40.38	118	17.53	11:37	49	10.08	0.87	527	A T	-
2207	8/11	M E	E	33	36.74	118	3.94	33	36.76	118	4.02	10:13	34	10.00	1.13	678	A T	-
2208	8/11	M E	E	33	36.11	118	3.39	33	36.10	118	3.25	16:36	37	10.00	1.16	697	A T	-
2209	8/10	M E	E	33	35.50	118	3.76	33	35.52	118	3.71	15:58	53	10.00	1.05	628	A T	-
2210	8/6	M E	SW	33	35.38	118	2.44	33	35.36	118	2.34	16:16	46	10.00	1.02	614	A T	-
2211	8/7	M E	SW	33	35.27	118	0.58	33	35.27	118	0.50	14:12	43	10.00	0.96	578	A T	-
2212	8/11	M E	SW	33	35.37	117	59.34	33	35.44	117	59.50	8:42	38	10.00	1.06	634	A T	-
2213	8/10	M E	E	33	34.31	117	58.64	33	34.33	117	58.61	14:15	59	9.00	0.77	418	A T	-
2214	8/3	SD	M	32	41.39	117	18.06	32	41.24	117	17.95	9:45	72	10.00	0.84	501	A T	-
2215	8/3	SD	M	32	40.88	117	18.60	32	40.72	117	18.51	11:40	81	10.00	0.85	508	A T	-
2216	8/4	SD	M	32	40.57	117	19.33	32	40.58	117	19.32	7:57	93	10.00	0.92	551	A T	-
2217	7/31	SD	M	32	39.75	117	18.64	32	39.54	117	18.48	9:23	85	10.00	0.94	563	A T	-
2218	7/31	SD	M	32	39.98	117	16.79	32	39.89	117	16.74	12:03	59	10.00	0.82	495	A T	-
2219	7/30	SD	M	32	39.30	117	19.89	32	39.10	117	19.86	11:42	107	10.00	0.90	538	A T	-
2220	7/31	SD	M	32	39.58	117	16.80	-	-	-	-	-	59	-	-	-	T	Ob
2223	7/23	SD	M	32	42.95	117	13.86	-	-	-	-	-	-	-	-	-	N	Ob
2225	7/23	SD	M T	32	42.80	117	13.80	-	-	-	-	-	-	-	-	-	N	Ob
2229	8/20	SD	M	32	42.54	117	10.56	-	-	-	-	-	-	-	-	-	N	Ob
2230	8/13	NV	Ec	32	42.12	117	10.72	32	42.14	117	10.59	9:37	6	5.00	0.86	259	A T	-
2231	8/13	SD	M	32	41.69	117	9.39	32	41.62	117	9.30	11:07	11	5.00	0.86	257	ABD	-
2232	8/13	NV	Ec	32	41.54	117	9.84	-	-	-	-	-	-	-	-	-	N	TS
2233	8/14	SD	M	32	41.14	117	9.11	32	41.14	117	8.99	11:57	10	5.00	0.99	296	ATD	-
2234	8/14	SD	M	32	40.87	117	9.33	-	-	-	-	-	-	-	-	-	N	TS
2235	7/23	SD	M T	32	38.45	117	8.22	-	-	-	-	-	-	-	-	-	N	Ob
2236	7/23	SD	M T	32	37.81	117	7.07	-	-	-	-	-	-	-	-	-	N	TS
2238	8/19	SD	M T	32	37.53	117	7.68	-	-	-	-	-	-	-	-	-	N	Ob
2239	8/17	SD	M	32	40.95	117	8.71	32	40.92	117	8.69	7:45	10	5.00	0.85	254	ATBD	-
2240	7/23	SD	M T	32	40.05	117	9.26	-	-	-	-	-	-	-	-	-	N	Ob
2241	8/17	SD	M	32	40.22	117	8.20	32	40.19	117	8.17	12:59	3	5.00	0.73	218	A T	-
2242	8/13	SD	M	32	39.90	117	9.00	32	39.86	117	8.99	12:13	5	5.00	0.84	251	ATD	-
2243	8/24	SD	M	32	39.88	117	8.57	32	39.87	117	8.58	12:49	4	5.00	0.95	284	A	-
2244	8/18	SD	M	32	39.58	117	7.91	32	39.58	117	7.92	9:15	4	5.00	0.99	297	A T	-
2245	8/18	SD	M	32	39.05	117	8.57	-	-	-	-	-	-	-	-	-	N	Ob
2246	7/23	SD	M T	32	38.71	117	7.15	-	-	-	-	-	-	-	-	-	N	TS
2247	7/23	SD	M T	32	38.54	117	7.50	-	-	-	-	-	-	-	-	-	N	Ob
2248	7/23	SD	M T	32	38.01	117	7.80	-	-	-	-	-	-	-	-	-	N	TS
2249	8/18	SD	M	32	37.25	117	7.68	32	37.43	117	7.69	12:27	3	5.00	0.76	228	A	-
2250	7/23	SD	M T	32	37.13	117	7.01	-	-	-	-	-	-	-	-	-	N	TS
2254	8/13	NV	Ec	32	40.60	117	9.80	32	40.66	117	9.81	10:48	4	4.00	0.87	209	A T	-
2256	8/17	SD	M	32	40.61	117	8.15	32	40.66	117	8.17	10:46	8	5.00	0.96	288	ATD	-
2258	8/17	SD	M	32	40.56	117	7.93	32	40.60	117	7.94	11:50	11	5.00	0.89	268	A	-
2259	8/18	SD	M	32	40.21	117	7.49	-	-	-	-	-	-	-	-	-	N	Ob
2261	7/23	SD	M T	32	39.05	117	7.59	-	-	-	-	-	-	-	-	-	N	Ob
2262	8/18	SD	M	32	39.09	117	7.38	32	39.05	117	7.37	11:16	11	5.00	0.89	268	A T	-
2266	8/10	AB	H	34	23.89	119	49.28	34	23.86	119	49.41	13:50	43	10.00	1.22	734	A T	-
2267	8/10	AB	H	34	24.34	119	49.52	34	24.38	119	49.47	12:46	14	10.00	1.13	676	A T	-

Appendix A1 (continued)

				Station Coordinates[a]								Tow Characteristics						
				Nominal Trawl				Trawl Start										
	Date												Depth	Dur.	Speed	Dist.	Trawl	
Station	(1998)	Ag.[b]	Ve.[c]	Lat N (dm)		Long W (dm)		Lat N (dm)		Long W (dm)		Time	(m)	(min)	(m/sec)	(m)	Type[d]	FC[e]
2268	8/10	AB	H	34	24.01	119	48.64	34	24.06	119	48.80	15:35	29	10.00	1.23	739	AT	-
2269	8/10	AB	H	34	23.84	119	40.01	-	-	-	-	-	-	-	-	-	N	RB
2270	8/10	AB	H	34	23.53	119	40.18	34	23.54	119	40.34	16:50	-	-	-	-	N	RB
2271	8/10	AB	H	34	23.44	119	39.78	34	23.39	119	39.77	17:58	-	-	-	-	N	RB
2272	8/10	AB	H	34	23.90	119	39.56	-	-	-	-	-	-	-	-	-	N	RB
2273	8/4	AB	H	34	7.81	119	11.91	34	7.85	119	11.80	15:23	14	9.00	1.16	629	AT	-
2274	7/31	AB	H	34	7.43	119	11.86	34	7.52	119	11.79	17:52	16	10.00	0.92	554	AT	-
2275	8/4	AB	H	34	7.80	119	11.64	34	7.83	119	11.68	13:38	13	10.00	0.96	576	AT	-
2276	7/13	AB	H	34	7.44	119	10.97	34	7.46	119	11.03	15:03	13	10.00	1.22	730	AT	-
2277	7/27	ME	E	33	30.49	117	45.91	33	30.48	117	45.89	10:45	36	10.00	0.75	452	AT	-
2278	7/27	ME	E	33	30.29	117	45.81	33	30.45	117	45.99	9:16	37	10.00	0.91	545	AT	-
2279	7/27	ME	E	33	30.94	117	45.97	33	30.91	117	45.94	12:56	18	10.00	0.83	497	A	-
2280	7/27	ME	E	33	30.53	117	46.13	33	30.48	117	46.07	11:24	41	10.00	0.87	523	AT	-
2281	7/28	ME	E	33	25.97	117	41.91	33	26.10	117	41.91	11:09	38	10.00	0.84	501	AT	-
2282	7/28	ME	E	33	26.16	117	40.73	33	26.17	117	40.75	12:20	18	10.00	0.96	575	AT	-
2283	7/28	ME	E	33	25.90	117	41.37	33	25.89	117	41.29	11:47	31	10.00	0.98	590	AT	-
2284	7/28	ME	E	33	26.04	117	41.82	33	25.99	117	41.75	10:33	34	10.00	0.93	558	AT	-
2285	7/30	ME	E	33	9.54	117	23.89	33	9.54	117	23.93	8:23	60	10.00	1.07	642	AT	-
2286	7/30	ME	E	33	10.00	117	23.32	33	10.11	117	23.42	7:19	19	10.00	1.10	663	AT	-
2287	7/30	ME	E	33	9.56	117	23.35	33	9.53	117	23.33	9:11	40	10.00	1.14	684	AT	-
2288	7/30	ME	E	33	9.52	117	23.08	33	9.53	117	23.09	9:56	33	10.00	1.01	607	AT	-
2289	7/30	ME	E	33	6.19	117	21.49	33	6.21	117	21.47	14:00	77	13.00	0.91	712	AT	-
2290	7/30	ME	E	33	6.96	117	21.52	33	7.00	117	21.49	15:49	135	10.00	1.07	644	AT	-
2291	7/30	ME	E	33	6.00	117	21.17	33	6.04	117	21.18	14:58	70	10.00	1.18	705	AT	-
2292	7/30	ME	E	33	7.15	117	21.38	33	7.20	117	21.38	11:40	154	10.00	0.97	585	AT	-
2293	7/31	ME	E	32	59.99	117	17.54	33	0.02	117	17.52	11:07	22	10.00	1.26	756	AT	-
2294	7/31	ME	E	33	0.20	117	18.29	33	0.18	117	18.32	8:23	46	10.00	4.05	2428	AT	-
2295	7/31	ME	E	32	59.47	117	17.95	32	59.44	117	17.98	9:07	42	10.00	1.16	696	AT	-
2296	7/31	ME	E	32	59.93	117	17.82	32	59.99	117	17.72	9:39	28	12.00	1.12	808	AT	-
2297	8/19	NV	Ec	33	43.38	118	14.12	33	43.30	118	14.08	8:54	13	5.00	0.86	259	A	-
2298	8/19	NV	Ec	33	43.75	118	14.03	33	43.61	118	13.95	9:36	12	5.00	0.67	202	ATD	-
2299	8/6	HY	Sur	33	43.22	118	14.02	33	43.14	118	14.08	10:46	13	5.07	1.11	336	AT	-
2300	8/6	HY	Sur	33	43.09	118	14.35	-	-	-	-	-	-	-	-	-	N	Ob
2301	8/10	AB	H	34	24.06	119	49.97	34	24.10	119	50.09	11:15	29	10.00	1.18	706	AT	-
2302	7/27	ME	E	33	30.59	117	46.59	33	30.54	117	46.53	12:09	51	12.00	1.15	826	AT	-
2303	7/27	ME	E	33	31.13	117	46.93	33	31.10	117	46.85	15:31	49	10.00	0.95	573	AT	-
2304	7/27	ME	E	33	31.28	117	46.19	33	31.15	117	46.13	14:06	16	10.00	0.80	477	A	-
2305	8/18	HY	LM	33	58.54	118	28.27	-	-	-	-	-	-	-	-	-	N	RB
2306	8/4	HY	LM	33	56.15	118	27.18	33	56.07	118	27.11	7:58	14	10.07	1.15	694	AT	-
2307	8/14	ME	E	33	57.75	118	28.57	33	57.65	118	28.47	14:30	17	10.00	1.02	615	A	-
2308	7/31	AB	H	34	5.05	119	5.45	-	-	-	-	-	-	-	-	-	N	Ob
2309	8/20	ME	E	34	4.55	119	6.25	34	4.27	119	6.45	12:10	161	9.00	-	-	N	IB
2310	7/22	AB	H	34	5.44	119	4.33	34	5.47	119	4.73	19:05	9	10.00	1.17	704	AT	-
2311	8/19	NV	Ec	33	45.34	118	11.11	-	-	-	-	-	-	-	-	-	N	Ob
2312	8/14	ME	E	34	1.24	118	39.90	34	1.19	118	39.94	11:44	32	10.00	0.97	584	AT	-
2313	8/12	HY	LM	34	1.67	118	40.96	-	-	-	-	-	-	-	-	-	N	RB

Appendix A1 (continued)

				Station Coordinates[a]								Tow Characteristics						
	Date			Nominal Trawl				Trawl Start					Depth	Dur.	Speed	Dist.	Trawl	
Station	(1998)	Ag.[b]	Ve.[c]	Lat N (dm)		Long W (dm)		Lat N (dm)		Long W (dm)		Time	(m)	(min)	(m/sec)	(m)	Type[d]	FC[e]
2314	8/14	ME	E	34	1.63	118	40.96	34	1.69	118	40.77	11:10	12	10.00	0.89	535	AT	-
2315	8/6	SD	M	32	46.17	117	16.19	-	-	-	-	-	-	-	-	-	N	Ob
2316	8/4	SD	M	32	44.04	117	16.09	-	-	-	-	-	-	-	-	-	N	KB
2317	8/7	SD	M	32	46.03	117	16.59	32	46.13	117	16.66	8:06	24	10.00	0.80	479	AT	-
2318	8/11	ME	E	33	43.42	118	7.62	33	43.47	118	7.55	13:48	14	10.00	0.96	576	A	-
2319	8/12	ME	E	33	44.23	118	8.60	33	44.22	118	8.61	7:21	10	10.00	1.05	632	AT	-
2320	8/12	ME	E	33	43.98	118	7.29	33	43.97	118	7.31	8:48	6	10.00	0.94	564	AT	-
2321	8/11	ME	E	33	43.77	118	8.04	33	43.72	118	7.99	15:34	12	10.00	1.01	603	A	-
2322	7/29	ME	E	33	11.27	117	24.43	33	11.22	117	24.40	17:10	17	10.00	0.93	557	AT	-
2323	7/29	ME	E	33	12.28	117	24.29	33	12.28	117	24.27	14:40	9	10.00	0.92	553	A	-
2324	7/29	ME	E	33	11.51	117	23.60	33	11.52	117	23.59	15:51	10	10.00	0.87	524	AT	-
2325	8/5	ME	SW	33	37.67	117	59.23	33	37.62	117	59.04	11:26	13	10.00	1.05	627	A	-
2326	8/7	ME	SW	33	37.36	117	57.37	33	37.35	117	57.37	11:23	7	10.00	0.91	549	A	-
2327	8/11	ME	E	33	37.68	117	57.70	33	37.87	117	58.29	7:51	8	10.00	0.94	566	A	-
2328	7/23	AB	H	34	13.21	119	17.33	34	13.36	119	17.39	18:44	16	10.00	1.28	768	AT	-
2329	7/23	AB	H	34	15.00	119	16.60	34	14.89	119	16.57	13:36	12	10.00	1.19	712	AT	-
2330	7/23	AB	H	34	14.36	119	16.84	34	14.42	119	16.89	17:35	13	10.00	1.23	740	AT	-
2331	7/23	AB	H	34	14.75	119	17.36	34	14.86	119	17.51	16:31	16	10.00	1.27	763	AT	-
2332	7/31	ME	E	33	13.69	117	26.24	33	12.63	117	24.26	14:24	7	5.00	0.87	260	A	-
2333	7/29	ME	E	33	12.85	117	24.58	33	12.33	117	24.40	13:57	10	10.00	0.85	510	AT	-
2334	7/15	SD	M	32	33.12	117	8.57	32	33.11	117	8.57	9:44	12	10.00	0.83	497	AT	-
2335	7/15	SD	M	32	32.68	117	9.29	32	32.63	117	9.30	8:17	17	10.00	0.77	464	AT	-
2336	7/15	SD	M	32	34.61	117	8.59	-	-	-	-	-	-	-	-	-	N	RB
2337	7/15	SD	M	32	33.55	117	8.35	-	-	-	-	-	-	-	-	-	N	RB
2338	7/23	AB	H	34	16.18	119	20.47	34	16.80	119	20.58	11:23	17	10.00	0.99	594	AT	-
2339	7/23	AB	H	34	16.02	119	18.73	34	15.25	119	17.22	15:14	15	10.00	1.43	858	AT	-
2340	7/23	AB	H	34	15.90	119	20.45	34	16.09	119	20.58	12:35	20	10.00	1.26	759	AT	-
2341	7/13	AB	H	34	5.30	119	9.08	34	5.34	119	9.26	12:27	32	10.00	1.13	680	AT	-
2342	7/16	AB	H	34	4.20	119	9.58	34	4.32	119	9.54	13:31	51	10.00	1.13	681	AT	-
2343	7/17	AB	H	34	1.47	118	51.11	34	1.41	118	51.14	17:37	24	10.00	1.26	986	AT	-
2344	7/17	AB	H	34	1.13	118	51.38	34	1.05	118	51.34	19:08	47	10.00	1.31	787	AT	-
2345	7/27	ME	E	33	30.45	117	46.11	33	30.40	117	46.03	10:02	41	10.00	0.93	559	AT	-
2346	7/28	ME	E	33	29.64	117	46.63	33	29.55	117	46.55	9:05	68	10.00	0.92	551	AT	-
2347	7/28	ME	E	33	24.29	117	39.27	33	24.26	117	39.23	15:05	34	10.00	1.02	609	AT	-
2348	7/28	ME	E	33	23.72	117	39.90	33	23.60	117	39.71	15:51	61	10.00	1.00	598	AT	-
2349	8/6	SD	M	32	53.68	117	16.13	32	53.60	117	16.12	8:22	32	10.00	0.78	467	AT	-
2350	8/6	SD	M	32	53.32	117	16.66	32	53.32	117	16.66	10:33	64	10.00	0.95	569	AT	-
2351	8/6	SD	M	32	49.29	117	19.21	32	49.14	117	19.22	12:22	52	10.00	0.72	432	AT	-
2352	7/15	SD	M	32	32.52	117	11.41	32	32.47	117	11.39	11:56	31	10.00	0.73	435	AT	-
2353	7/16	SD	M	32	33.12	117	15.82	32	33.03	117	15.75	8:50	59	10.00	0.79	474	AT	-
2354	8/17	ME	S	34	27.53	120	18.77	34	27.54	120	18.62	15:52	17	10.00	1.03	620	AT	-
2355	8/17	ME	S	34	27.10	120	20.17	34	27.00	120	20.25	16:42	24	10.00	0.99	595	AT	-
2356	8/18	ME	S	34	26.87	120	4.41	34	26.87	120	4.17	9:38	45	10.00	1.06	635	AT	-
2357	8/18	ME	S	34	24.38	119	56.45	34	24.40	119	56.30	12:50	57	10.00	1.06	634	AT	-
2358	8/18	ME	S	34	23.81	119	58.35	34	24.02	119	58.11	11:52	73	10.00	1.09	652	AT	-
2359	8/18	ME	S	34	23.90	119	51.89	34	23.89	119	51.66	15:05	27	10.00	1.01	605	AT	-

Appendix A1 (continued)

				Station Coordinates[a]								Tow Characteristics						
				Nominal Trawl				Trawl Start									Trawl	
Station	Date (1998)	Ag.[b]	Ve.[c]	Lat N (dm)		Long W (dm)		Lat N (dm)		Long W (dm)		Time	Depth (m)	Dur. (min)	Speed (m/sec)	Dist. (m)	Type[d]	FC[e]
2360	8/18	ME	S	34	23.64	119	52.52	34	23.60	119	52.36	13:57	45	10.00	1.13	676	AT	-
2361	8/10	AB	H	34	23.98	119	34.26	34	23.93	119	34.40	19:05	13	10.00	1.36	817	AT	-
2362	8/28	AB	H	34	22.13	119	40.10	34	22.18	119	40.40	17:37	55	10.00	1.92	1150	AT	-
2363	8/12	AB	H	34	21.32	119	37.73	34	21.23	119	38.80	18:21	-	-	-	-	N	RB
2364	8/28	AB	H	34	20.56	119	39.41	34	20.65	119	39.64	16:07	61	10.00	0.82	493	AT	-
2365	8/12	AB	H	34	20.64	119	33.75	34	20.78	119	34.86	17:13	46	10.00	3.96	2375	AT	-
2366	8/21	ME	S	34	19.89	119	36.64	34	19.86	119	36.60	8:13	58	5.00	0.07	269	N	TN
2367	8/12	AB	H	34	19.04	119	31.99	34	19.25	119	31.79	15:09	58	10.00	1.26	753	AT	-
2368	8/11	AB	H	34	18.07	119	27.79	34	18.02	119	27.81	17:24	47	10.00	1.31	787	AT	-
2369	8/11	AB	H	34	18.25	119	25.52	34	18.34	119	25.64	15:21	34	10.00	1.15	692	AT	-
2370	7/23	AB	H	34	17.92	119	21.74	34	18.26	119	21.85	10:44	9	10.00	0.84	503	AT	-
2371	8/11	AB	H	34	15.89	119	30.58	34	16.04	119	30.41	19:12	77	10.00	1.30	779	AT	-
2372	8/19	ME	S	34	14.39	119	36.13	34	14.44	119	36.15	10:39	110	10.00	0.95	569	AT	-
2373	8/11	AB	H	34	13.23	119	23.15	34	13.26	119	23.34	14:11	28	10.00	1.26	753	AT	-
2374	8/19	ME	S	34	11.31	119	29.48	34	11.31	119	29.37	14:51	101	10.00	1.00	601	AT	-
2375	7/31	AB	H	34	11.25	119	21.32	34	11.24	119	21.29	12:05	26	10.00	1.14	685	AT	-
2376	7/31	AB	H	34	10.72	119	20.81	34	10.75	119	20.85	13:36	26	10.00	1.25	748	AT	-
2377	7/22	AB	H	34	2.31	118	56.36	34	2.32	118	56.32	16:40	20	10.00	1.15	689	AT	-
2378	7/22	AB	H	34	1.92	118	55.34	34	2.00	118	55.33	15:07	24	10.00	1.30	779	AT	-
2379	7/17	AB	H	34	1.14	118	50.24	34	1.23	118	50.54	16:30	20	10.00	1.04	814	AT	-
2380	8/14	ME	E	34	1.09	118	45.57	34	1.07	118	45.65	9:48	23	10.00	0.90	541	AT	-
2381	7/28	HY	LM	34	0.18	118	46.16	-	-	-	-	9:50	42	9.48	-	-	AT	-
2382	7/28	HY	LM	34	1.39	118	35.57	-	-	-	-	9:26	23	-	-	-	AT	-
2383	8/14	ME	E	34	0.67	118	30.78	34	0.55	118	30.67	13:27	11	10.00	0.98	589	AT	-
2384	8/13	ME	E	33	55.81	118	30.28	33	55.80	118	30.29	13:46	47	10.00	1.07	641	AT	-
2385	8/4	HY	LM	33	54.38	118	27.42	33	54.50	118	27.48	9:22	25	10.15	0.91	555	AT	-
2386	8/12	LA	OS	33	52.69	118	25.47	33	52.82	118	25.53	9:27	16	10.07	0.87	523	AT	-
2387	8/12	LA	OS	33	50.90	118	27.13	33	50.84	118	26.97	10:20	75	10.12	0.85	515	AT	-
2388	9/9	NV	Ec	33	44.89	118	8.93	-	-	-	-	-	-	-	-	-	N	Ab
2389	8/13	LA	OS	33	42.57	118	19.32	-	-	-	-	-	-	-	-	-	N	Ob
2390	8/13	LA	OS	33	41.60	118	15.88	33	41.69	118	15.58	12:33	26	10.08	-	-	T	TN
2391	8/10	LA	OS	33	42.56	118	8.26	33	42.60	118	8.45	10:16	19	10.10	0.89	538	AT	-
2392	8/10	LA	OS	33	42.30	118	9.32	33	42.35	118	9.42	8:48	20	10.03	0.84	503	AT	-
2393	8/10	LA	OS	33	40.97	118	5.30	33	41.09	118	5.43	12:00	18	10.07	0.85	511	AT	-
2394	8/13	LA	OS	33	39.06	118	14.94	33	38.96	118	14.82	13:26	43	10.08	0.81	490	AT	-
2395	8/10	LA	OS	33	40.36	118	3.24	33	40.50	118	-	12:39	-	10.05	-	-	N	TN
2396	8/14	LA	OS	33	38.88	118	8.97	33	38.86	118	8.73	9:33	31	10.07	0.84	506	AT	-
2397	8/10	LA	OS	33	39.00	118	7.57	33	38.98	118	7.35	13:43	30	10.20	0.86	529	AT	-
2398	8/14	LA	OS	33	37.15	118	8.58	33	37.15	118	8.36	10:18	43	10.12	0.84	511	AT	-
2399	8/5	ME	SW	33	38.09	117	59.69	33	38.06	117	59.58	13:36	12	10.00	0.99	595	A	-
2400	8/11	ME	SW	33	36.21	118	5.73	33	36.24	118	5.62	12:29	52	10.00	0.92	554	AT	-
2401	8/7	ME	SW	33	35.48	117	57.47	33	35.48	117	57.42	16:02	46	10.00	1.27	763	AT	-
2402	8/10	ME	E	33	33.45	117	49.78	33	33.47	117	49.78	11:00	29	10.00	1.00	598	ATBD	-
2403	7/27	ME	E	33	31.12	117	48.18	33	31.11	117	48.15	16:19	92	10.00	1.04	626	AT	-
2404	7/28	ME	E	33	25.32	117	39.32	33	25.25	117	39.33	13:41	22	10.00	1.06	636	AT	-
2405	7/29	ME	E	33	17.67	117	33.57	33	17.61	117	33.50	9:30	59	10.00	0.90	540	AT	-

Appendix A1 (continued)

				Station Coordinates[a]								Tow Characteristics						
	Date			Nominal Trawl				Trawl Start					Depth	Dur.	Speed	Dist.	Trawl	
Station	(1998)	Ag.[b]	Ve.[c]	Lat N (dm)		Long W (dm)		Lat N (dm)		Long W (dm)		Time	(m)	(min)	(m/s)	(m)	Type[d]	FC[e]
2406	7/29	ME	E	33	16.90	117	28.26	33	16.95	117	28.28	12:27	11	10.00	0.86	514	AT	-
2407	7/29	ME	E	33	15.61	117	31.41	33	15.62	117	31.38	10:24	59	10.00	1.04	622	AT	-
2408	7/30	ME	E	33	6.31	117	21.71	33	6.40	117	21.70	13:07	82	9.00	1.25	673	AT	-
2409	7/31	ME	E	33	0.04	117	17.00	-	-	-	-	-	-	-	-	-	N	Ob
2410	8/7	SD	M	32	46.33	117	21.28	-	-	-	-	-	-	-	-	-	N	RB
2411	8/7	SD	M	32	45.16	117	20.58	32	44.98	117	20.48	10:43	88	10.00	0.97	584	AT	-
2412	8/4	SD	M	32	43.29	117	17.78	32	43.13	117	17.71	11:22	61	10.00	1.01	605	AT	-
2413	8/3	SD	M	32	41.42	117	16.70	32	41.26	117	16.67	8:18	47	10.00	0.96	577	AT	-
2414	7/17	SD	M	32	40.61	117	11.40	32	40.56	117	11.28	9:01	8	10.00	0.78	469	A	-
2415	7/17	SD	M	32	39.52	117	10.93	32	39.55	117	10.96	7:53	14	10.00	0.82	492	A	-
2416	7/16	SD	M	32	39.71	117	9.82	32	39.67	117	9.81	12:29	7	10.00	0.73	438	AT	-
2417	7/31	SD	M	32	37.50	117	12.89	32	37.51	117	12.67	8:00	24	10.00	0.94	562	AT	-
2418	7/23	SD	M	32	35.71	117	18.89	32	35.58	117	18.80	8:06	99	10.00	0.91	547	AT	-
2419	7/16	SD	M	32	35.36	117	15.82	32	35.33	117	15.80	10:06	56	10.00	0.83	496	AT	-
2420	8/13	ME	E	33	46.00	118	14.95	33	45.85	118	14.85	9:01	14	5.00	1.09	328	A	-
2426	8/12	ME	E	33	44.06	118	13.89	33	44.05	118	13.81	12:05	12	10.00	1.04	623	ATBD	-
2427	8/19	NV	Ec	33	43.86	118	14.12	33	43.98	118	14.10	14:28	10	5.00	0.71	212	ATD	-
2430	8/12	ME	E	33	46.15	118	13.47	33	46.21	118	13.40	15:41	18	5.00	0.92	275	ABD	-
2434	8/14	SD	M	32	43.49	117	11.02	-	-	-	-	-	-	-	-	-	N	Ob
2435	8/13	SD	M	32	42.70	117	13.37	32	42.72	117	13.31	8:44	14	10.00	0.82	492	ATD	-
2436	8/14	SD	M	32	42.90	117	10.98	32	42.92	117	11.00	8:35	10	5.00	0.82	246	ATD	-
2438	7/23	SD	MT	32	37.34	117	6.09	-	-	-	-	-	-	-	-	-	N	Ob
2439	7/23	SD	MT	32	43.56	117	11.37	-	-	-	-	-	-	-	-	-	N	Ob
2443	9/2	AB	H	33	59.00	118	27.03	33	58.97	118	27.16	14:38	3	5.00	1.25	374	ATBD	-
2444	9/2	AB	H	33	58.88	118	26.89	33	58.84	118	26.90	13:30	3	5.00	1.21	364	ATBD	-
2445	9/2	AB	H	33	58.70	118	27.33	33	58.66	118	27.32	12:52	3	6.00	-	-	N	Ob
2446	9/2	AB	H	33	58.64	118	26.49	33	58.61	118	26.64	10:34	3	5.00	1.00	299	ATBD	-
2447	9/2	AB	H	33	58.44	118	26.83	33	58.57	118	26.86	9:37	5	5.00	1.33	399	ATBD	-
2448	9/2	AB	H	33	58.22	118	26.89	33	58.40	118	26.89	8:52	5	5.00	1.37	411	ATBD	-
2449	9/2	AB	H	33	57.83	118	27.43	33	57.78	118	27.46	11:17	4	5.00	1.38	415	ATBD	-
2450	8/13	ME	E	33	45.60	118	11.95	33	45.57	118	11.81	6:55	6	5.00	0.95	286	A	-
2451	8/12	ME	E	33	45.13	118	10.44	33	45.07	118	10.39	17:03	10	10.00	0.95	570	A	-
2452	8/12	ME	E	33	44.48	118	7.02	33	44.15	118	7.16	9:40	5	10.00	1.62	975	A	-
2453	8/15	ME	SW	33	37.68	117	58.49	33	37.70	117	58.29	10:35	10	10.00	1.03	617	A	-
2454	7/28	ME	E	33	30.59	117	45.18	-	-	-	-	-	-	-	-	-	N	Ob
2459	7/30	SD	M	32	38.81	117	26.65	-	-	-	-	-	-	-	-	-	N	RB
2460	7/30	SD	M	32	36.17	117	24.85	-	-	-	-	-	-	-	-	-	N	RB
2461	7/23	SD	M	32	36.79	117	21.19	32	36.69	117	21.15	11:45	188	10.00	0.94	561	AT	-
2462	7/30	SD	M	32	36.03	117	24.79	-	-	-	-	-	151	-	-	-	T	RB
2463	7/29	SD	M	32	35.31	117	-	-	-	-	-	-	-	-	-	-	N	FN
2464	6/1	CI	B	34	2.06	120	27.08	-	-	-	-	-	-	1.00	-	-	N	TS
2465	6/1	CI	B	34	4.13	120	23.51	-	-	-	-	-	-	1.00	-	-	N	RB
2466	6/1	CI	B	34	0.93	120	18.02	-	-	-	-	-	-	1.00	-	-	N	KB
2467	8/25	CI	B	33	57.91	119	51.16	33	58.04	119	51.54	13:04	28	10.00	1.06	638	ATBD	-
2468	6/1	CI	B	34	3.78	120	24.80	-	-	-	-	-	-	1.00	-	-	N	RB
2469	8/12	CI	B	34	0.67	120	22.33	34	-	120	-	-	-	-	-	-	N	RB

Appendix A1 (continued)

Station	Date (1998)	Ag.[b]	Ve.[c]	Station Coordinates[a]: Nominal Trawl Lat N (dm)		Nominal Trawl Long W (dm)		Trawl Start Lat N (dm)		Trawl Start Long W (dm)		Tow Characteristics: Time	Depth (m)	Dur. (min)	Speed (m/sec)	Dist. (m)	Trawl Type[d]	Trawl FC[e]
2470	6/1	CI	B	34	0.57	119	53.21	-	-	-	-	-	-	1.00	-	-	N	RB
2471	6/1	CI	B	34	3.37	120	27.24	-	-	-	-	-	-	1.00	-	-	N	RB
2472	8/23	CI	B	34	0.73	119	53.84	34	0.78	119	53.85	9:26	25	10.10	0.72	437	A T	-
2473	6/1	CI	B	34	3.19	119	48.81	-	-	-	-	-	-	1.00	-	-	N	TC
2474	6/1	CI	B	34	3.70	120	27.83	-	-	-	-	-	-	1.00	-	-	N	RB
2475	8/25	CI	B	34	2.86	119	54.70	34	2.73	119	54.51	11:05	24	10.00	0.80	482	A T	-
2476	8/11	CI	B	34	3.06	120	20.12	-	-	-	-	-	-	-	-	-	N	TC
2477	6/1	CI	B	34	3.45	120	24.29	-	-	-	-	-	-	1.00	-	-	N	TC
2478	8/23	CI	B	34	4.66	119	54.85	-	-	-	-	-	-	-	-	-	N	TC
2479	8/13	CI	B	34	4.13	119	46.19	-	-	-	-	-	-	-	-	-	N	RB
2480	8/11	CI	B	34	9.00	120	21.27	34	9.03	120	20.87	11:29	107	10.07	0.99	598	ATBD	-
2481	6/1	CI	B	34	8.35	120	29.71	-	-	-	-	-	-	1.00	-	-	N	RB
2482	8/12	CI	B	33	53.61	120	1.73	33	53.65	120	1.29	11:11	44	1.00	-	-	N	TN
2483	9/14	CI	B	34	4.84	120	7.63	34	4.84	120	7.83	11:20	85	10.00	1.08	648	ATBD	-
2484	6/1	CI	B	34	1.64	120	11.52	-	-	-	-	-	-	1.00	-	-	N	KB
2485	8/26	CI	B	33	50.54	120	2.18	-	-	-	-	-	-	-	-	-	N	RB
2486	6/1	CI	B	34	3.19	120	4.05	-	-	-	-	-	-	1.00	-	-	N	RB
2487	9/15	CI	B	34	0.86	120	26.24	34	0.81	120	25.82	10:00	63	10.00	1.17	705	ATBD	-
2488	6/1	CI	B	33	59.93	120	15.38	-	-	-	-	-	-	1.00	-	-	N	RB
2489	8/12	CI	B	33	56.62	120	14.44	-	-	-	-	-	-	-	-	-	N	RB
2490	9/14	CI	B	34	2.73	120	29.41	34	2.84	120	29.50	16:12	79	10.00	1.18	709	ATBD	-
2491	9/15	CI	B	34	0.69	120	28.48	34	0.70	120	28.53	8:07	94	10.00	1.22	735	ATBD	-
2492	8/12	CI	B	33	54.77	119	56.86	33	55.01	119	56.71	13:41	72	10.05	0.96	580	A T	-
2493	8/25	CI	B	34	4.72	119	53.27	34	4.74	119	53.39	9:17	44	10.05	0.93	561	ATBD	-
2494	8/26	CI	B	33	47.50	120	2.22	33	47.46	120	2.26	9:23	164	10.05	0.96	578	AT	-
2495	8/12	CI	B	33	56.22	119	53.77	-	-	-	-	-	-	-	-	-	N	RB
2496	8/11	CI	B	34	5.52	120	34.77	-	-	-	-	-	-	-	-	-	N	RB
2497	8/26	CI	B	33	47.02	119	57.43	33	46.98	119	57.05	14:47	162	10.45	0.93	582	AT	-
2498	8/26	CI	B	33	43.78	119	52.04	-	-	-	-	-	-	-	-	-	N	RB
2499	8/24	CI	B	34	6.69	119	46.69	34	6.68	119	46.60	16:37	184	10.15	0.85	517	A T	-
2500	8/26	CI	B	33	47.40	119	53.86	-	-	-	-	-	-	-	-	-	N	RB
2501	9/16	CI	B	33	39.04	119	52.46	33	39.06	119	52.51	8:26	189	10.00	1.29	773	A T	-
2502	8/11	CI	B	34	10.41	120	24.15	34	10.28	120	23.79	13:29	129	10.18	1.10	672	ATB	-
2503	8/26	CI	B	33	42.11	119	55.97	-	-	-	-	-	-	-	-	-	N	RB
2504	9/16	CI	B	33	39.45	120	0.53	33	39.47	120	0.52	10:02	150	10.00	-	-	N	RB
2505	8/26	CI	B	33	47.79	119	54.61	-	-	-	-	-	-	-	-	-	N	RB
2506	9/1	CI	B	33	42.14	119	59.47	-	-	-	-	-	-	-	-	-	N	RB
2507	9/14	CI	B	34	11.33	120	33.36	-	-	-	-	-	-	-	-	-	N	TD
2508	9/15	CI	B	33	55.07	120	19.33	33	55.09	120	19.91	12:22	231	9.00	-	-	N	TD
2509	6/1	CI	B	34	2.09	119	20.09	-	-	-	-	-	-	1.00	-	-	N	RB
2510	7/29	CI	B	34	0.16	119	28.93	34	0.20	119	28.63	10:47	52	10.23	-	-	N	FN
2511	8/6	CI	B	33	30.58	119	4.56	33	30.58	119	4.53	9:33	102	6.00	-	-	N	Ob
2512	8/5	CI	B	33	28.57	119	0.04	33	28.88	119	0.01	13:38	88	10.55	1.15	728	A T	-
2513	7/29	CI	B	33	59.46	119	23.27	-	-	-	-	-	-	-	-	-	N	RB
2514	8/22	CI	B	34	1.98	119	30.55	-	-	-	-	-	-	-	-	-	N	RB
2515	8/13	CI	B	34	5.06	119	40.05	34	4.71	119	39.52	10:37	101	10.00	1.39	831	ATBD	-

Appendix A1 (continued)

				Station Coordinates[a]								Tow Characteristics						
	Date			Nominal Trawl				Trawl Start					Depth	Dur.	Speed	Dist.	Trawl	
Station	(1998)	Ag.[b]	Ve.[c]	Lat N (dm)		Long W (dm)		Lat N (dm)		Long W (dm)		Time	(m)	(min)	(m/sec)	(m)	Type[d]	FC[e]
2516	7/28	CI	B	34	4.00	119	35.33	34	4.04	119	35.46	10:30	90	10.00	1.07	642	A T	-
2517	7/29	CI	B	34	1.15	119	28.48	34	1.21	119	28.53	12:54	60	10.00	1.25	749	A	-
2518	8/24	CI	B	34	5.80	119	44.23	34	5.83	119	44.29	13:05	127	10.10	0.81	490	ATBD	-
2519	7/29	CI	B	33	58.16	119	37.87	33	58.15	119	37.54	7:47	67	10.00	1.25	749	ATBD	-
2520	7/30	CI	B	34	1.86	119	25.37	34	1.28	119	24.86	14:36	85	10.00	2.01	1208	A T	-
2521	8/25	CI	B	33	56.61	119	46.93	33	56.65	119	46.84	14:37	-	4.00	-	-	N	FN
2522	8/13	CI	B	34	3.52	119	29.80	34	3.52	119	29.35	8:31	82	10.08	1.14	690	ATBD	-
2523	8/6	CI	B	33	28.36	119	5.65	33	28.39	119	5.34	8:30	105	10.12	1.23	745	ATBD	-
2524	8/22	CI	B	33	57.59	119	28.96	-	-	-	-	-	-	-	-	-	N	RB
2525	7/30	CI	B	34	3.27	119	19.95	34	3.30	119	19.98	12:53	175	10.00	0.99	594	ATBD	-
2526	8/24	CI	B	34	6.24	119	44.06	34	5.72	119	42.52	14:48	109	10.35	0.86	533	A T	-
2527	8/5	CI	B	33	31.19	119	1.62	-	-	-	-	-	-	-	-	-	N	IB
2528	7/30	CI	B	34	4.31	119	25.15	34	4.27	119	25.22	10:40	160	10.55	0.97	616	ATBD	-
2529	8/22	CI	B	34	3.17	119	17.73	-	-	-	-	-	-	-	-	-	N	RB
2530	8/5	CI	B	33	32.68	119	3.95	33	32.70	119	3.76	15:41	137	9.77	-	-	N	RB
2531	7/30	CI	B	34	5.25	119	30.22	34	5.27	119	29.55	8:30	187	10.57	1.16	732	A T	-
2532	8/22	CI	B	34	2.33	119	18.01	-	-	-	-	-	-	-	-	-	N	RB
2533	7/29	CI	B	33	58.25	119	31.82	-	-	-	-	-	-	-	-	-	N	IB
2534	7/30	CI	B	34	5.13	119	32.87	34	5.14	119	32.65	7:11	147	10.00	0.99	594	ATBD	-
2535	8/12	CI	B	33	55.85	119	47.66	-	-	-	-	-	-	-	-	-	N	RB
2536	8/22	CI	B	33	57.49	119	34.85	-	-	-	-	-	-	-	-	-	N	TD
2537	8/22	CI	B	34	6.10	119	39.50	34	6.01	119	39.14	9:53	191	10.00	1.20	719	A T	-
2538	8/24	CI	B	34	6.03	119	43.70	34	6.01	119	43.54	11:01	117	10.00	0.93	558	A T	-
2539	6/1	CI	B	34	0.80	119	26.06	-	-	-	-	-	-	1.00	-	-	N	OL
2540	8/12	CI	B	33	57.68	119	42.73	-	-	-	-	-	-	-	-	-	N	TC
2541	6/1	CI	B	33	28.05	119	2.53	-	-	-	-	-	-	1.00	-	-	N	TC
2542	8/7	CI	B	33	27.73	119	1.79	-	-	-	-	-	-	-	-	-	N	TC
2543	8/29	CI	B	34	0.21	119	25.72	-	-	-	-	-	-	-	-	-	N	RB
2544	6/1	CI	B	34	2.38	119	36.21	-	-	-	-	-	-	1.00	-	-	N	OL
2545	8/22	CI	B	34	1.15	119	21.88	-	-	-	-	-	-	-	-	-	N	RB
2546	8/22	CI	B	34	0.63	119	24.29	-	-	-	-	-	-	-	-	-	N	RB
2547	8/29	CI	B	34	3.26	119	34.41	-	-	-	-	-	-	-	-	-	N	RB
2548	6/1	CI	B	33	59.27	119	32.86	-	-	-	-	-	-	1.00	-	-	N	Ab
2549	8/29	CI	B	33	59.22	119	35.32	-	-	-	-	-	-	-	-	-	N	RB
2550	6/1	CI	B	33	29.50	119	4.06	-	-	-	-	-	-	1.00	-	-	N	RB
2551	8/22	CI	B	33	59.98	119	32.32	-	-	-	-	-	-	-	-	-	N	RB
2552	6/1	CI	B	33	59.12	119	36.75	-	-	-	-	-	-	1.00	-	-	N	TC
2553	6/1	CI	B	33	29.33	119	3.36	-	-	-	-	-	-	1.00	-	-	N	RB
2554	8/26	M E	E	33	34.69	118	0.87	33	34.77	118	0.89	9:47	54	10.00	0.98	997	A T	-
2555	8/26	M E	E	33	34.63	118	0.24	33	34.45	117	59.89	8:23	54	10.00	1.78	1067	A T	-
2556	8/24	SD	M	32	41.44	117	18.35	32	41.34	117	18.26	8:31	76	10.00	0.75	452	A T	-
2557	8/21	M E	S	34	15.09	119	16.06	34	14.83	119	15.88	10:22	5	5.00	1.02	306	ABD	-
2558	8/27	M E	E	33	44.95	118	6.84	33	45.04	118	6.90	8:52	5	6.00	0.89	320	ATBD	-
2559	8/27	M E	E	33	44.22	118	9.07	33	44.24	118	9.03	7:15	12	10.00	0.76	458	ATBD	-
2560	8/27	M E	E	33	43.50	118	9.64	33	43.51	118	9.57	10:18	16	10.00	1.12	673	A	-
2565	8/20	NV	Ec	33	43.09	118	16.33	33	42.96	118	16.32	9:12	16	5.00	0.78	233	A	-

Appendix A1 (continued)

				Station Coordinates[a]								Tow Characteristics						
	Date			Nominal Trawl				Trawl Start					Depth	Dur.	Speed	Dist.	Trawl	
Station	(1998)	Ag.[b]	Ve.[c]	Lat N (dm)		Long W (dm)		Lat N (dm)		Long W (dm)		Time	(m)	(min)	(m/sec)	(m)	Type[d]	FC[e]
2566	8/27	ME	E	33	45.29	118	12.97	33	45.38	118	13.03	13:06	25	5.00	1.00	300	ABD	-
2571	8/24	SD	M	32	43.13	117	12.62	32	43.16	117	12.59	11:07	15	5.00	0.87	262	A	-
2573	8/24	SD	M	32	42.36	117	13.63	32	42.39	117	13.59	10:20	15	5.00	0.78	234	A	-
2580	8/20	ME	S	34	14.81	119	15.87	34	14.95	119	16.14	11:33	7	5.00	1.16	349	ATBD	-
2585	8/25	ME	E	33	13.05	117	23.92	33	12.93	117	23.97	15:26	6	5.00	0.87	260	A	-
2586	8/25	ME	E	33	12.77	117	24.23	33	12.77	117	24.28	14:51	7	5.00	1.13	340	ABD	-
2590	8/28	ME	E	33	50.89	118	24.00	33	50.88	118	23.96	9:01	7	5.00	0.94	283	ABD	-
2591	8/26	ME	E	33	45.92	118	7.61	33	45.63	118	7.22	14:10	6	5.00	0.08	295	ATBD	-
2592	8/26	ME	E	33	45.76	118	7.08	33	45.73	118	7.10	14:46	4	5.00	0.77	232	ABD	-
2593	8/26	ME	E	33	45.35	118	7.79	33	45.32	118	7.78	13:14	6	5.00	0.74	223	ATBD	-
2594	9/1	ME	O	32	46.98	117	13.87	32	47.05	117	13.44	12:25	2	5.00	1.02	307	A	-
2596	9/1	ME	O	32	46.29	117	14.61	32	46.33	117	14.58	13:05	3	5.00	1.28	383	A	-
2597	8/27	ME	E	33	44.46	118	16.54	33	44.52	118	16.50	15:05	17	5.00	0.94	283	ABD	-
2598	8/20	NV	Ec	33	44.98	118	13.35	-	-	-	-	-	-	-	-	-	N	IB
2599	8/27	ME	E	33	43.20	118	16.06	33	42.94	118	15.89	16:58	16	5.00	0.90	269	ABD	-
2600	8/20	NV	Ec	33	43.88	118	12.09	33	43.86	118	12.14	10:15	21	5.00	0.74	222	A	-
2601	8/27	ME	E	33	46.21	118	13.32	33	46.14	118	13.33	11:43	19	5.00	0.83	249	ABD	-
2602	8/20	NV	Ec	33	44.96	118	14.51	33	44.97	118	14.56	13:30	10	5.00	0.75	224	A	-
2603	8/20	NV	Ec	33	44.79	118	13.40	33	44.89	118	13.38	14:14	-	-	-	-	N	Ob
2604	8/20	NV	Ec	33	44.57	118	12.66	33	44.51	118	12.59	11:05	15	5.00	0.84	251	AT	-
2605	8/19	ME	S	34	15.99	119	22.79	34	15.99	119	22.73	16:00	26	10.00	1.04	625	AT	-
2606	8/19	ME	S	34	12.62	119	19.23	34	12.60	119	19.22	15:05	19	10.00	1.02	614	AT	-
2607	8/20	ME	S	34	7.81	119	16.46	34	7.82	119	16.44	14:01	22	10.00	0.82	492	AT	-
2608	8/19	ME	S	34	14.88	119	37.53	34	14.87	119	37.57	11:40	125	10.00	1.03	618	AT	-
2609	8/19	ME	S	34	12.45	119	37.34	34	12.51	119	37.39	12:45	158	10.00	0.99	596	AT	-
2610	8/26	ME	S	33	35.10	118	5.68	33	35.25	118	5.26	11:01	182	10.00	0.99	593	AT	-
2611	8/19	HY	LM	33	57.30	118	33.33	33	57.23	118	33.19	8:53	58	10.15	0.97	593	AT	-
2612	8/25	LA	OS	33	45.67	118	26.48	33	45.54	118	26.37	9:13	55	10.15	0.82	501	AT	-
2613	8/25	LA	OS	33	42.54	118	19.80	-	-	-	-			-	-	-	N	Ob

Dur. = Duration; Dist. = Distance.

[a]Station Coordinates

Lat N (dm) = Latitude North (degree and minutes).

Long W (dm) = Longitude West (degree and minutes).

[b]Ag = Agency (SCCWRP served as the QAQC agency)

AB = Aquatic Bioassay and Consulting Laboratories.

CI = Channel Islands National Marine Sanctuary and SCCWRP.

HY = City of Los Angeles, Environmental Monitoring Division.

LA = County Sanitation Districts of Los Angeles County.

ME = MEC Analytical Systems Inc.

NV = U.S. Navy, Space and Warfare Systems Center and SD.

SCCWRP = Southern California Coastal Water Research.

SD = City of San Diego, Metropolitan Wastewater Department.

WI = University of Southern California Wrigley Institute for Environmental Studies

[c]Ve = Vessels

B = *Ballena* ; E = *Earlybird* ; Ec = *Ecos* ; H = *Hey Jude* ;
LM = *La Mer* ; M = *Monitor III* ; MT = *Metro* ; O = *Osprey* ;
OS = *Ocean Sentinel* ; S = *Spirit of Santa Barbara* ;
Sur = *Surveyor* ; SW = *Sea Watch*

[d]Type = Sample Type: A = Assemblage; B = Biomaker (Bile FACS); D = DNA; N = None; T = Tissue

[e]FC = Fail Code

FN = Fouled net.	Ob = Obstructions
TN = Torn net.	TS = too shallow.
NC = No contact with bottom.	TD = too deep >200m.
ID = Improper distance/time.	Ab = Abandoned.
IB = Irregular Bottom.	RB = Rocky Bottom.
BB = Beyond Border.	TC = too close to shore
KB = Kelp Bed.	OL = on land

[f] End latitude and end longitude were not recorded.

Appendix A2. Subpopulation designation and area-weights of trawl stations sampled in the Southern California Bight 1998 Regional Survey, July-September 1998.

Station	Shelf Zone[a]	Supraregion	Region[b]	Sub-region[b]	Subpopulation[c]	Area-Weights[d]
2065	Outer Shelf	Island	Warm	Catalina	Island (O)	7.89
2067	Outer Shelf	Island	Warm	Catalina	Island (O)	7.89
2069	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2070	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2071	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2072	Inner Shelf	Island	Warm	Catalina	Island (I)	7.89
2073	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2074	Outer Shelf	Island	Warm	Catalina	Island (O)	7.89
2075	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2076	Outer Shelf	Island	Warm	Catalina	Island (O)	7.89
2077	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2078	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2079	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2082	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2084	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2085	Outer Shelf	Island	Warm	Catalina	Island (O)	7.89
2087	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2088	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2089	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2090	Outer Shelf	Island	Warm	Catalina	Island (O)	7.89
2091	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2092	Outer Shelf	Island	Warm	Catalina	Island (O)	7.89
2093	Middle Shelf	Island	Warm	Catalina	Island (M)	7.89
2094	Outer Shelf	Island	Warm	Catalina	Island (O)	7.89
2095	Outer Shelf	Island	Warm	Catalina	Island (O)	7.89
2096	Outer Shelf	Island	Warm	Catalina	Island (O)	7.89
2097	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2098	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2099	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2100	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2101	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2102	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2103	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2104	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2105	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2106	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2108	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2110	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2111	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2112	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2113	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2114	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2115	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	55.28
2116	Outer Shelf	Mainland	Central	Central	Mainland	17.83
2117	Outer Shelf	Mainland	Central	Central	Mainland	17.83
2118	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	55.28
2119	Outer Shelf	Mainland	Central	Central	Mainland	17.83
2122	Outer Shelf	Mainland	Southern	Southern	Mainland	17.83
2129	Bays & Harbors	Mainland	Northern	Northern	Marinas	1.31
2137	Bays & Harbors	Mainland	Central	Central	Marinas	1.31
2147	Bays & Harbors	Mainland	Central	Central	Marinas	1.31
2152	Bays & Harbors	Mainland	Central	Central	Other Bay	2.79

Appendix A2 (continued)

Station	Shelf Zone[a]	Supraregion	Region[b]	Sub-region[b]	Subpopulation[c]	Area-Weights[d]
2153	Bays & Harbors	Mainland	Central	Central	Other Bay	2.79
2155	Bays & Harbors	Mainland	Central	Central	Other Bay	2.79
2158	Bays & Harbors	Mainland	Central	Central	Other Bay	2.79
2162	Bays & Harbors	Mainland	Central	Central	Other Bay	2.79
2167	Bays & Harbors	Mainland	Central	Central	Other Bay	2.79
2168	Bays & Harbors	Mainland	Central	Central	Other Bay	2.79
2180	Bays & Harbors	Mainland	Central	Central	Port	1.95
2186	Bays & Harbors	Mainland	Central	Central	Port	1.95
2189	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2190	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2191	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2192	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2194	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2195	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2197	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2198	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2200	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2201	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2202	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2204	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2205	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2206	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2207	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2208	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2209	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2210	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2211	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2212	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2213	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2214	Middle Shelf	Mainland	Southern	Southern	Large POTWs	4.39
2215	Middle Shelf	Mainland	Southern	Southern	Large POTWs	4.39
2216	Middle Shelf	Mainland	Southern	Southern	Large POTWs	4.39
2217	Middle Shelf	Mainland	Southern	Southern	Large POTWs	4.39
2218	Middle Shelf	Mainland	Southern	Southern	Large POTWs	4.39
2219	Middle Shelf	Mainland	Southern	Southern	Large POTWs	4.39
2230	Bays & Harbors	Mainland	Southern	Southern	Other Bay	1.03
2231	Bays & Harbors	Mainland	Southern	Southern	Other Bay	1.03
2233	Bays & Harbors	Mainland	Southern	Southern	Other Bay	1.03
2239	Bays & Harbors	Mainland	Southern	Southern	Other Bay	1.03
2241	Bays & Harbors	Mainland	Southern	Southern	Other Bay	1.03
2242	Bays & Harbors	Mainland	Southern	Southern	Other Bay	1.03
2243	Bays & Harbors	Mainland	Southern	Southern	Other Bay	1.03
2244	Bays & Harbors	Mainland	Southern	Southern	Other Bay	1.03
2249	Bays & Harbors	Mainland	Southern	Southern	Other Bay	1.03
2254	Bays & Harbors	Mainland	Southern	Southern	Port	1.30
2256	Bays & Harbors	Mainland	Southern	Southern	Port	1.30
2258	Bays & Harbors	Mainland	Southern	Southern	Port	1.30
2262	Bays & Harbors	Mainland	Southern	Southern	Port	1.30
2266	Middle Shelf	Mainland	Northern	Northern	SPOTW (M)	1.39
2267	Inner Shelf	Mainland	Northern	Northern	SPOTW (I)	1.39
2268	Inner Shelf	Mainland	Northern	Northern	SPOTW (I)	1.39
2273	Inner Shelf	Mainland	Northern	Northern	SPOTW (I)	1.39
2274	Inner Shelf	Mainland	Northern	Northern	SPOTW (I)	1.39

Appendix A2 (continued)

Station	Shelf Zone[a]	Supraregion	Region[b]	Sub-region[b]	Subpopulation[c]	Area-Weights[d]
2275	Inner Shelf	Mainland	Northern	Northern	SPOTW (I)	1.39
2276	Inner Shelf	Mainland	Northern	Northern	SPOTW (I)	1.39
2277	Middle Shelf	Mainland	Central	Central	SPOTW (M)	1.39
2278	Middle Shelf	Mainland	Central	Central	SPOTW (M)	1.39
2279	Inner Shelf	Mainland	Central	Central	SPOTW (I)	1.39
2280	Middle Shelf	Mainland	Central	Central	SPOTW (M)	1.39
2281	Middle Shelf	Mainland	Southern	Southern	SPOTW (M)	1.39
2282	Inner Shelf	Mainland	Southern	Southern	SPOTW (I)	1.39
2283	Middle Shelf	Mainland	Southern	Southern	SPOTW (M)	1.39
2284	Middle Shelf	Mainland	Southern	Southern	SPOTW (M)	1.39
2285	Middle Shelf	Mainland	Southern	Southern	SPOTW (M)	1.39
2286	Inner Shelf	Mainland	Southern	Southern	SPOTW (I)	1.39
2287	Middle Shelf	Mainland	Southern	Southern	SPOTW (M)	1.39
2288	Middle Shelf	Mainland	Southern	Southern	SPOTW (M)	1.39
2289	Middle Shelf	Mainland	Southern	Southern	SPOTW (M)	1.39
2290	Outer Shelf	Mainland	Southern	Southern	Mainland	1.39
2291	Middle Shelf	Mainland	Southern	Southern	SPOTW (M)	1.39
2292	Outer Shelf	Mainland	Southern	Southern	Mainland	1.39
2293	Inner Shelf	Mainland	Southern	Southern	SPOTW (I)	1.39
2294	Middle Shelf	Mainland	Southern	Southern	SPOTW (M)	2.22
2295	Middle Shelf	Mainland	Southern	Southern	SPOTW (M)	2.22
2296	Inner Shelf	Mainland	Southern	Southern	SPOTW (I)	2.22
2297	Inner Shelf	Mainland	Central	Central	SPOTW (I)	2.22
2298	Inner Shelf	Mainland	Central	Central	SPOTW (I)	1.39
2299	Inner Shelf	Mainland	Central	Central	SPOTW (I)	1.39
2301	Inner Shelf	Mainland	Northern	Northern	SPOTW (I)	1.39
2302	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	1.08
2303	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	1.08
2304	Inner Shelf	Mainland	Central	Central	River Mouths	1.08
2306	Inner Shelf	Mainland	Central	Central	River Mouths	1.08
2307	Inner Shelf	Mainland	Central	Central	River Mouths	1.08
2310	Inner Shelf	Mainland	Northern	Northern	River Mouths	1.08
2312	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	1.08
2314	Inner Shelf	Mainland	Central	Central	River Mouths	1.08
2317	Inner Shelf	Mainland	Southern	Southern	River Mouths	1.08
2318	Inner Shelf	Mainland	Central	Central	River Mouths	1.08
2319	Inner Shelf	Mainland	Central	Central	River Mouths	1.08
2320	Inner Shelf	Mainland	Central	Central	River Mouths	1.08
2321	Inner Shelf	Mainland	Central	Central	River Mouths	1.08
2322	Inner Shelf	Mainland	Southern	Southern	River Mouths	1.08
2323	Inner Shelf	Mainland	Southern	Southern	River Mouths	1.08
2324	Inner Shelf	Mainland	Southern	Southern	River Mouths	1.08
2325	Inner Shelf	Mainland	Central	Central	River Mouths	1.08
2326	Inner Shelf	Mainland	Central	Central	River Mouths	1.08
2327	Inner Shelf	Mainland	Central	Central	River Mouths	1.08
2328	Inner Shelf	Mainland	Northern	Northern	River Mouths	1.08
2329	Inner Shelf	Mainland	Northern	Northern	River Mouths	1.08
2330	Inner Shelf	Mainland	Northern	Northern	River Mouths	1.08
2331	Inner Shelf	Mainland	Northern	Northern	River Mouths	1.08
2332	Inner Shelf	Mainland	Southern	Southern	River Mouths	1.08
2333	Inner Shelf	Mainland	Southern	Southern	River Mouths	1.08
2334	Inner Shelf	Mainland	Southern	Southern	River Mouths	1.08
2335	Inner Shelf	Mainland	Southern	Southern	River Mouths	1.08

Appendix A2 (continued)

Station	Shelf Zone[a]	Supraregion	Region[b]	Sub-region[b]	Subpopulation[c]	Area-Weights[d]
2338	Inner Shelf	Mainland	Northern	Northern	River Mouths	1.08
2339	Inner Shelf	Mainland	Northern	Northern	River Mouths	1.08
2340	Inner Shelf	Mainland	Northern	Northern	River Mouths	1.08
2341	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	1.00
2342	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	1.00
2343	Inner Shelf	Mainland	Northern	Northern	Other Mainland	1.00
2344	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	1.00
2345	Middle Shelf	Mainland	Central	Central	SPOTW (M)	1.00
2346	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	1.00
2347	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	1.00
2348	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	1.00
2349	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	1.00
2350	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	1.00
2351	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	1.00
2352	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	1.00
2353	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	1.00
2354	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2355	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2356	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	55.28
2357	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	55.28
2358	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	55.28
2359	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2360	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	55.28
2361	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2362	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	55.28
2364	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	55.28
2365	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	55.28
2367	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	55.28
2368	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	55.28
2369	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	55.28
2370	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2371	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	55.28
2372	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	55.28
2373	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2374	Middle Shelf	Mainland	Northern	Northern	Mainland Non-POTW	55.28
2375	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2376	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2377	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2378	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2379	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2380	Inner Shelf	Mainland	Central	Central	Other Mainland	29.37
2381	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	55.28
2382	Inner Shelf	Mainland	Central	Central	Other Mainland	29.37
2383	Inner Shelf	Mainland	Central	Central	Other Mainland	29.37
2384	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	55.28
2385	Inner Shelf	Mainland	Central	Central	Other Mainland	29.37
2386	Inner Shelf	Mainland	Central	Central	Other Mainland	29.37
2387	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	55.28
2391	Inner Shelf	Mainland	Central	Central	Other Mainland	29.37
2392	Inner Shelf	Mainland	Central	Central	Other Mainland	29.37
2393	Inner Shelf	Mainland	Central	Central	Other Mainland	29.37
2394	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	55.28
2396	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	55.28

Appendix A2 (continued)

Station	Shelf Zone[a]	Supraregion	Region[b]	Sub-region[b]	Subpopulation[c]	Area-Weights[d]
2397	Inner Shelf	Mainland	Central	Central	Other Mainland	29.37
2398	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	55.28
2399	Inner Shelf	Mainland	Central	Central	Other Mainland	29.37
2400	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	55.28
2401	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	55.28
2402	Inner Shelf	Mainland	Central	Central	Other Mainland	29.37
2403	Middle Shelf	Mainland	Central	Central	Mainland Non-POTW	55.28
2404	Inner Shelf	Mainland	Southern	Southern	Other Mainland	29.37
2405	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	55.28
2406	Inner Shelf	Mainland	Southern	Southern	Other Mainland	29.37
2407	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	55.28
2408	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	55.28
2411	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	55.28
2412	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	55.28
2413	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	55.28
2414	Inner Shelf	Mainland	Southern	Southern	Other Mainland	29.37
2415	Inner Shelf	Mainland	Southern	Southern	Other Mainland	29.37
2416	Inner Shelf	Mainland	Southern	Southern	Other Mainland	29.37
2417	Inner Shelf	Mainland	Southern	Southern	Other Mainland	29.37
2418	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	55.28
2419	Middle Shelf	Mainland	Southern	Southern	Mainland Non-POTW	55.28
2420	Bays & Harbors	Mainland	Central	Central	Port	1.95
2426	Bays & Harbors	Mainland	Central	Central	Other Bay	2.79
2427	Bays & Harbors	Mainland	Central	Central	Other Bay	2.79
2430	Bays & Harbors	Mainland	Central	Central	Port	1.95
2435	Bays & Harbors	Mainland	Southern	Southern	Other Bay	1.03
2436	Bays & Harbors	Mainland	Southern	Southern	Other Bay	1.03
2443	Bays & Harbors	Mainland	Central	Central	Marinas	1.14
2444	Bays & Harbors	Mainland	Central	Central	Marinas	1.14
2446	Bays & Harbors	Mainland	Central	Central	Marinas	1.14
2447	Bays & Harbors	Mainland	Central	Central	Marinas	1.14
2448	Bays & Harbors	Mainland	Central	Central	Marinas	1.14
2449	Bays & Harbors	Mainland	Central	Central	Marinas	1.14
2450	Inner Shelf	Mainland	Central	Central	River Mouths	1.00
2451	Inner Shelf	Mainland	Central	Central	River Mouths	1.00
2452	Inner Shelf	Mainland	Central	Central	River Mouths	1.00
2453	Inner Shelf	Mainland	Central	Central	River Mouths	1.00
2461	Outer Shelf	Mainland	Southern	Southern	Mainland	17.83
2467	Inner Shelf	Island	Cool	NWI	Island (I)	10.53
2472	Inner Shelf	Island	Cool	NWI	Island (I)	10.53
2475	Inner Shelf	Island	Cool	NWI	Island (I)	10.53
2480	Middle Shelf	Island	Cool	NWI	Island (M)	142.86
2483	Middle Shelf	Island	Cool	NWI	Island (M)	142.86
2487	Middle Shelf	Island	Cool	NWI	Island (M)	142.86
2490	Middle Shelf	Island	Cool	NWI	Island (M)	142.86
2491	Middle Shelf	Island	Cool	NWI	Island (M)	142.86
2492	Middle Shelf	Island	Cool	NWI	Island (M)	142.86
2493	Middle Shelf	Island	Cool	NWI	Island (M)	142.86
2494	Outer Shelf	Island	Cool	NWI	Island (O)	66.67
2497	Outer Shelf	Island	Cool	NWI	Island (O)	66.67
2499	Outer Shelf	Island	Cool	NWI	Island (O)	66.67
2501	Outer Shelf	Island	Cool	NWI	Island (O)	66.67
2502	Outer Shelf	Island	Cool	NWI	Island (O)	66.67

Appendix A2 (continued)

Station	Shelf Zone[a]	Supraregion	Region[b]	Sub-region[b]	Subpopulation[c]	Area-Weights[d]
2512	Middle Shelf	Island	Warm	SEI	Island (M)	45.45
2515	Middle Shelf	Island	Warm	SEI	Island (M)	45.45
2516	Middle Shelf	Island	Warm	SEI	Island (M)	45.45
2517	Middle Shelf	Island	Warm	SEI	Island (M)	45.45
2518	Outer Shelf	Island	Warm	SEI	Island (O)	45.45
2519	Middle Shelf	Island	Warm	SEI	Island (M)	45.45
2520	Middle Shelf	Island	Warm	SEI	Island (M)	45.45
2522	Middle Shelf	Island	Warm	SEI	Island (M)	45.45
2523	Middle Shelf	Island	Warm	SEI	Island (M)	45.45
2525	Outer Shelf	Island	Warm	SEI	Island (O)	13.33
2526	Middle Shelf	Island	Warm	SEI	Island (M)	45.45
2528	Outer Shelf	Island	Warm	SEI	Island (O)	13.33
2531	Outer Shelf	Island	Warm	SEI	Island (O)	13.33
2534	Outer Shelf	Island	Warm	SEI	Island (O)	13.33
2537	Outer Shelf	Island	Warm	SEI	Island (O)	13.33
2538	Middle Shelf	Island	Warm	SEI	Island (M)	13.33
2554	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2555	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2556	Middle Shelf	Mainland	Southern	Southern	Large POTWs	4.39
2557	Bays & Harbors	Mainland	Northern	Northern	Marinas	1.31
2558	Bays & Harbors	Mainland	Central	Central	Marinas	1.31
2559	Bays & Harbors	Mainland	Central	Central	Other Bay	2.79
2560	Bays & Harbors	Mainland	Central	Central	Other Bay	2.79
2565	Bays & Harbors	Mainland	Central	Central	Port	1.95
2566	Bays & Harbors	Mainland	Central	Central	Port	1.95
2571	Bays & Harbors	Mainland	Southern	Southern	Other Bay	1.03
2573	Bays & Harbors	Mainland	Southern	Southern	Other Bay	1.03
2580	Bays & Harbors	Mainland	Northern	Northern	Marinas	1.22
2585	Bays & Harbors	Mainland	Southern	Southern	Marinas	1.22
2586	Bays & Harbors	Mainland	Southern	Southern	Marinas	1.22
2590	Bays & Harbors	Mainland	Central	Central	Marinas	1.22
2591	Bays & Harbors	Mainland	Central	Central	Marinas	1.22
2592	Bays & Harbors	Mainland	Central	Central	Marinas	1.22
2593	Bays & Harbors	Mainland	Central	Central	Marinas	1.22
2594	Bays & Harbors	Mainland	Southern	Southern	Other Bay	2.79
2596	Bays & Harbors	Mainland	Southern	Southern	Other Bay	2.79
2597	Bays & Harbors	Mainland	Central	Central	Port	1.76
2599	Bays & Harbors	Mainland	Central	Central	Other Bay	2.79
2600	Bays & Harbors	Mainland	Central	Central	Port	1.76
2601	Bays & Harbors	Mainland	Central	Central	Port	1.76
2602	Bays & Harbors	Mainland	Central	Central	Port	1.76
2604	Bays & Harbors	Mainland	Central	Central	Port	1.76
2605	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2606	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2607	Inner Shelf	Mainland	Northern	Northern	Other Mainland	29.37
2608	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2609	Outer Shelf	Mainland	Northern	Northern	Mainland	17.83
2610	Outer Shelf	Mainland	Central	Central	Mainland	17.83
2611	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39
2612	Middle Shelf	Mainland	Central	Central	Large POTWs	4.39

Total Area=3,279 $km^{2.}$

[a]Bays & Harbors (2-30 m); Inner Shelf (Coast= 2-30 m); Middle Shelf= 31-120 m; Outer Shelf = 121-202 m.

Appendix A2 (continued)

[b]Northern = Point Conception to Point Dume; Central = Point Dume to Dana Point; Southern = Dana Point to U.S.-Mexico International Border; Warm = eastern Santa Cruz Island to Santa Catalina Island; Cool = San Miguel Island to Western Santa Cruz Island; NWI = Northwest Channel Islands; SEI = Southeast Channel Islands.

[c]Island (I) = Island Inner Shelf; Island (M) = Island Middle Shelf; Island (O) = Island Outer Shelf; Large POTW = Large publicly owned treatment work monitoring area; SPOTW(I) = Small POTW monitoring area on Inner Shelf; SPOTW(M) = Small POTW area Middle Shelf; Other Mainland = Mainland Inner Shelf areas other than SPOTW or River Mouth areas; Other Bay = Areas in bays outside of port or marina areas

[d]Area-Weights = Area represented by trawl station.

Appendix A3. Physical characteristics and organochlorine compounds in sediments at trawl stations in the Southern California Bight 1998 Regional Survey, July-September 1998.

	Depth(m)				Sediment Concentration (ng/g)[a]		
Station	Mean Trawl	Grab Sample	% Fines in Sediment	TOC (%)	Total Chlordanes	Total DDTs	Total PCBs
2065	201	nc	nc	nc	nc	nc	nc
2067	190	nc	nc	nc	nc	nc	nc
2069	106	109	na	na	na	na	na
2070	98	83	na	na	na	na	na
2071	88	87	90	na	na	na	na
2072	23	20	38	na	na	na	na
2073	86	90	26	na	na	na	na
2074	121	nc	nc	nc	nc	nc	nc
2075	66	64	84	na	na	na	na
2076	153	nc	nc	nc	nc	nc	nc
2077	49	42	41	na	na	na	na
2078	111	110	51	na	na	na	na
2079	53	55	nc	nc	nc	nc	nc
2082	81	80	43	na	na	na	na
2084	88	nc	nc	nc	nc	nc	nc
2085	177	nc	nc	nc	nc	nc	nc
2087	69	69	54	na	na	na	na
2088	42	40	34	na	na	na	na
2089	91	90	47	na	na	na	na
2090	172	na	na	na	na	na	na
2091	71	71	49	na	na	na	na
2092	164	nc	nc	nc	nc	nc	nc
2093	97	97	10	na	na	na	na
2094	195	nc	nc	nc	nc	nc	nc
2095	131	nc	nc	nc	nc	nc	nc
2096	179	nc	nc	nc	nc	nc	nc
2097	174	nc	nc	nc	nc	nc	nc
2098	181	nc	nc	nc	nc	nc	nc
2099	174	nc	nc	nc	nc	nc	nc
2100	165	nc	nc	nc	nc	nc	nc
2101	202	nc	nc	nc	nc	nc	nc
2102	145	nc	nc	nc	nc	nc	nc
2103	199	nc	nc	nc	nc	nc	nc
2104	200	nc	nc	nc	nc	nc	nc
2105	184	nc	nc	nc	nc	nc	nc
2106	196	nc	nc	nc	nc	nc	nc
2108	152	nc	nc	nc	nc	nc	nc
2110	154	nc	nc	nc	nc	nc	nc
2111	167	nc	nc	nc	nc	nc	nc
2112	179	nc	nc	nc	nc	nc	nc
2113	130	nc	nc	nc	nc	nc	nc
2114	165	nc	nc	nc	nc	nc	nc
2115	75	nc	nc	nc	nc	nc	nc
2116	186	nc	nc	nc	nc	nc	nc
2117	184	nc	nc	nc	nc	nc	nc

Appendix A3 (continued)

Station	Depth(m) Mean Trawl	Depth(m) Grab Sample	% Fines in Sediment	TOC (%)	Sediment Concentration (ng/g)[a] Total Chlordanes	Total DDTs	Total PCBs
2118	82	nc	nc	nc	nc	nc	nc
2119	193	nc	nc	nc	nc	nc	nc
2122	121	nc	nc	nc	nc	nc	nc
2129	3	5	73	2.44	14.1	371.4	5.8
2137	3	4	79	2.21	3.7	53.9	75.2
2147	4	3	80	1.14	3.5	53.9	9.0
2152	7	6	66	0.81	nd	nd	nd
2153	9	5	35	0.64	nd	0.9	nd
2155	12	12	85	1.82	17.8	77.1	96.6
2158	24	21	76	1.63	nd	18.6	4.1
2162	21	14	85	1.15	nd	104.2	12.1
2167	15	13	82	1.68	9.4	94.8	76.1
2168	27	27	75	1.85	nd	142.3	47.5
2180	19	nc	nc	nc	nc	nc	nc
2186	17	15	48	0.81	nd	27.8	7.9
2189	64	63	17	0.80	nd	31.5	22.1
2190	50	50	32	0.61	nd	51.3	44.0
2191	99	102	16	0.77	1.0	47.2	55.6
2192	49	48	35	0.58	nd	49.9	29.9
2194	57	57	41	0.76	1.0	68.8	33.3
2195	61	59	41	0.78	1.2	50.4	57.8
2197	53	54	53	0.85	nd	102.7	54.0
2198	58	57	20	1.37	nd	26.5	9.6
2200	53	51	47	3.64	nd	1516.4	122.4
2201	89	86	60	2.75	nd	4716.1	293.6
2202	48	48	70	2.06	nd	2034.8	145.4
2204	74	76	63	3.09	nd	5728.1	402.8
2205	65	64	39	1.10	nd	1247.9	104.1
2206	49	49	26	0.54	nd	412.4	45.7
2207	34	33	7	0.13	nd	1.4	nd
2208	37	37	18	0.26	0.3	3.3	0.9
2209	53	67	25	0.41	0.2	4.9	2.8
2210	46	45	24	0.40	0.2	3.8	2.9
2211	43	41	27	0.44	nd	5.2	1.3
2212	38	40	37	0.39	0.2	7.2	4.5
2213	59	60	9	0.23	nd	2.3	nd
2214	72	74	53	0.74	nd	nd	nd
2215	81	81	55	0.64	nd	0.9	nd
2216	93	92	42	0.59	nd	0.5	nd
2217	85	86	45	0.59	nd	nd	nd
2218	59	59	45	0.65	nd	nd	nd
2219	107	106	37	1.01	nd	nd	nd
2230	6	4	10	0.20	nd	nd	nd
2231	11	13	29	0.64	nd	nd	1.5
2233	10	9	34	0.45	nd	nd	nd
2239	10	11	34	0.72	nd	nd	nd

Appendix A3 (continued)

Station	Depth(m) Mean Trawl	Grab Sample	% Fines in Sediment	TOC (%)	Sediment Concentration (ng/g)[a] Total Chlordanes	Total DDTs	Total PCBs
2241	3	4	18	0.52	nd	nd	nd
2242	5	4	31	0.74	nd	2.1	nd
2243	4	4	35	0.49	nd	nd	nd
2244	4	3	20	0.30	nd	nd	nd
2249	3	3	72	1.35	nd	0.9	nd
2254	4	5	33	0.66	nd	nd	2.9
2256	8	8	67	1.26	nd	nd	nd
2258	11	11	71	1.44	nd	nd	nd
2262	11	10	74	1.64	nd	nd	nd
2266	43	41	51	1.43	1.6	7.8	1.3
2267	14	15	17	0.34	nd	nd	nd
2268	29	31	27	0.68	1.1	1.1	nd
2273	14	14	27	0.23	nd	3.1	nd
2274	16	16	4	0.14	nd	3.8	nd
2275	13	13	7	0.15	nd	2.0	nd
2276	13	16	5	0.15	nd	2.3	nd
2277	36	35	54	0.73	0.8	2.7	nd
2278	37	37	51	1.14	1.0	5.9	0.5
2279	18	22	20	0.15	nd	1.8	nd
2280	41	42	66	0.75	1.1	6.0	7.5
2281	38	37	56	0.63	nd	5.7	nd
2282	18	18	19	0.15	nd	1.9	nd
2283	31	31	54	0.65	nd	5.0	nd
2284	34	33	49	0.51	nd	2.9	nd
2285	60	56	64	1.12	nd	9.4	nd
2286	19	22	21	0.25	nd	0.6	nd
2287	40	40	56	0.90	nd	7.4	0.1
2288	33	33	66	0.42	nd	3.0	nd
2289	77	78	59	0.66	nd	4.0	0.3
2290	135	187	78	1.94	nd	4.0	0.6
2291	70	69	59	0.70	nd	2.9	nd
2292	154	160	78	1.82	nd	36.3	nd
2293	22	23	0	0.05	nd	nd	nd
2294	46	45	40	0.47	nd	2.7	nd
2295	42	41	34	0.41	nd	1.3	nd
2296	28	32	18	0.24	nd	0.5	nd
2297	13	12	74	1.40	nd	84.6	25.3
2298	12	11	67	0.93	nd	24.8	nd
2299	13	13	62	1.36	nd	127.0	30.6
2301	29	21	23	0.57	nd	2.7	nd
2302	51	50	75	1.02	nd	7.3	0.3
2303	49	48	69	0.83	0.3	6.2	1.8
2304	16	14	0	0.08	nd	0.2	nd
2306	14	14	0	0.17	0.1	1.6	0.5
2307	17	16	14	0.21	0.4	1.3	0.8
2310	9	19	33	0.25	0.6	12.0	2.5

Appendix A3 (continued)

	Depth(m)				Sediment Concentration (ng/g)[a]		
Station	Mean Trawl	Grab Sample	% Fines in Sediment	TOC (%)	Total Chlordanes	Total DDTs	Total PCBs
2312	32	30	57	1.26	0.3	21.4	2.3
2314	12	12	14	0.24	nd	2.3	nd
2317	24	23	0	0.08	nd	nd	nd
2318	14	12	12	0.23	0.5	3.6	3.7
2319	10	12	64	0.99	2.9	37.4	32.0
2320	6	7	5	0.15	1.0	2.2	4.6
2321	12	12	26	0.41	1.0	12.7	6.9
2322	17	na	na	na	na	na	na
2323	9	nc	nc	nc	nc	nc	nc
2324	10	na	na	na	na	na	na
2325	13	13	16	0.14	nd	0.8	0.2
2326	7	8	17	0.08	0.2	1.6	0.6
2327	8	nc	nc	nc	nc	nc	nc
2328	16	15	40	0.37	0.4	3.0	nd
2329	12	11	0	0.18	nd	0.8	nd
2330	13	12	35	0.38	0.4	4.4	0.9
2331	16	16	93	0.92	1.9	12.7	nd
2332	7	nc	nc	nc	nc	nc	nc
2333	10	na	na	na	na	na	na
2334	12	nc	nc	nc	nc	nc	nc
2335	17	18	17	0.16	nd	0.8	nd
2338	17	19	23	0.31	nd	2.6	nd
2339	15	15	73	0.73	1.3	4.8	1.0
2340	20	20	13	0.20	nd	2.4	0.2
2341	32	30	26	0.29	nd	7.2	nd
2342	51	53	38	0.55	nd	6.8	0.3
2343	24	21	6	0.15	nd	1.6	nd
2344	47	45	35	0.71	nd	20.1	3.3
2345	41	42	71	0.82	nd	6.2	nd
2346	68	69	73	0.83	nd	9.7	1.6
2347	34	34	59	0.48	nd	8.1	0.2
2348	61	61	74	1.01	nd	11.2	0.9
2349	32	32	na	0.17	nd	nd	nd
2350	64	61	29	0.41	nd	nd	nd
2351	52	50	22	1.27	nd	nd	nd
2352	31	31	0	0.10	nd	nd	nd
2353	59	59	0	0.10	nd	nd	nd
2354	17	17	17	0.34	nd	nd	nd
2355	24	16	11	0.25	nd	0.5	nd
2356	45	44	30	0.74	nd	6.2	nd
2357	57	57	73	1.82	nd	18.6	nd
2358	73	75	42	1.13	nd	10.0	nd
2359	27	26	20	0.66	0.7	9.7	2.2
2360	45	46	47	2.82	nd	68.0	nd
2361	13	13	13	0.19	nd	1.0	nd
2362	55	55	71	1.41	0.4	19.6	5.9

Appendix A3 (continued)

Station	Depth(m) Mean Trawl	Depth(m) Grab Sample	% Fines in Sediment	TOC (%)	Sediment Concentration (ng/g)[a] Total Chlordanes	Total DDTs	Total PCBs
2364	61	53	21	0.32	nd	3.9	0.7
2365	46	45	56	0.75	0.2	8.3	1.3
2367	58	61	98	1.52	nd	13.1	nd
2368	47	45	99	1.39	nd	4.5	nd
2369	34	33	96	1.21	nd	4.4	nd
2370	9	11	21	0.28	nd	43.3	1.3
2371	77	76	95	1.58	nd	16.8	nd
2372	110	107	39	0.63	nd	2.8	nd
2373	28	28	71	0.54	nd	3.9	0.2
2374	101	98	74	1.42	1.2	11.2	0.9
2375	26	27	58	0.45	nd	7.3	nd
2376	26	26	49	0.36	nd	6.2	1.1
2377	20	19	11	0.18	nd	3.0	0.2
2378	24	27	14	0.23	nd	4.9	nd
2379	20	18	3	0.18	nd	1.2	nd
2380	23	20	28	0.64	nd	15.7	27.1
2381	42	42	56	0.94	nd	37.8	8.9
2382	23	23	43	0.71	nd	15.8	2.3
2383	11	10	19	0.31	nd	1.9	2.7
2384	47	47	48	0.77	nd	85.7	47.3
2385	25	24	5	0.15	nd	2.5	0.2
2386	16	16	5	0.16	nd	3.7	nd
2387	75	75	42	0.88	nd	224.0	36.2
2391	19	19	50	0.75	nd	27.9	nd
2392	20	21	18	0.26	nd	13.8	nd
2393	18	17	0	0.07	nd	1.0	nd
2394	43	42	14	0.53	nd	37.6	nd
2396	31	31	15	0.32	nd	13.5	nd
2397	30	30	23	0.56	nd	89.9	15.7
2398	43	41	13	0.26	nd	17.6	nd
2399	12	12	12	0.14	nd	0.5	nd
2400	52	52	22	0.29	nd	6.5	3.2
2401	46	41	42	0.53	0.2	8.2	5.2
2402	29	30	46	1.19	0.4	5.8	1.3
2403	92	90	74	0.86	0.3	11.2	2.5
2404	22	20	36	0.27	nd	0.8	nd
2405	59	58	63	0.78	nd	6.1	0.3
2406	11	11	28	0.23	nd	0.9	nd
2407	59	58	56	0.69	nd	5.4	1.1
2408	82	83	58	0.66	nd	3.3	nd
2411	88	89	53	0.68	nd	nd	nd
2412	61	62	48	0.67	nd	nd	nd
2413	47	49	29	0.48	nd	nd	nd
2414	8	9	0	0.15	nd	nd	nd
2415	14	14	8	0.10	nd	nd	nd
2416	7	nc	nc	nc	nc	nc	nc

Appendix A3 (continued)

	Depth(m)				Sediment Concentration (ng/g)[a]		
Station	Mean Trawl	Grab Sample	% Fines in Sediment	TOC (%)	Total Chlordanes	Total DDTs	Total PCBs
2417	24	24	0	0.23	nd	nd	nd
2418	99	100	24	0.48	nd	nd	nd
2419	56	56	11	0.39	nd	1.1	nd
2420	14	nc	nc	nc	nc	nc	nc
2426	12	11	38	0.46	nd	15.5	7.3
2427	10	9	89	1.47	nd	106.5	23.1
2430	18	18	83	1.56	1.3	89.2	92.3
2435	14	12	49	0.55	nd	nd	nd
2436	10	11	53	1.36	nd	nd	nd
2443	3	3	79	1.66	7.1	59.9	177.3
2444	3	3	86	1.59	nd	14.2	20.1
2446	3	3	55	1.07	4.8	41.1	63.4
2447	5	3	75	1.42	4.7	35.7	52.1
2448	5	5	55	1.37	6.8	22.8	41.5
2449	4	4	57	2.31	20.5	37.6	82.2
2450	6	4	68	3.44	21.4	43.5	58.1
2451	10	12	61	0.97	8.3	20.1	52.6
2452	5	nc	nc	nc	nc	nc	nc
2453	10	11	29	0.12	nd	1.2	0.2
2461	188	nc	nc	nc	nc	nc	nc
2467	28	19	0	na	na	na	na
2472	25	25	10	na	na	na	na
2475	24	24	0	na	na	na	na
2480	107	106	16	na	na	na	na
2483	85	81	44	na	na	na	na
2487	63	67	3	na	na	na	na
2490	79	74	0	na	na	na	na
2491	94	94	16	na	na	na	na
2492	72	71	24	na	na	na	na
2493	44	41	0	na	na	na	na
2494	164	nc	nc	nc	nc	nc	nc
2497	162	nc	nc	nc	nc	nc	nc
2499	184	nc	nc	nc	nc	nc	nc
2501	189	nc	nc	nc	nc	nc	nc
2502	129	nc	nc	nc	nc	nc	nc
2512	88	89	7	na	na	na	na
2515	101	102	20	na	na	na	na
2516	90	88	22	na	na	na	na
2517	60	na	na	na	na	na	na
2518	127	110	13	na	na	na	na
2519	67	64	19	na	na	na	na
2520	85	84	19	na	na	na	na
2522	82	86	10	na	na	na	na
2523	105	103	9	na	na	na	na
2525	175	nc	nc	nc	nc	nc	nc
2526	109	nc	nc	nc	nc	nc	nc

Appendix A3 (continued)

Station	Depth(m) Mean Trawl	Depth(m) Grab Sample	% Fines in Sediment	TOC (%)	Sediment Concentration (ng/g)[a] Total Chlordanes	Total DDTs	Total PCBs
2528	160	nc	nc	nc	nc	nc	nc
2531	187	nc	nc	nc	nc	nc	nc
2534	147	nc	nc	nc	nc	nc	nc
2537	191	nc	nc	nc	nc	nc	nc
2538	117	nc	nc	nc	nc	nc	nc
2554	54	nc	nc	nc	nc	nc	nc
2555	54	nc	nc	nc	nc	nc	nc
2556	76	nc	nc	nc	nc	nc	nc
2557	5	nc	nc	nc	nc	nc	nc
2558	5	nc	nc	nc	nc	nc	nc
2559	12	nc	nc	nc	nc	nc	nc
2560	16	nc	nc	nc	nc	nc	nc
2565	16	nc	nc	nc	nc	nc	nc
2566	25	nc	nc	nc	nc	nc	nc
2571	15	nc	nc	nc	nc	nc	nc
2573	15	nc	nc	nc	nc	nc	nc
2580	7	nc	nc	nc	nc	nc	nc
2585	6	nc	nc	nc	nc	nc	nc
2586	7	nc	nc	nc	nc	nc	nc
2590	7	nc	nc	nc	nc	nc	nc
2591	6	nc	nc	nc	nc	nc	nc
2592	4	nc	nc	nc	nc	nc	nc
2593	6	nc	nc	nc	nc	nc	nc
2594	2	nc	nc	nc	nc	nc	nc
2596	3	nc	nc	nc	nc	nc	nc
2597	17	nc	nc	nc	nc	nc	nc
2599	16	nc	nc	nc	nc	nc	nc
2600	21	nc	nc	nc	nc	nc	nc
2601	19	nc	nc	nc	nc	nc	nc
2602	10	nc	nc	nc	nc	nc	nc
2604	15	nc	nc	nc	nc	nc	nc
2605	26	nc	nc	nc	nc	nc	nc
2606	19	nc	nc	nc	nc	nc	nc
2607	22	nc	nc	nc	nc	nc	nc
2608	125	nc	nc	nc	nc	nc	nc
2609	155	nc	nc	nc	nc	nc	nc
2610	182	nc	nc	nc	nc	nc	nc
2611	58	nc	nc	nc	nc	nc	nc
2612	55	nc	nc	nc	nc	nc	nc

[a]Measurement values are rounded. See Southern California Bight 1998 Regional Survey database for unrounded values.

TOC = Total organic carbon; nc = Not collected; na = Sample collected but not analyzed; nd = Not detected; Detection limits varied by individual analyte, laboratory, and sample, and therefore are not reported here. See text for a discussion of detection limits and how nondetectable concentrations were treated for specific analyses.

Appendix A4. Comparison of abundance and species richness differences between 5- and 10-min trawls in Marina del Rey (MDR) and Los Angeles Harbor (LAH), CA, 1996-1999. 5-min=first duplicate 5-min trawl; 10 min = combined first and second duplicate 5 min trawls, Southern California Bight 1998 Regional Survey, July-September 1998.

		Fish						Invertebrates					
	Trawl	No. Individuals			No. Species			No. Individuals			No. Species		
Site	No.	5 min	10 min	Ratio	5 min	10 min	Ratio	5 min	10 min	Ratio	5 min	10 min	Ratio
MDR	1	8	36	4.50	5	8	1.60	6	23	3.83	3	5	1.67
MDR	2	15	37	2.47	7	8	1.14	11	16	1.45	4	6	1.50
MDR	3	38	71	1.87	8	10	1.25	5	9	1.80	2	4	2.00
MDR	4	7	13	1.86	3	5	1.67	25	38	1.52	11	14	1.27
MDR	5	39	55	1.41	7	9	1.29	9	34	3.78	1	1	1.00
MDR	6	62	69	1.11	5	6	1.20	5	5	1.00	2	2	1.00
MDR	7	43	147	3.42	8	14	1.75	34	45	1.32	7	11	1.57
MDR	8	10	20	2.00	5	6	1.20	6	19	3.17	3	5	1.67
MDR	9	11	20	1.82	4	8	2.00	4	12	3.00	1	3	3.00
MDR	10	7	15	2.14	6	11	1.83	2	8	4.00	2	7	3.50
MDR	11	0	4	---	0	3	---	1	1	1.00	1	1	1.00
MDR	12	14	54	3.86	5	7	1.40	0	0	---	0	0	---
MDR	13	51	62	1.22	11	11	1.00	0	0	---	0	0	---
MDR	14	32	40	1.25	4	5	1.25	0	0	---	0	0	---
MDR	15	6	18	3.00	5	8	1.60	3	10	3.33	3	7	2.33
MDR	16	8	18	2.25	4	7	1.75	0	1	---	0	1	---
MDR	17	37	70	1.89	5	6	1.20	0	0	---	0	0	---
MDR	18	12	25	2.08	5	6	1.20	4	11	2.75	3	6	2.00
MDR	19	55	73	1.33	5	6	1.20	5	5	1.00	5	5	1.00
MDR	20	41	59	1.44	3	6	2.00	6	12	2.00	2	5	2.50
LAH	1	392	991	2.53	5	7	1.40	25	47	1.88	3	7	2.33
LAH	2	251	1096	4.37	10	12	1.20	3	6	2.00	2	4	2.00
LAH	3	18	33	1.83	4	5	1.25	20	50	2.50	5	7	1.40
LAH	4	13	23	1.77	3	7	2.33	6	7	1.17	3	3	1.00
LAH	5	348	475	1.36	7	8	1.14	8	9	1.13	3	3	1.00
LAH	6	368	395	1.07	11	11	1.00	16	18	1.13	4	5	1.25
LAH	7	5	24	4.80	4	6	1.50	23	58	2.52	4	8	2.00
LAH	8	28	58	2.07	7	10	1.43	29	63	2.17	5	8	1.60
LAH	9	26	77	2.96	5	10	2.00	7	19	2.71	5	7	1.40
LAH	10	101	232	2.30	11	12	1.09	3	18	6.00	3	4	1.33
LAH	11	27	48	1.78	6	8	1.33	20	33	1.65	1	4	4.00
LAH	12	599	991	1.65	6	7	1.17	22	47	2.14	6	7	1.17
LAH	13	845	1096	1.30	8	12	1.50	3	6	2.00	2	4	2.00
LAH	14	15	33	2.20	5	5	1.00	30	50	1.67	6	7	1.17
LAH	15	10	23	2.30	6	7	1.17	1	7	7.00	1	3	3.00
LAH	16	127	475	3.74	6	8	1.33	1	9	9.00	1	3	3.00
LAH	17	27	395	14.63	5	11	2.20	2	18	9.00	2	5	2.50
LAH	18	19	24	1.26	5	6	1.20	35	58	1.66	6	8	1.33
LAH	19	30	58	1.93	8	10	1.25	34	63	1.85	8	8	1.00
LAH	20	51	77	1.51	9	10	1.11	12	19	1.58	4	7	1.75
LAH	21	131	232	1.77	8	12	1.50	15	18	1.20	3	4	1.33
LAH	22	21	48	2.29	6	8	1.33	13	33	2.54	3	4	1.33
Mean		94	186	2.50	6	8	1.41	11	22	2.69	3	4.80	1.78
S.D.		174	307	2.16	2	3	0.34	11	20	2.01	2	3.00	0.76
C.V. (%)		185	165	86.00	39	31	24.00	101	90	75.00	76	62.00	43.00

Appendix A5. Fish Response Index (FRI) pollution gradient position (p_i) values by shelf zone for fish species collected at depths of 2-202 m Southern California Bight 1998 Regional Survey, July-September 1998. (from Allen *et al*. 2001a).

	p_i by shelf zone*		
Species Name**	9-40 m	30-120 m	100-215 m
Anoplopoma fimbria	-	56.97	93.25
Argentina sialis	-	-4.50	-22.52
Brosmophycis marginata	-	22.04	-
Cephaloscyllium ventriosum	-	10.20	-
Chilara taylori	181.26	-13.10	-2.46
Chitonotus pugetensis	25.10	12.38	-
Citharichthys fragilis	-	6.06	11.83
Citharichthys sordidus	59.29	19.29	-21.71
Citharichthys stigmaeus	24.83	29.81	-
Citharichthys xanthostigma	10.71	-13.87	17.41
Coryphopterus nicholsii	-	-18.40	-
Cymatogaster aggregata	169.84	160.68	-
Engraulis mordax	15.87	63.14	-29.61
Eopsetta jordani	-	1.51	-4.18
Genyonemus lineatus	58.20	54.39	42.07
Glyptocephalus zachirus	-	17.88	71.27
Hippoglossina stomata	24.50	17.31	30.56
Hydrolagus colliei	-	66.81	98.73
Icelinus filamentosus	-	-	-25.00
Icelinus quadriseriatus	17.59	1.66	34.29
Icelinus tenuis	-	-7.92	-66.58
Kathetostoma averruncus	-	120.76	55.12
Lepidogobius lepidus	41.35	1.79	-10.43
Lycodes cortezianus	-	-	87.00
Lycodes pacificus	-	21.66	43.34
Lyconema barbatum	-	-	27.98
Lyopsetta exilis	-	16.83	32.28
Merluccius productus	-	-18.77	13.51
Microstomus pacificus	102.34	70.58	87.20
Odontopyxis trispinosa	-	18.96	-
Ophiodon elongatus	-	2.53	29.16
Paralabrax nebulifer	10.60	9.08	-
Paralichthys californicus	11.63	20.87	-
Parophrys vetulus	49.63	48.13	-10.29
Peprilus simillimus	-	17.42	-
Phanerodon furcatus	72.37	-	-
Physiculus rastrelliger	-	-	105.45
Platyrhinoidis triseriata	-3.03	2.08	-
Plectobranchus evides	-	-	39.28
Pleuronichthys coenosus	121.93	-	-
Pleuronichthys decurrens	92.94	71.21	-
Pleuronichthys ritteri	13.12	78.46	-
Pleuronichthys verticalis	21.12	16.29	-2.34
Porichthys myriaster	10.47	33.91	-
Porichthys notatus	17.89	21.54	22.10

Appendix A5 (continued)

	p_i by shelf zone*		
Species Name**	9-40 m	30-120 m	100-215 m
Raja binoculata	22.20	31.61	-
Raja inornata	11.13	20.13	-13.32
Rathbunella hypoplecta	-	-8.02	-
Rhacochilus vacca	137.71	-	-
Sardinops sagax	-	-	-33.01
Scorpaena guttata	26.07	86.99	7.59
Sebastes auriculatus	18.99	29.71	-
Sebastes caurinus	11.59	18.43	-
Sebastes chlorostictus	-	-25.76	-0.12
Sebastes crameri	-	196.71	78.14
Sebastes dallii	11.59	50.23	45.40
Sebastes diploproa	-	-11.77	68.00
Sebastes elongatus	-	-10.16	36.56
Sebastes eos	-	-21.72	4.83
Sebastes goodei	169.84	108.27	
Sebastes hopkinsi	-	86.25	87.58
Sebastes jordani	-	191.72	86.45
Sebastes levis	-	44.31	57.83
Sebastes macdonaldi	-	-	105.48
Sebastes miniatus	90.18	46.66	-
Sebastes mystinus	-	81.93	-
Sebastes paucispinis	-	20.73	86.21
Sebastes pinniger	-	-10.38	-
Sebastes rosaceus	-	13.66	-
Sebastes rosenblatti	-	18.24	36.41
Sebastes rubrivinctus	-	9.89	-
Sebastes saxicola	65.88	44.38	49.19
Sebastes semicinctus	-	9.86	-19.36
Sebastes serranoides	-	85.11	-
Sebastolobus alascanus	-	33.38	53.18
Seriphus politus	35.83	-	-
Symphurus atricaudus	37.14	3.33	35.62
Synodus lucioceps	16.23	27.24	-5.21
Torpedo californica	-	118.08	-
Xeneretmus latifrons	-	10.05	22.27
Xeneretmus triacanthus	-	6.39	-7.08
Xystreurys liolepis	13.55	32.12	-
Zalembius rosaceus	49.94	28.92	-19.96
Zaniolepis frenata	-	10.27	16.19
Zaniolepis latipinnis	21.71	30.19	-11.28

*Range of depth categories are those of Allen *et al*. 2001a.
**See Glossary G2 for common names of fish species.

Appendix A6. Invertebrate Response Index (IRI) pollution gradient position (p_i) values for invertebrate species collected at depths of 2-202 m Southern California Bight 1998 Regional Survey, July-September 199. (from Allen *et al*. 2001a).

Species*	p_i	Species*	p_i
Acanthodoris brunnea	41.4	*Euvola diegensis*	28.2
Adelogorgia phyllosclera	25.3	*Flabellina iodinea*	31.0
Allocentrotus fragilis	29.3	*Florometra serratissima*	13.6
Amphichondrius granulatus	25.5	*Fusinus barbarensis*	15.0
Amphiodia urtica	27.9	*Gastropteron pacificum*	52.8
Amphiura arcystata	23.0	*Gorgonocephalus eucnemis*	14.3
Antiplanes catalinae	33.9	*Hamatoscapellum californicum*	31.4
Aphrodita japonica	31.3	*Havelockia benti*	29.6
Armina californica	35.8	*Hemisquilla ensigera californiensis*	22.3
Asterina miniata	49.8	*Henricia leviuscula*	15.8
Astropecten armatus	41.9	*Heptacarpus stimpsoni*	40.9
Astropecten ornatissimus	22.6	*Heptacarpus tenuissimus*	59.6
Astropecten verrilli	31.0	*Heptacarpus tenuissiumus*	22.8
Babelomurex oldroydi	23.3	*Heterocrypta occidentalis*	32.0
Balanus nubilus	16.9	*Heterogorgia tortuosa*	25.5
Balanus pacificus	34.1	*Isocheles pilosus*	28.8
Brisaster latifrons	28.1	*Kelletia kelletii*	29.2
Brissopsis pacifica	29.2	*Lamellaria diegoensis*	33.3
Calinaticina oldroydii	54.8	*Laqueus californianus*	8.1
Calliostoma tricolor	30.8	*Leptasterias hexactis*	17.9
Calliostoma turbinum	29.0	*Leptopecten latiauratus*	32.0
Cancellaria cooperii	26.4	*Leucilla nuttingi*	25.7
Cancellaria crawfordiana	35.9	*Livoneca californica*	25.1
Cancer antennarius	61.3	*Livoneca vulgaris*	38.5
Cancer anthonyi	64.1	*Loligo opalescens*	34.5
Cancer gracilis	45.4	*Lophogorgia chilensis*	39.0
Cancer jordani	41.0	*Lopholithodes foraminatus*	40.5
Cancer productus	61.5	*Lophopanopeus bellus*	47.8
Chlamys hastate	26.0	*Lovenia cordiformis*	29.6
Cidarina cidaris	8.1	*Loxorhynchus crispatus*	25.0
Ciona intestinalis	32.2	*Loxorhynchus grandis*	32.3
Conus californicus		*Luidia armata*	29.1
Corynactis californica	38.9	*Luidia asthenosoma*	26.8
Crangon alaskensis	42.2	*Luidia foliolata*	29.0
Crangon nigromaculata	54.4	*Lysmata californica*	47.5
Crepidula onyx	78.0	*Lytechinus pictus*	24.5
Crossata californica	23.7	*Mediaster aequalis*	26.2
Diaulula sandiegensis	30.2	*Megasurcula carpenteriana*	28.9
Doriopsilla albopunctata	29.3	*Metacrangon spinosissima*	30.0
Dromalia alexandri	37.4	*Metridium farcimen*	29.2
Erileptus spinosus	34.5	*Muricea californica*	77.0
Eualus herdmani	19.4	*Nassarius insculptus*	63.3
Eugorgia rubens	28.4	*Nassarius mendicus*	73.1
Eugyra arenosa californica	34.2	*Nassarius perpinguis*	39.3
Euspira draconis	59.0	*Neocrangon communis*	35.4

Appendix A6 (continued)

Species*	p_i	Species*	p_i
Neocrangon resima	33.0	*Platymera gaudichaudii*	57.0
Neocrangon zacae	33.6	*Pleurobranchaea californica*	41.5
Neosabellaria cementarium	27.8	*Pleuroncodes planipes*	54.0
Neosimnia aequalis	24.3	*Podochela hemphillii*	35.4
Neosimnia loebbeckeana	37.6	*Podochela lobifrons*	25.1
Neptunea tabulata	19.0	*Pododesmus macroschisma*	32.6
Nerocila acuminata	72.3	*Portunus xantusii*	64.8
Neverita reclusiana	40.8	*Protula superba*	20.2
Nymphon pixellae	31.6	*Pteropurpura macroptera*	12.4
Octopus californicus	29.3	*Pteropurpura vokesae*	58.2
Octopus rubescens	29.4	*Ptilosarcus gurneyi*	26.3
Octopus veligero	23.8	*Pycnopodia helianthoides*	39.9
Ophionereis eurybrachiplax	14.5	*Pyromaia tuberculata*	33.8
Ophiopholis bakeri	19.4	*Randallia ornata*	31.0
Ophiopteris papillosa	22.9	*Rathbunaster californicus*	31.6
Ophiothrix spiculata	28.9	*Renilla koellikeri*	28.3
Ophiura luetkenii	29.2	*Rossia pacifica*	35.4
Orthopagurus minimus	36.6	*Schmittius politus*	29.4
Paguristes bakeri	18.1	*Sclerasterias heteropaes*	14.1
Paguristes turgidus	23.9	*Sicyonia ingentis*	45.2
Paguristes ulreyi	32.3	*Spatangus californicus*	26.1
Pagurus spilocarpus	30.7	*Spirontocaris holmesi*	50.8
Pandalus danae	48.5	*Spirontocaris sica*	43.7
Pandalus jordani	44.7	*Strongylocentrotus franciscanus*	26.4
Pandalus platyceros	40.7	*Strongylocentrotus purpuratus*	31.9
Paracyathus stearnsii	21.3	*Styela gibbsii*	31.8
Paralithodes californiensis	25.9	*Stylasterias forreri*	24.4
Paralithodes rathbuni	34.8	*Stylatula elongata*	35.4
Parapagurodes laurentae	20.1	*Terebra pedroana*	24.1
Parapagurodes makarovi	20.6	*Terebratalia occidentalis*	13.5
Parastichopus californicus	31.7	*Triopha maculata*	29.9
Pegea confoederata	39.4	*Tritonia diomedea*	36.3
Philine alba	16.4	*Tritonia festiva*	33.5
Phimochirus californiensis	26.3	*Virgularia bromleyi*	28.0
Pisaster brevispinus	30.0	*Virgularia galapagensis*	30.2
Platydoris macfarlandi	21.2		

*See Glossary G4 for common name of invertebrate species.

Appendix A7. Trawl Response Index (TRI) pollution gradient position (p_i) values for fish (F) and invertebrate (I) species collected at depths of 2-202 Southern California Bight 1998 Regional Survey, July-September 1998 (from Allen *et al*. 2001a).

Species*	Type	p_i	Species*	Type	p_i
Acanthodoris brunnea	I	60.646	*Crepidula onyx*	I	188.002
Adelogorgia phyllosclera	I	4.804	*Crossata californica*	I	-0.670
Allocentrotus fragilis	I	18.526	*Cymatogaster aggregata*	F	167.488
Amphichondrius granulatus	I	5.633	*Diaulula sandiegensis*	I	21.961
Amphiodia urtica	I	13.861	*Doriopsilla albopunctata*	I	18.720
Amphiura arcystata	I	-3.081	*Dromalia alexandri*	I	46.883
Anoplopoma fimbria	F	159.400	*Engraulis mordax*	F	36.593
Antiplanes catalinae	I	34.540	*Eopsetta jordani*	F	2.931
Aphrodita japonica	I	25.550	*Erileptus spinosus*	I	36.882
Argentina sialis	F	20.631	*Eualus herdmani*	I	-15.865
Armina californica	I	41.228	*Eugorgia rubens*	I	15.644
Asterina miniata	I	89.938	*Eugyra arenosa californica*	I	35.860
Astropecten armatus	I	62.340	*Euspira draconis*	I	121.873
Astropecten ornatissimus	I	-4.744	*Euvola diegensis*	I	14.765
Astropecten verrilli	I	24.514	*Flabellina iodinea*	I	24.435
Babelomurex oldroydi	I	-2.246	*Florometra serratissima*	I	-35.876
Balanus nubilus	I	-24.352	*Fusinus barbarensis*	I	-31.127
Balanus pacificus	I	35.450	*Gastropteron pacificum*	I	100.480
Brisaster latifrons	I	14.644	*Genyonemus lineatus*	F	89.954
Brissopsis pacifica	I	18.260	*Glyptocephalus zachirus*	F	40.469
Brosmophycis marginata	F	-30.970	*Gorgonocephalus eucnemis*	I	-33.610
Calinaticina oldroydii	I	107.449	*Hamatoscapellum*	I	25.909
Calliostoma tricolor	I	23.832	*Havelockia benti*	I	19.828
Calliostoma turbinum	I	17.567	*Hemisquilla ensigera*	I	-5.740
Cancellaria cooperii	I	8.546	*Henricia leviuscula*	I	-28.378
Cancellaria crawfordiana	I	41.567	*Heptacarpus stimpsoni*	I	59.135
Cancer antennarius	I	129.857	*Heptacarpus tenuissimus*	I	124.127
Cancer anthonyi	I	139.622	*Heptacarpus tenuissiumus*	I	-3.827
Cancer gracilis	I	74.773	*Heterocrypta occidentalis*	I	27.970
Cancer jordani	I	59.414	*Heterogorgia tortuosa*	I	5.444
Cancer productus	I	130.573	*Hippoglossina stomata*	F	38.155
Cephaloscyllium ventriosum	F	45.537	*Hydrolagus colliei*	F	95.329
Chilara taylori	F	41.257	*Icelinus filamentosus*	F	-9.071
Chitonotus pugetensis	F	28.501	*Icelinus quadriseriatus*	F	30.084
Chlamys hastata	I	7.169	*Icelinus tenuis*	F	-43.720
Cidarina cidaris	I	-54.841	*Isocheles pilosus*	I	16.937
Ciona intestinalis	I	28.755	*Kathetostoma averruncus*	F	109.628
Citharichthys fragilis	F	25.016	*Kelletia kelletii*	I	18.340
Citharichthys sordidus	F	15.572	*Lamellaria diegoensis*	I	32.409
Citharichthys stigmaeus	F	39.530	*Laqueus californianus*	I	-54.841
Citharichthys xanthostigma	F	18.036	*Lepidogobius lepidus*	F	30.453
Conus californicus	I	158.704	*Leptasterias hexactis*	I	-21.106
Corynactis californica	I	51.922	*Leptopecten latiauratus*	I	28.100
Coryphopterus nicholsii	F	9.332	*Leucilla nuttingi*	I	6.279
Crangon alaskensis	I	63.460	*Livoneca californica*	I	3.975
Crangon nigromaculata	I	106.013	*Livoneca vulgaris*	I	50.673

Appendix A7 (continued)

Species*	Type	p_i	Species*	Type	p_i
Loligo opalescens	I	36.872	*Paguristes turgidus*	I	-0.144
Lophogorgia chilensis	I	52.365	*Paguristes ulreyi*	I	28.975
Lopholithodes foraminatus	I	57.620	*Pagurus spilocarpus*	I	23.517
Lophopanopeus bellus	I	82.994	*Pandalus danae*	I	85.484
Lovenia cordiformis	I	19.716	*Pandalus jordani*	I	71.704
Loxorhynchus crispatus	I	3.567	*Paracyathus stearnsii*	I	-9.291
Loxorhynchus grandis	I	29.155	*Paralabrax nebulifer*	F	34.527
Luidia armata	I	18.119	*Paralichthys californicus*	F	28.520
Luidia asthenosoma	I	9.865	*Paralithodes californiensis*	I	6.684
Luidia foliolata	I	17.727	*Paralithodes rathbuni*	I	37.643
Lycodes cortezianus	F	84.649	*Parapagurodes laurentae*	I	-13.452
Lycodes pacificus	F	63.664	*Parapagurodes makarovi*	I	-11.475
Lyconema barbatum	F	14.323	*Parastichopus californicus*	I	27.046
Lyopsetta exilis	F	43.355	*Parophrys vetulus*	F	53.322
Lysmata californica	I	81.795	*Pegea confoederata*	I	53.662
Lytechinus pictus	I	1.899	*Peprilus simillimus*	F	44.712
Mediaster aequalis	I	8.010	*Phanerodon furcatus*	F	73.802
Megasurcula carpenteriana	I	17.407	*Philine alba*	I	-26.200
Merluccius productus	F	50.573	*Phimochirus californiensis*	I	8.231
Metacrangon spinosissima	I	21.250	*Physiculus rastrelliger*	F	120.653
Metridium farcimen	I	18.307	*Pisaster brevispinus*	I	20.987
Microstomus pacificus	F	64.816	*Platydoris macfarlandi*	I	-9.410
Muricea californica	I	184.340	*Platymera gaudichaudii*	I	114.797
Nassarius insculptus	I	136.721	*Platyrhinoidis triseriata*	F	36.896
Nassarius mendicus	I	170.833	*Plectobranchus evides*	F	33.573
Nassarius perpinguis	I	53.492	*Pleurobranchaea californica*	I	61.116
Neocrangon communis	I	40.032	*Pleuroncodes planipes*	I	104.407
Neocrangon resima	I	31.526	*Pleuronichthys coenosus*	F	188.566
Neocrangon zacae	I	33.594	*Pleuronichthys decurrens*	F	94.670
Neosabellaria cementarium	I	13.595	*Pleuronichthys ritteri*	F	27.466
Neosimnia aequalis	I	1.397	*Pleuronichthys verticalis*	F	28.779
Neosimnia loebbeckeana	I	47.346	*Podochela hemphillii*	I	39.864
Neptunea tabulata	I	-17.101	*Podochela lobifrons*	I	4.222
Nerocila acuminata	I	167.996	*Pododesmus macroschisma*	I	30.302
Neverita reclusiana	I	58.804	*Porichthys myriaster*	F	30.057
Nymphon pixellae	I	26.829	*Porichthys notatus*	F	34.852
Octopus californicus	I	18.608	*Portunus xantusii*	I	141.936
Octopus rubescens	I	19.108	*Protula superba*	I	-12.958
Octopus veligero	I	-0.322	*Pteropurpura macroptera*	I	-39.890
Odontopyxis trispinosa	F	28.141	*Pteropurpura vokesae*	I	119.071
Ophiodon elongatus	F	37.600	*Ptilosarcus gurneyi*	I	8.203
Ophionereis eurybrachiplax	I	-32.880	*Pycnopodia helianthoides*	I	55.537
Ophiopholis bakeri	I	-15.682	*Pyromaia tuberculata*	I	34.226
Ophiopteris papillosa	I	-3.624	*Raja binoculata*	F	28.502
Ophiothrix spiculata	I	17.373	*Raja inornata*	F	29.956
Ophiura luetkenii	I	18.309	*Randallia ornata*	I	24.487
Orthopagurus minimus	I	44.102	*Rathbunaster californicus*	I	26.499
Paguristes bakeri	I	-20.328	*Rathbunella hypoplecta*	F	-10.923

Appendix A7 (continued)

Species*	Type	p_i	Species*	Type	p_i
Renilla koellikeri	I	15.091	*Sebastes serranoides*	F	80.724
Rhacochilus vacca	F	141.968	*Sebastolobus alascanus*	F	46.807
Rossia pacifica	I	39.795	*Seriphus politus*	F	60.930
Sardinops sagax	F	-44.255	*Sicyonia ingentis*	I	73.770
Schmittius politus	I	19.098	*Spatangus californicus*	I	7.380
Scorpaena guttata	F	57.510	*Spirontocaris holmesi*	I	93.462
Sebastes auriculatus	F	44.405	*Spirontocaris sica*	I	68.888
Sebastes caurinus	F	38.225	*Strongylocentrotus*	I	8.745
Sebastes chlorostictus	F	23.681	*Strongylocentrotus purpuratus*	I	27.592
Sebastes constellatus	F	-2.538	*Styela gibbsii*	I	27.214
Sebastes crameri	F	149.249	*Stylasterias forreri*	I	1.754
Sebastes dallii	F	36.472	*Stylatula elongata*	I	39.864
Sebastes diploproa	F	79.982	*Symphurus atricaudus*	F	31.444
Sebastes elongatus	F	41.364	*Syngnathus exilis*	F	-13.962
Sebastes eos	F	9.445	*Synodus lucioceps*	F	36.372
Sebastes goodei	F	140.688	*Terebra pedroana*	I	0.596
Sebastes hopkinsi	F	92.953	*Terebratalia occidentalis*	I	-36.337
Sebastes jordani	F	119.310	*Torpedo californica*	F	120.945
Sebastes levis	F	71.981	*Triopha maculata*	I	20.691
Sebastes macdonaldi	F	155.200	*Tritonia diomedea*	I	42.840
Sebastes miniatus	F	68.806	*Tritonia festiva*	I	33.131
Sebastes mystinus	F	82.783	*Virgularia bromleyi*	I	14.115
Sebastes paucispinis	F	95.451	*Virgularia galapagensis*	I	21.797
Sebastes pinniger	F	-3.531	*Xeneretmus latifrons*	F	43.304
Sebastes rosaceus	F	12.277	*Xeneretmus triacanthus*	F	6.702
Sebastes rosenblatti	F	46.583	*Xystreurys liolepis*	F	39.518
Sebastes rubrivinctus	F	2.190	*Zalembius rosaceus*	F	36.948
Sebastes saxicola	F	66.083	*Zaniolepis frenata*	F	28.272
Sebastes semicinctus	F	28.185	*Zaniolepis latipinnis*	F	33.400

*See Glossary G2 for common names of fish species; see Glossary G4 for common names of invertebrate species.

APPENDIX B

APPENDIX B. QUALITY ASSURANCE

Appendix B1. Compliance with field manual guidelines by agency, Southern California Bight 1998 Regional Survey, July-September 1998.

Category	Guideline[a]	Agency A	B	C	D	E	F	G	H
Trawl Equipment									
Bridle length (m)	22.9	Yes	23.2	20.1	18.8	21.3	Yes	21.9	17.7
Otter board dimensions									
Width (cm)	51	53	53	53	54	53	53	41	52
Length (cm)	76	76	77	76	77	76	76	76	76
Headrope flotation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Footrope chain	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Net headrope length (m)	7.6	7.8		7.5	Yes	7.3	7.1	7.9	7.4
Net mesh size (side length)									
Body (cm)	4.1	Yes	ND	Yes	Yes	Yes	Yes	4.0	4.14
Cod-end liner (cm)	1.3	Yes	ND	Yes	Yes	Yes	Yes	1.0	Yes
Trawl Operations									
Proper deployment	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Proper wire scope	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bottom time (min)	10	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Qualified crew	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Proper trawl acceptance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trawl Processing Equipment									
Sorted buckets/trays	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Holding tanks (optional)	Yes	Yes	No	Yes	Yes	No	No	No	No
Measuring boards	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Data sheets									
Trawl cover sheet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fish species sheet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Size class sheets	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Invertebrate species sheet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Debris data sheets	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tare container	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spring scales (kg)									
Small (3 kg)	Yes	Yes	Yes	No	Yes	No	No	No	Yes
Large (15 kg)	Yes	Yes	Yes	Yes	No	No	No	No	No
Other	Yes	ND	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Field guides and aids									
Miller and Lea (1972)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Eschmeyer et al. (1983)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Field identification aid notebook	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Field identification tool kit	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wide-mouth jars	Yes	Yes	No	Yes	Yes	No	Yes	No	No
Plastic bags	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10% buffered formalin	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Spring Scale - Accuracy Check	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trawl Processing Procedures									
Proper trawl acceptance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Remove animals from net	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Appendix B1 (continued)

Category	Guideline[a]	Agency A	B	C	D	E	F	G	H
Species identifications									
Qualified crew	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Accuracy ID-common species	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Difficult species to lab	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Proper length measurements									
Proper size class designation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bony Fish (BSL)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sharks, rays, ratfishes (TL)	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stingrays (wingspan)	Yes	N/A	N/A	N/A	Yes	Yes	Yes	ND	N/A
Proper weight measurements									
Scale calibration	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tare bucket wt.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Proper weighing procedures									
Species > 0.1 kg	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Species < 0.1 kg	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Proper invertebrate counts made	Yes	Yes	ND	ND	Yes	ND	ND	ND	ND
Invertebrate counts from weights	Yes	N/A	Yes	Yes	Yes	ND	Yes	Yes	N/A
Pathology exam conducted	Yes	ND	ND	ND	Yes	ND	ND	ND	ND
Proper pathology identification	Yes	Yes	Yes	Yes	Yes	ND	Yes	Yes	Yes
Debris Assess. Conducted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Proper FID/QC preservation									
10% formalin	Yes	N/A	Yes	Yes	Yes	ND	Yes	Yes	Yes
Slitting gut cavity-fish	Yes	N/A	Yes	Yes	Yes	ND	Yes	Yes	Yes
Proper labeling	Yes	N/A	Yes	Yes	Yes	ND	Yes	Yes	Yes
Proper photo techniques	Yes	N/A	ND	ND	ND	Yes	Yes	ND	ND
Complete photo log	Yes	N/A	Yes	Yes	Yes	Yes	Yes	N/A	N/A
Tissue Sampling									
Proper choice of species	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Proper labeling	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Proper freezing tech.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Completion of data sheets									
Trawl cover sheet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fish species sheet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fish size class sheets	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Invertebrate species sheet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Debris data sheets	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[a]Condition or values recommended in B'98, FSLC (1998).

FID/QC = Further identification/quality control; BSL = Board standard length; ID = Identification; TL = Total length; WS = Wingspan; Yes = In compliance; No = Not in compliance; N/A = Not applicable; ND = No data record.

Appendix B2. Fish and invertebrate species that were misidentified at least once in presurvey, survey, or postsurvey audits for the Southern California Bight 1998 Regional Survey, July-September 1998.

Final Correct Identification		Initial Incorrect Identification		
Scientific Name	Common Name	Scientific Name	Common Name	QC Check
FISHES				
Agonopsis sterletus	southern spearnose poacher	*Odontopyxis trispinosa*	pygmy poacher	IS, FID
Anchoa delicatissima	slough anchovy	*Anchoa compressa*	deepbody anchovy	Voucher
Chilara taylori	spotted cusk-eel	*Lycodes pacificus*	blackbelly eelpout	Voucher
Citharichthys fragilis	gulf sanddab	*Citharichthys* sp	sanddab unid.	IS, FID
Citharichthys xanthostigma	longfin sanddab	*Citharichthys sordidus*	Pacific sanddab	IS, FID
Citharichthys xanthostigma	longfin sanddab	*Citharichthys* sp	sanddab unid.	IS, FID
Clupea pallasii (=*harengus*)	Pacific herring	*Clupea harengus*	Pacific herring	NOMEN
Embiotoca jacksoni	black perch	*Rhacochilus toxotes*	rubberlip seaperch	Voucher
Engraulis mordax	northern anchovy	*Anchoa delicatissima*	slough anchovy	Voucher
Engyophrys sanctilaurentii	speckletail flounder	*Lepidopsetta bilineata*	rock sole	IS, FID
Eopsetta jordani	petrale sole	*Paralichthys californicus*	California halibut	Voucher
Hippoglossina stomata	bigmouth sole	*Citharichthys stigmaeus*	speckled sanddab	Voucher
Hypsoblennius jenkinsi	mussel blenny	*Hypsoblennius gilberti*	rockpool blenny	Voucher
Icelinus cavifrons	pit-head sculpin	*Icelinus filamentosus*	threadfin sculpin	IS, FID
Icelinus tenuis	spotfin sculpin	*Chitonotus pugetensis*	roughback sculpin	Voucher
Ilypnus gilberti	cheekspot goby	*Llypnus gilberti*	cheekspot goby	NOMEN
Lepidogobius lepidus	bay goby	*Coryphopterus nicholsii*	blackeye goby	IS, FID
Leptocottus armatus	Pacific staghorn sculpin		Fish unid.	IS, FID
Lycodes cortezianus	bigfin eelpout	*Lycodes pacificus*	blackbelly eelpout	Voucher
Menticirrhus undulatus ??	California corbina??	*Cynoscion parvipinnis*	shortfin corvina	No Voucher
Oxylebius pictus	painted greenling	*Hexagrammos decagrammus*	kelp greenling	Voucher
Peprilus simillimus	Pacific pompano	*Brama japonica*	Pacific pomfret	IS, FID
Phanerodon atripes	sharpnose seaperch	*Phanerodon furcatus*	white seaperch	Voucher
Phanerodon furcatus	white seaperch	*Cymatogaster aggregata*	shiner perch	IS, FID
Porichthys myriaster	specklefin midshipman	*Porichthys notatus*	plainfin midshipman	Voucher
Raja stellulata	starry skate	*Raja inornata*	California skate	Voucher
Rathbunella hypoplecta	stripedfin ronquil	*Poroclinus rothrocki*	whitebarred prickleback	IS, FID
Sardinops sagax	Pacific sardine	*Clupea pallasii*	Pacific herring	Voucher
Sebastes atrovirens	kelp rockfish	*Sebastes maliger*	quillback rockfish	IS, FID
Sebastes caurinus	copper rockfish	*Sebastes auriculatus*	brown rockfish	IS, FID
Sebastes caurinus	copper rockfish	*Sebastes babcocki*	redbanded rockfish	IS, FID
Sebastes caurinus	copper rockfish	*Sebastes* sp	rockfish unid.	IS, FID
Sebastes chlorostictus	greenspotted rockfish	*Sebastes* (*Sebastomus*) sp	rockfish unid.	IS, FID
Sebastes chlorostictus	greenspotted rockfish	*Sebastes* sp	rockfish unid.	IS, FID
Sebastes constellatus	starry rockfish	*Sebastes* (*Sebastomus*) sp	rockfish unid.	IS, FID
Sebastes constellatus	starry rockfish	*Sebastes* sp	rockfish unid.	IS, FID
Sebastes dallii	calico rockfish	*Sebastes dalli*	calico rockfish	NOMEN
Sebastes elongatus	greenstriped rockfish	*Sebastes* sp	rockfish unid.	IS, FID
Sebastes ensifer	swordspine rockfish	*Sebastes chlorostictus*	greenspotted rockfish	Voucher
Sebastes ensifer	swordspine rockfish	*Sebastes rosenblatti*	greenblotched rockfish	Voucher
Sebastes eos	pink rockfish	*Sebastes* (*Sebastomus*) sp	rockfish unid.	IS, FID
Sebastes eos	pink rockfish	*Sebastes hopkinsi*	squarespot rockfish	Voucher
Sebastes eos	pink rockfish	*Sebastes rosaceus*	rosy rockfish	IS, FID
Sebastes eos	pink rockfish	*Sebastes rosenblatti*	greenblotched rockfish	Voucher
Sebastes eos	pink rockfish	*Sebastes* sp	rockfish unid.	IS, FID

Appendix B2 (continued)

Final Correct Identification		Initial Incorrect Identification		
Scientific Name	Common Name	Scientific Name	Common Name	QC Check
Sebastes lentiginosus	freckled rockfish	*Sebastes* sp	rockfish unid.	IS, FID
Sebastes lentiginosus	freckled rockfish	*Sebastes* (*Sebastomus*) sp	rockfish unid.	IS, FID
Sebastes macdonaldi	Mexican rockfish	*Sebastes* sp	rockfish unid.	IS, FID
Sebastes miniatus	vermilion rockfish	*Sebastes crameri*	darkblotched rockfish	IS, FID
Sebastes rosaceus	rosy rockfish	*Sebastes* (*Sebastomus*) sp	rockfish unid.	IS, FID
Sebastes rosaceus	rosy rockfish	*Sebastes* sp	rockfish unid.	IS, FID
Sebastes rosenblatti	greenblotched rockfish	*Sebastes* (*Sebastomus*) sp	rockfish unid.	IS, FID
Sebastes rosenblatti	greenblotched rockfish	*Sebastes* (*Sebastomus*) sp	rockfish unid.	IS, FID
Sebastes rosenblatti	greenblotched rockfish	*Sebastes* sp	rockfish unid.	IS, FID
Sebastes rosenblatti	greenblotched rockfish	*Sebastes* (*Sebastomus*) sp	rockfish unid.	IS, FID
Sebastes simulator	pinkrose rockfish	*Sebastes* (*Sebastomus*) sp	rockfish unid.	IS, FID
Symphurus atricaudus	California tonguefish	Cynoglossidae	tonguefish unid.	No Voucher
Synchiropus atrilabiatus	blacklip dragonet	*Gymnocanthus galeatus*	armorhead sculpin	Voucher
Syngnathus exilis	barcheek pipefish	*Syngnathus californiensis*	kelp pipefish	Voucher
Syngnathus exilis	barcheek pipefish	*Syngnathus euchrous*	chocolate pipefish	IS, FID
Syngnathus exilis	barcheek pipefish	*Syngnathus leptorhynchus*	bay pipefish	Voucher
Syngnathus exilis	barcheek pipefish	*Syngnathus* sp	pipefish unid	IS, FID
INVERTEBRATES				
Amphichondrius granulatus	roughdisk brittlestar	*Amphichondrius granulosus*	roughdisk brittlestar	Voucher
Amphiodia digitata	"brittlestar"	*Amphiodia* sp	"brittlestar"	IS, FID
Amphiodia digitata	"brittlestar"	*Amphiodia urtica*	red brittlestar	Voucher
Amphiodia digitata	"brittlestar"	Ophiuroidea	"brittlestar"	IS, FID
Aphrocallistes vastus	cloud sponge		Sponges	IS, FID
Aphrodita sp	"seamouse"	*Aphrodita japonica*	black seamouse	Voucher
Archidoris montereyensis	Monterey sea-lemon	*Doriopsilla albopunctata*	salted yellow doris	IS, FID
Argeia pugettensis	bay shrimp isopod		Bopyridae isopod parasit	IS, FID
Argopecten ventricosus	Pacific calico scallop	*Argopecton aequisulcatus*	Pacific calico scallop	NOMEN
Argopecten ventricosus	Pacific calico scallop		Scallop Unid.	IS, FID
Ascidia zara	"tunicate"	*Ascidia ceratodes*	horned tunicate	IS, FID
Ascidia zara	"tunicate"		Solitary tunicate sp.#4	IS, FID
Ascidiacea sp	"tunicate"		Colonial tunicate sp.#1	IS, FID
Ascidiacea sp	"tunicate"		Solitary tunicate sp.#2	IS, FID
Astropecten armatus	spiny sand star	*Astropecten verrilli*	California sand star	Voucher
Astropecten verrilli	California sand star	*Astropecten armatus*	spiny sand star	Voucher
Axinellidae	"sponge"	Demospongiae	"sponge"	IS, FID
Brisaster latifrons	northern heart urchin	*Brissopsis pacifica*	Pacific heart urchin	Voucher
Calinaticina oldroydii	delicate moonsnail	*Polinices lewisii*	Lewis moonsnail	Voucher
Caryophyllia alaskensis	"cup coral"	*Caryophyllia* sp	"cup coral"	IS, FID
Ceramaster sp	"cookie star"	*Ceramaster patagonicus*	cookie star	Voucher
Chaetopterus variopedatus cmplx	"parchment tube worm"	*Chaetopterus variopedatus*	parchment tube worm	NOMEN
Chama arcana	secret jewelbox	*Chama pellucida*	secret jewelbox	Voucher
Cidarina cidaris	spiny margarite	*Cidarina cidarus*	spiny margarite	NOMEN
Ciona sp	"sea squirt"	*Ascidia ceratodes*	horned tunicate	IS, FID
Ciona sp	"sea squirt"	Ascidiacea	"tunicate"	IS, FID
Ciona sp	"sea squirt"	*Euherdmania claviformis*	"sea squirt"	IS, FID
Ciona sp	"sea squirt"		Solitary tunicate sp.#1	IS, FID

Appendix B2 (continued)

Final Correct Identification		Initial Incorrect Identification		
Scientific Name	Common Name	Scientific Name	Common Name	QC Check
Cliona celata	boring sponge	Demospongiae	"sponge"	IS, FID
Cucumaria salma	salmon sea cucumber	*Corynactis californica*	strawberry corallimorpharian	Voucher
Crepidula sp	"slippersnail"	*Crepidula perforans*	white slippersnail	Voucher
Crepipatella dorsata	Pacific half-slippersnail	*Crepipatella lingulata*	Pacific half-slippersnail	NOMEN
Cucumaria sp	"nestling sea cucumber"	*Cucmaria salma*	salmon sea cucumber	Voucher
Demonax sp	"feather-duster worm"	Sabellidae	"feather-duster worm"	IS, FID
Dendronotus iris	giant frond-aeolis	*Dendronotus frondosus*	frond-aeolis	Voucher
Diaulula sandiegensis	ringed doris	Doridoidea	"nudibranch"	IS, FID
Elthusa (=*Livoneca*) *vulgaris*	Pacific fish louse	*Livoneca panamaensis*	Panama fish louse	Voucher
Eunice multipectinata	"tube worm"	Nereidae	"clam worm"	IS, FID
Flabellina pricei	smooth-tooth aeolis	*Coryphella pricei*	smooth-tooth aeolis	NOMEN
Florometra serratissima	feather star		Invertebrate Unid.	IS, FID
Gorgonocephalus eucnemis	basket star	*Gorgonacephalus eucnemis*	basket star	NOMEN
Halosydna johnsoni	"scaleworm"	Polynoidae	"scaleworm"	IS, FID
Halosydna johnsoni	"scaleworm"	Polynoidae	"scaleworm"	IS, FID
Halosydna johnsoni	"scaleworm"		Scaleworm UI	IS, FID
Haminoea vesicula	blister glassy-bubble	*Bulla gouldiana*	California bubble	IS, FID
Harmothoe imbricata	imbricated scaleworm	*Hesionura* sp	"phyllodocid polychaete"	IS, FID
Heptacarpus stimpsoni	Stimpson coastal shrimp	*Eualus* sp	"eualid shrimp"	IS, FID
Heptacarpus stimpsoni	Stimpson coastal shrimp	*Heptacarpus herdmani*	Herdman eualid	Voucher
Hyalinoecia juvenalis	"tube worm"	Onuphidae	"tube worm"	IS, FID
Iniconea sp. A	"terebellid polychaete"	*Streblosoma crassibranchia*	"terebellid polychaete"	IS, FID
Laqueus californiensis	California lamp shell	*Laques californianus*	California lamp shell	NOMEN
Loligo opalescens	California market squid	*Loligo pealeii*	longfin squid	Voucher
Lophopanopeus sp.	crestleg crab	*Lophopanopeus bellus*	blackleg crestleg crab	Voucher
Luidia foliolata	gray sand star	*Luidia* sp	"velvet sand star"	IS, FID
Lytechinus pictus	white sea urchin	*Lytechinus anamesus*	white sea urchin	NOMEN
Metridium farcimen (= *senile* cmplx)	gigantic anemone	*Metridium* sp	"plumose anemone"	NOMEN
Metridium farcimen (= *senile* cmplx)	gigantic anemone	*Metridium senile*	clonal plumose anemone	NOMEN
Microcosmus exasperatus	scaly tunicate	*Styela plicata*	cobblestone sea squirt	Voucher
Molgula verrucifera	warty tunicate		Solitary tunicate sp.#3	IS, FID
Molgula verrucifera	warty tunicate		Solitary tunicate sp.#5	IS, FID
Mytilus galloprovincialis	Mediterranean mussel	*Mytilus edulis*	blue mussel	Voucher
Mytilus sp	"mussel"	*Mytilus edulis*	blue mussel	Voucher
Nassarius fossatus	channeled nassa	*Nassarius* sp	"nassa"	IS, FID
Nassarius perpinguis	fat western nassa	*Nassarius* sp	"nassa"	IS, FID
Navanax inermis	California aglaja	*Aglaja ocelligera*	eyespot aglaja	IS, FID
Navanax inermis	California aglaja	*Navanax* sp	"aglaja"	IS, FID
Neosimnia barbarensis	seapen spindlesnail	*Neosimnia loebbeckeana*	Loebbeck spindlesnail	IS, FID
Octopus bimaculoides	California two-spot octopus	*Octopus bimaculatus*	California two-spot octopus	NOMEN
Octopus californicus	orange bigeye octopus	*Octopus rubescens*	red octopus	Voucher
Octopus rubescens	red octopus	Cephalopoda	"cephalopod"	IS, FID

Appendix B2 (continued)

Final Correct Identification		Initial Incorrect Identification		
Scientific Name	Common Name	Scientific Name	Common Name	QC Check
Octopus rubescens	red octopus	*Octopus* sp	"octopus"	IS, FID
Ophiacantha diplasia	"spinyarm brittlestar"	*Ophiacantha phragma*	fragile spinywarm brittlestar	Voucher
Ophiura luetkenii	brokenspine brittlestar	*Ophiura luetkeni*	brokenspine brittlestar	NOMEN
Pachycheles sp	porcelain crab	*Pachycheles pubescens*	pubescent porcelain crab	Voucher
Paguristes bakeri	digger hermit	*Paguristes* sp	"left-handed hermit"	IS, FID
Paguristes ulreyi	furryhermit	*Paguristes turgidus*	slenderclaw hermit	Voucher
Pagurus sp	"right-handed hermit"	Paguridae	"right-handed hermit"	IS, FID
Pagurus spilocarpus	spotwrist hermit		Hermit crab	IS, FID
Pagurus spilocarpus	spotwrist hermit	*Pagurus* sp	"right-handed hermit"	IS, FID
Panulirus interruptus	California spiny lobster		Spiny lobster	NOMEN
Panulirus interruptus	California spiny lobster		Voucher	IS, FID
Paralithodes californiensis	Calfiornia king crab	*Paralithodes rathbuni*	forknose king crab	IS, FID
Paramaga scutata	"ampharetid polychaete"	Polychaeta	"polychaete"	IS, FID
Pentamera pseudocalcigera	globose hooked cucumber	*Cucumaria* sp	"nestling sea cucumber"	IS, FID
Phidiana hiltoni	Hilton aeolid	*Phidiana pugnax*	Hilton aeolid	NOMEN
Philine auriformis	New Zealand paperbubble	*Philine* sp	"paperbubble"	IS, FID
Phyllodoce longipes	"phyllodocid polychaete"	*Nereiphylla castanea*	"phyllodocid polychaete"	IS, FID
Pista alata	"terebellid polychaete"	*Streblosoma crassibranchia*	"terebellid polychaete"	IS, FID
Podochela sp	"neck crab"	*Podochela hemphillii*	Hemphill neck crab	Voucher
Poecillastra tenuilaminaris	plate sponge		Sponges	IS, FID
Porifera unid.	"sponge"		Sponge Unid.	NOMEN, FID
Porifera unid.	"sponge"		Sponges	IS, FID
Protothaca tenerrima	thin-shell littleneck	*Chione undatella*	frilled venus	Voucher
Protula superba	chalktube worm	Nereidae	"clam worm"	IS, FID
Pseudocnus lubricus	"nestling sea cucumber"	*Pentamera* sp	"hooked sea cucumber"	IS, FID
Psolus sp	"psolid sea cucumber"	Holothuroidea	"sea cucumber"	IS, FID
Pteropurpura macroptera	frill-wing murex	*Pteropurpura vokesae*	wrinkle-wing murex	Voucher
Randallia ornata	globose sand crab	*Randilia ornata*	globose sand crab	NOMEN
Rhabdocalyptus dawsoni	"glass sponge"		Sponge Unid.	IS, FID
Schmittius politus	polished mantis shrimp	Stomatopoda	"mantis shrimp"	IS, FID
Sicyonia penicillata	peanut rock shrimp	*Sicyonia disedwardsi*	target shrimp	Voucher
Solenocera mutator	blossom shrimp	*Bentheogennema burkenroadi*	Burkenroad blunt-tail shrimp	Voucher
Sphinctrella sp A	"sponge"		Sponges	IS, FID
Spirontocaris holmesi	slender blade shrimp	*Spirontocaris sica*	offshore blade shrimp	Voucher
Staurocalyptus solidus	"glass sponge"		Sponge UI	IS, FID
Strongylocentrotus franciscanus	red sea urchin		Black urchin	NOMEN
Strongylocentrotus purpuratus	Pacific purple urchin		Purple urchin	NOMEN
Suberites suberea	hermitcrab sponge	*Suberites subea*	hermitcrab sponge	NOMEN
Tethya aurantium	orange puffball sponge	Porifera unid.	"sponge"	IS, FID
Thesea sp.	"sea twig"	*Thesea* sp. B	yellow sea twig	IS, FID
Thysanoessa spinifera	spiny euphausiid	Sergestidae? sp.F	"sergestid shrimp"	IS, FID

Appendix B2 (continued)

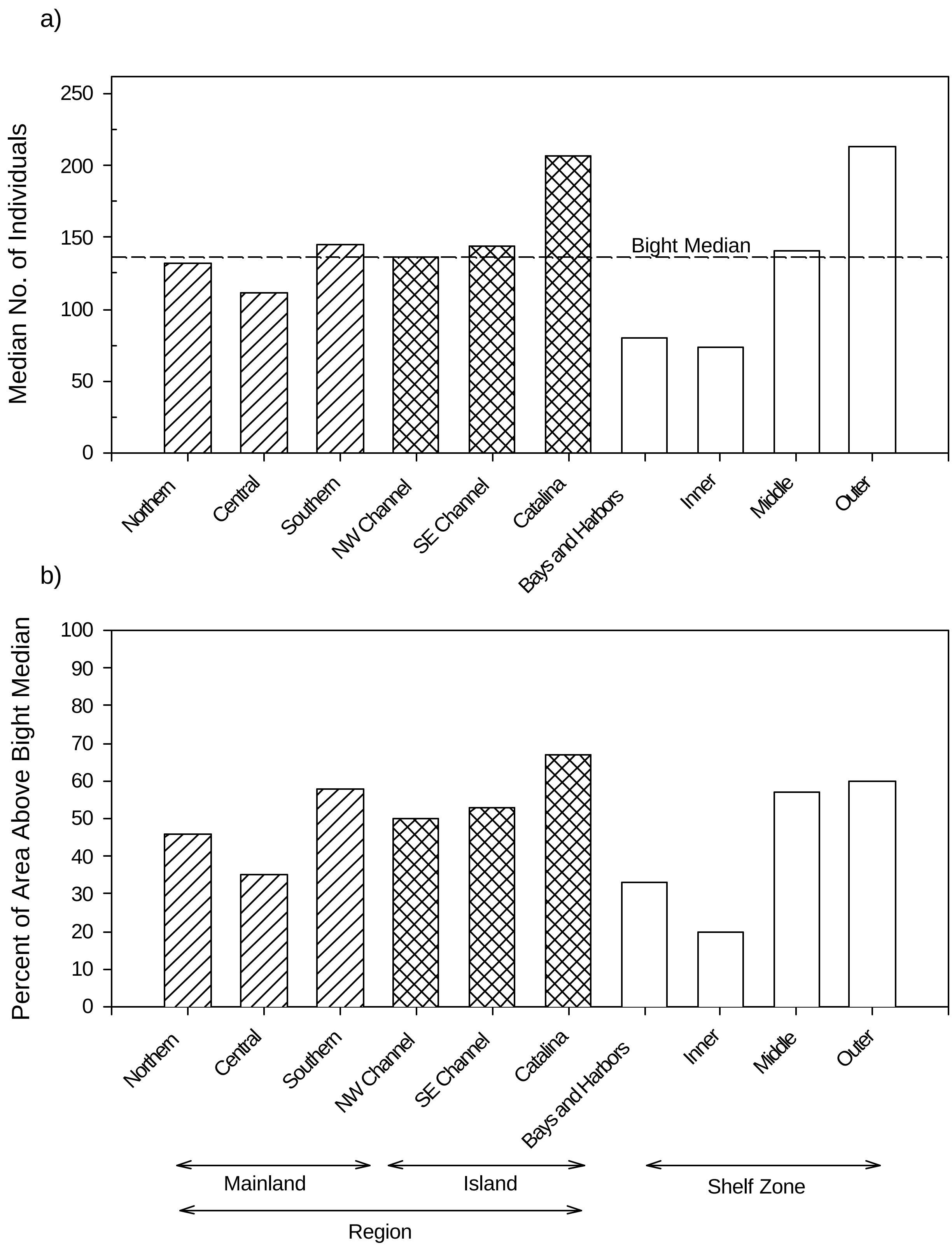
Final Correct Identification		Initial Incorrect Identification		
Scientific Name	Common Name	Scientific Name	Common Name	QC Check
Tochuina tetraquetra	giant orange tochui	Nudibranchia	"nudibranch"	IS, FID
Trachycardium quadragenarium	spiny pricklecockle	*Clinocardium nuttallii*	Nuttall cockle	Voucher
Triopha maculata	maculated triopha	Doridoidea	"nudibranch"	IS, FID
Virgularia californica (= *galapagensis*)	California sea pen	*Virgularia bromleyi*	"sea pen"	Voucher
			Squid eggs	IS, FID

IS = In-survey (field) misidentification; FID = Further Identification: Organisms returned to the laboratory but were incorrectly identified; NOMEN = nomenclature error (e.g., spelling error or currently synonymized name).

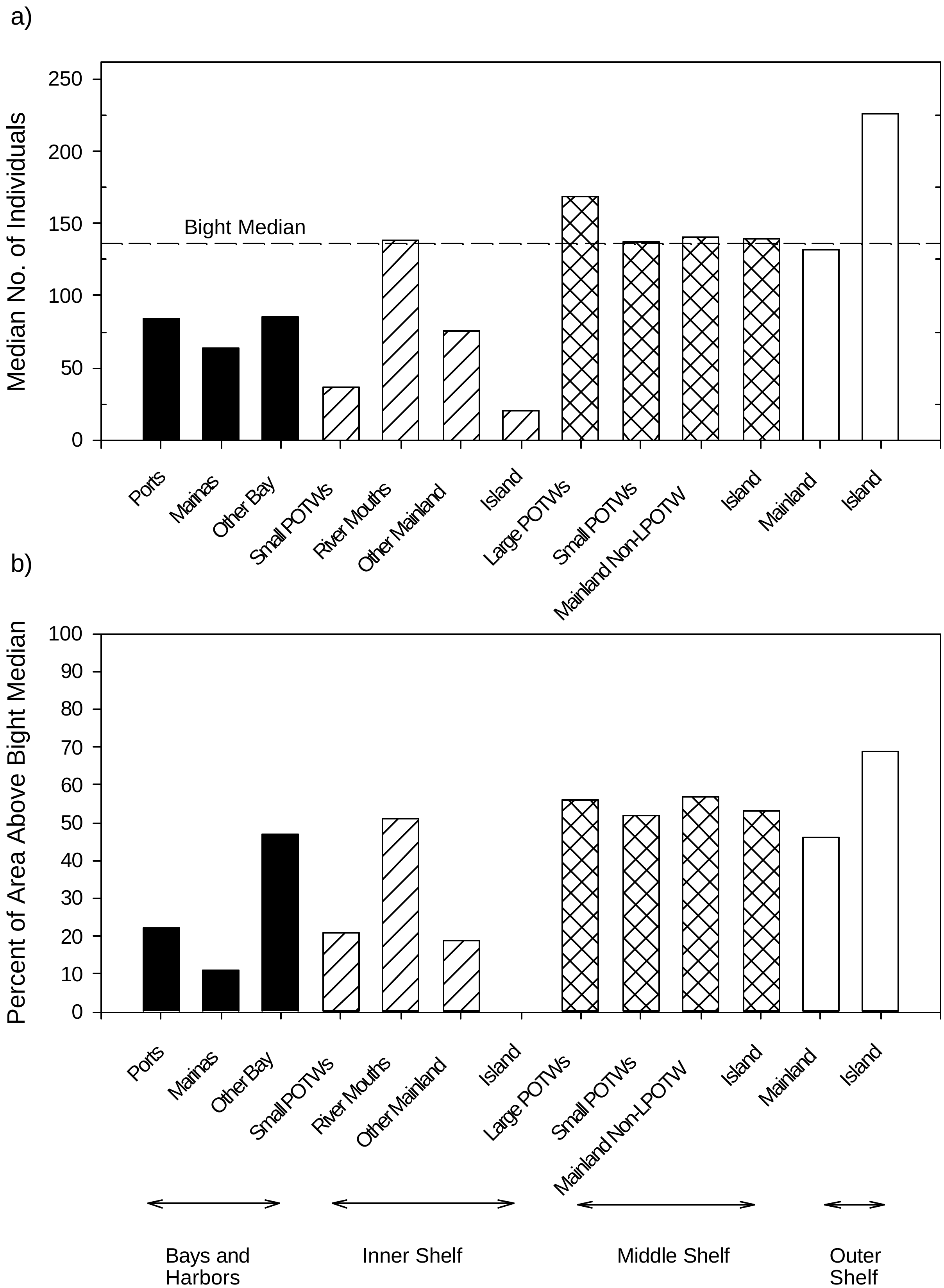
APPENDIX C

APPENDIX C. FISH POPULATION ATTRIBUTES

NUMBER		PAGE

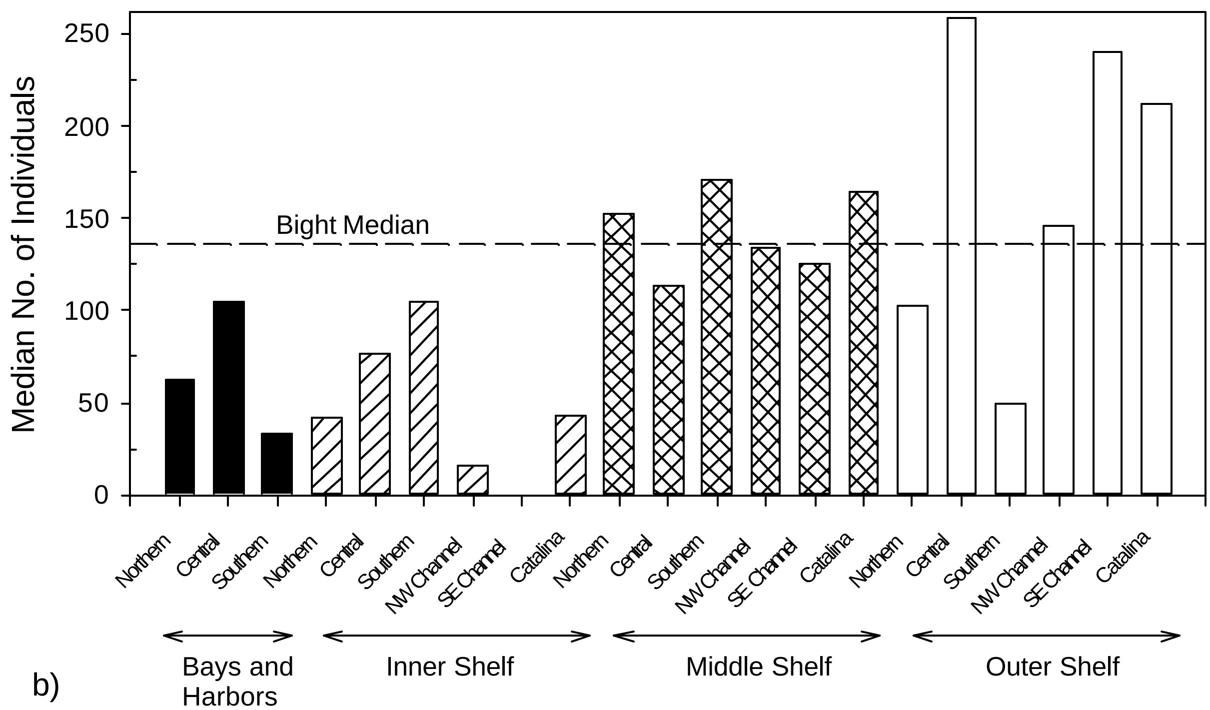


Appendix C1. Fish abundance per haul by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.

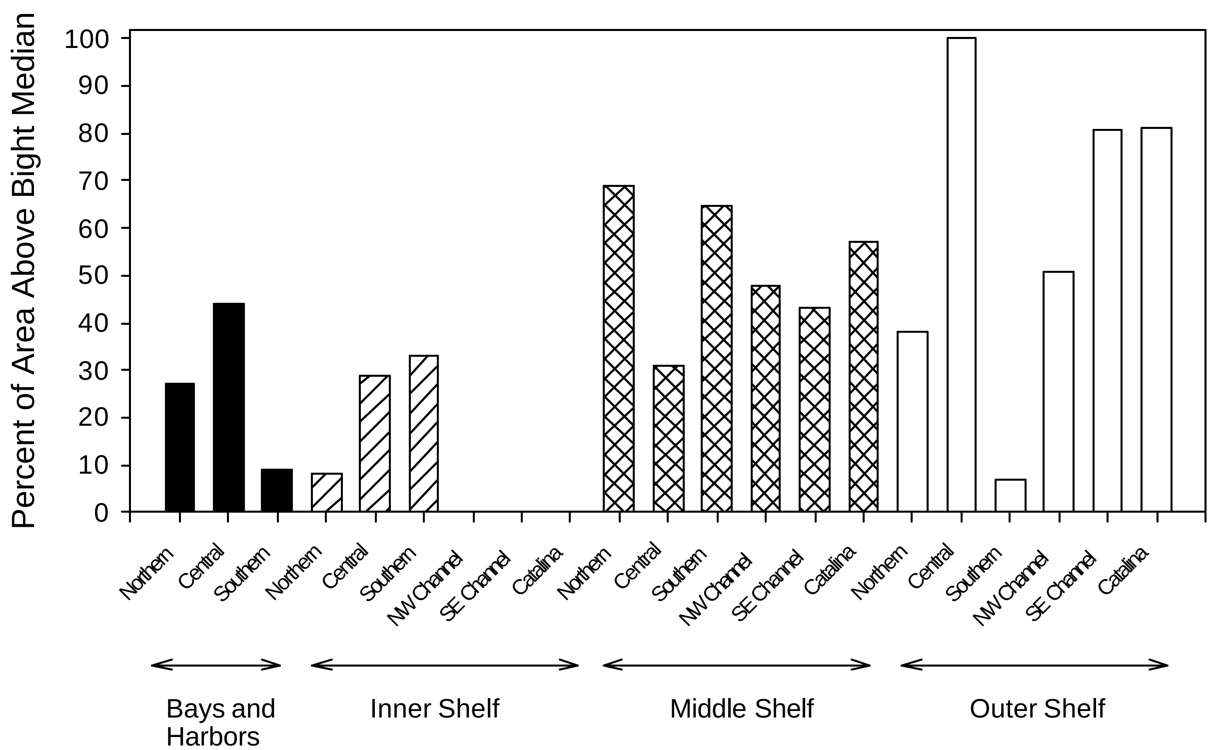


Appendix C2. Fish abundance per haul by shelf zone subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.

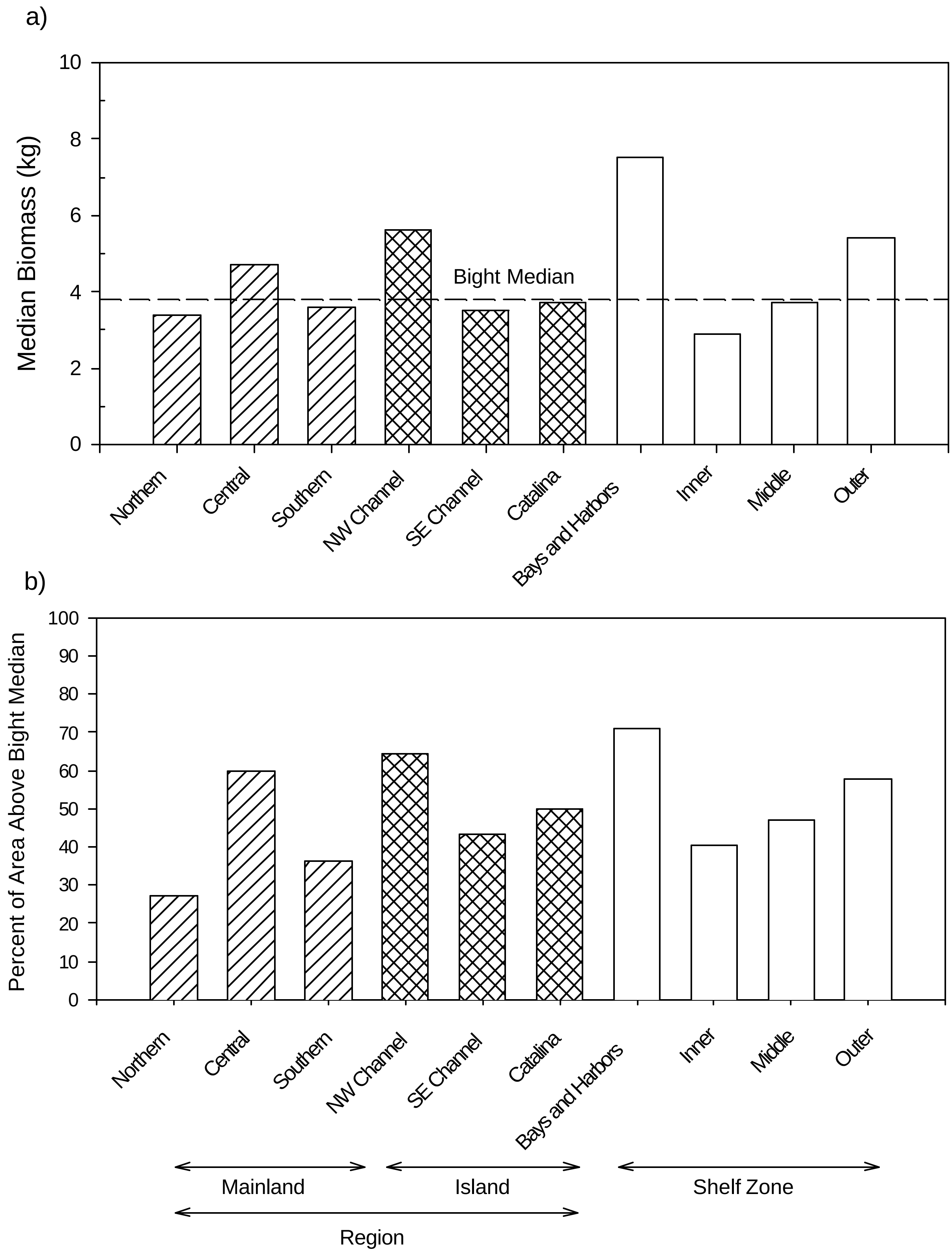
a)



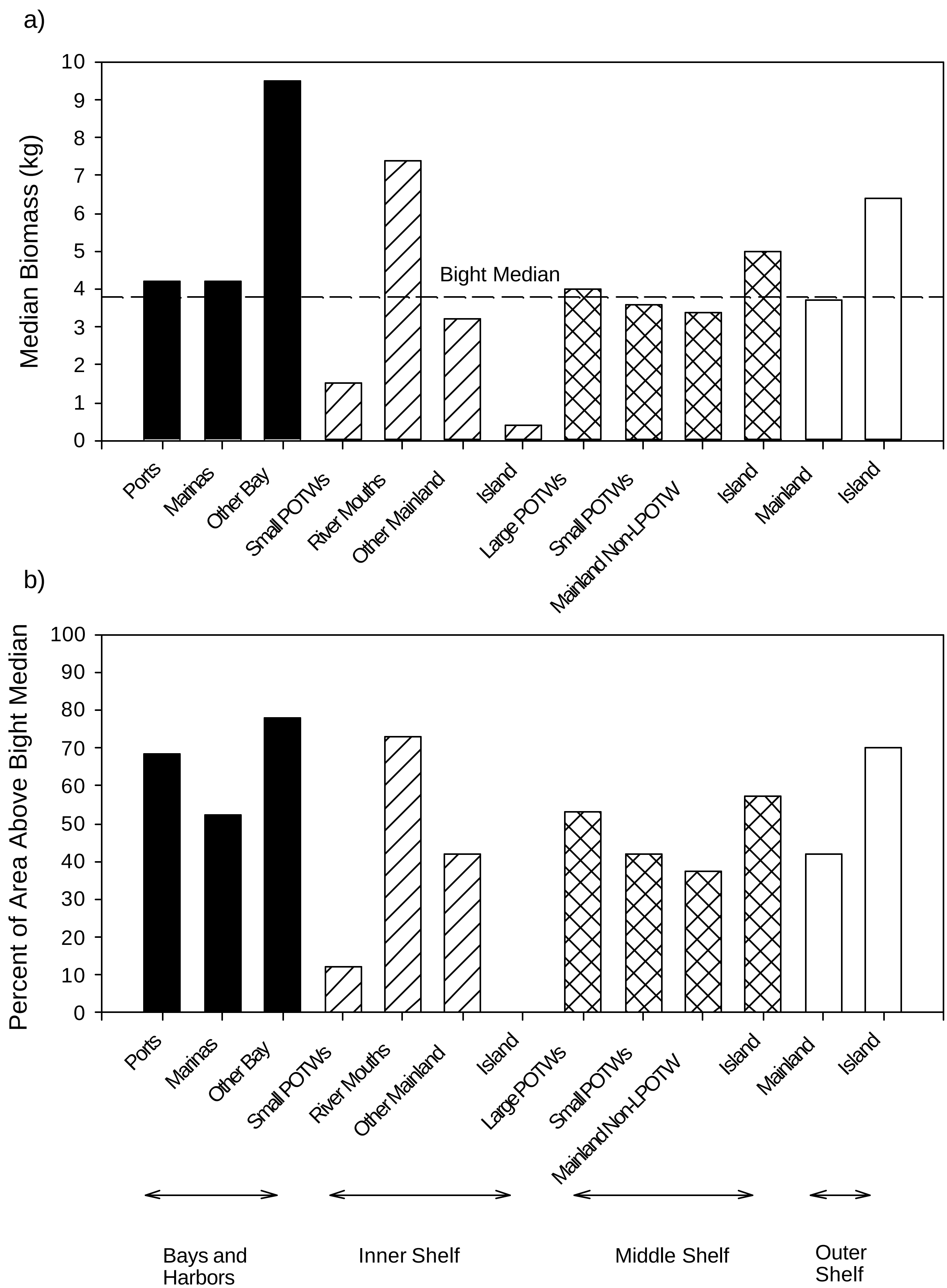
b)



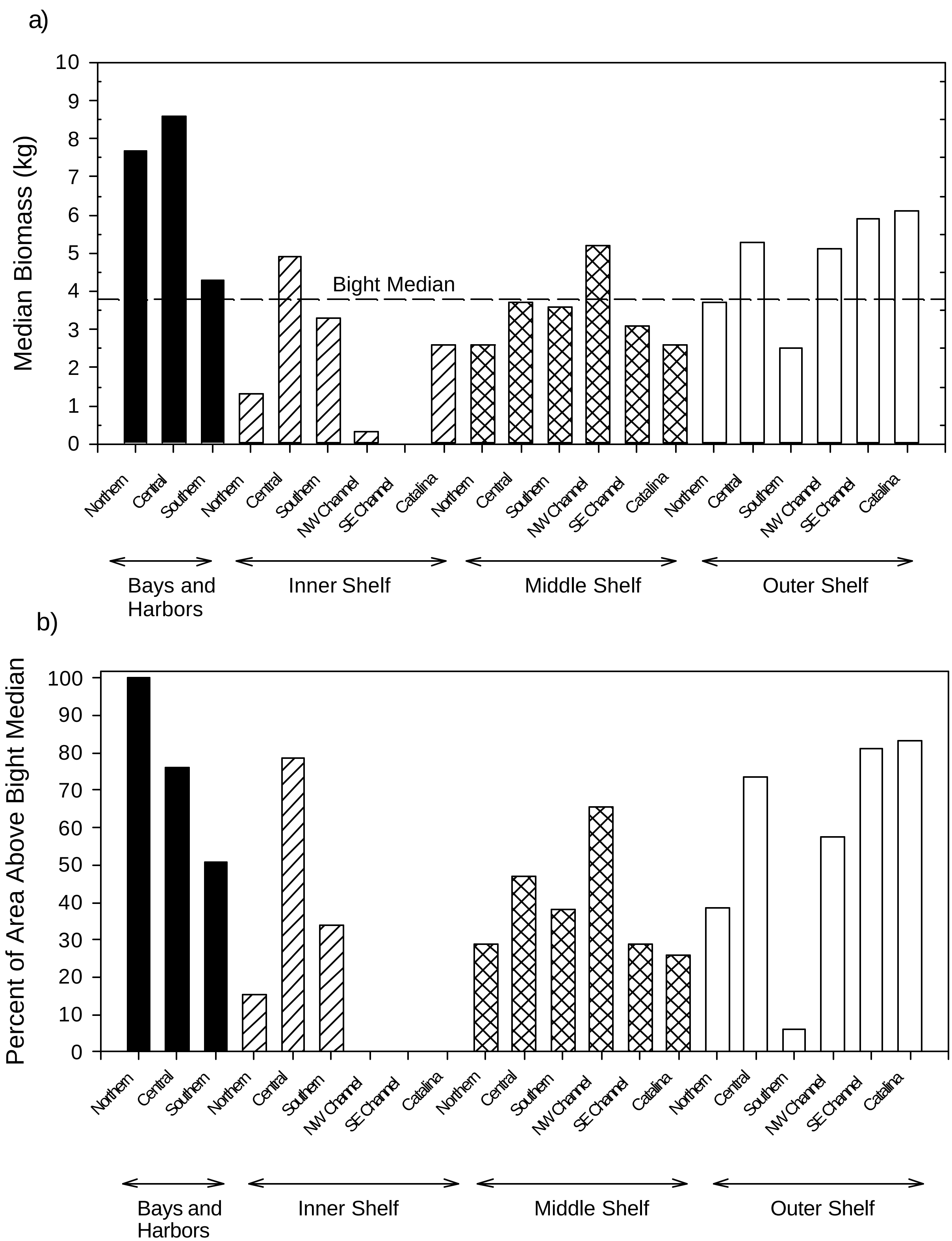
Appendix C3. Fish abundance per haul by region within shelf zone subpopulations on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



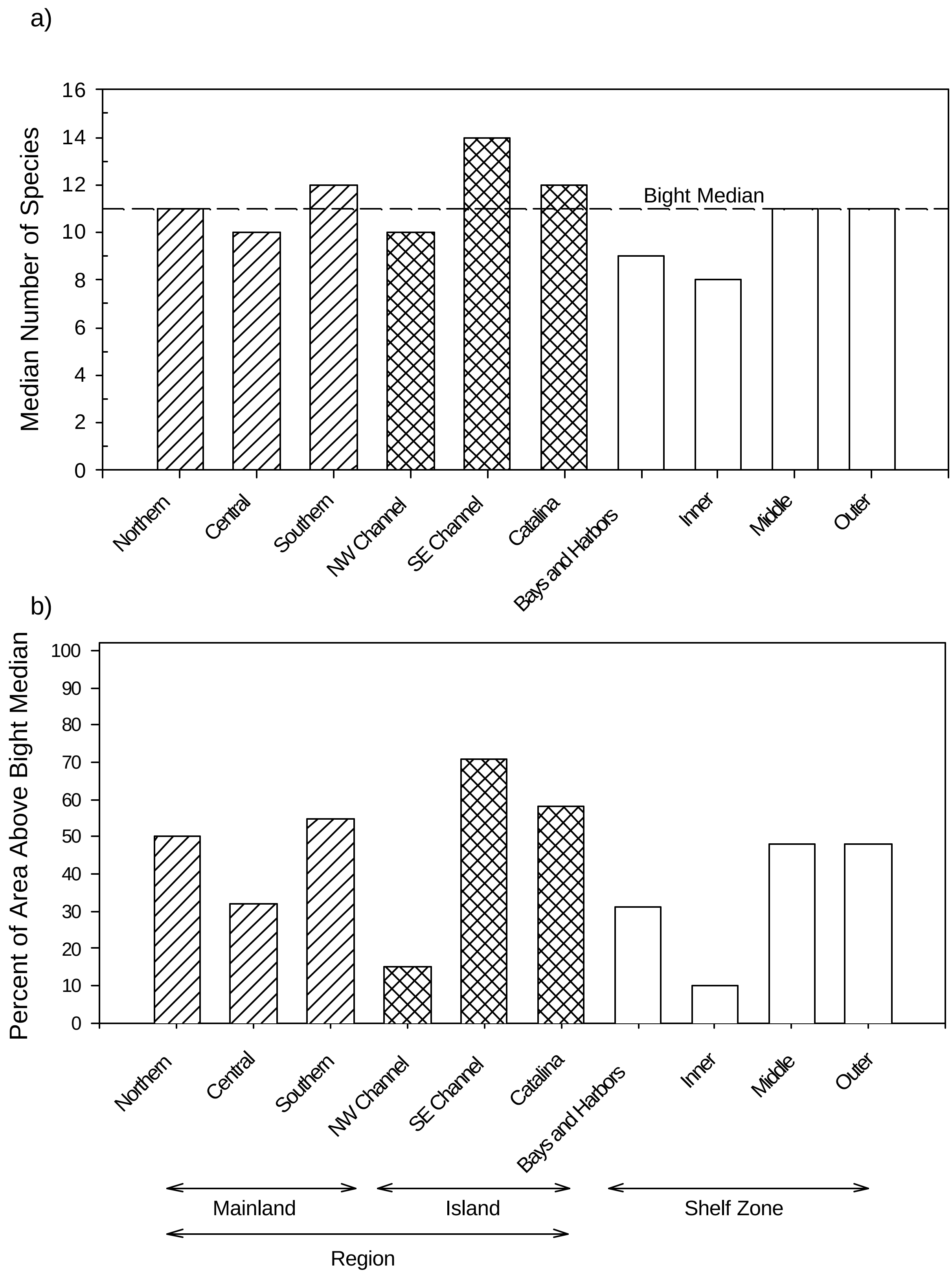
Appendix C4. Fish biomass per haul by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



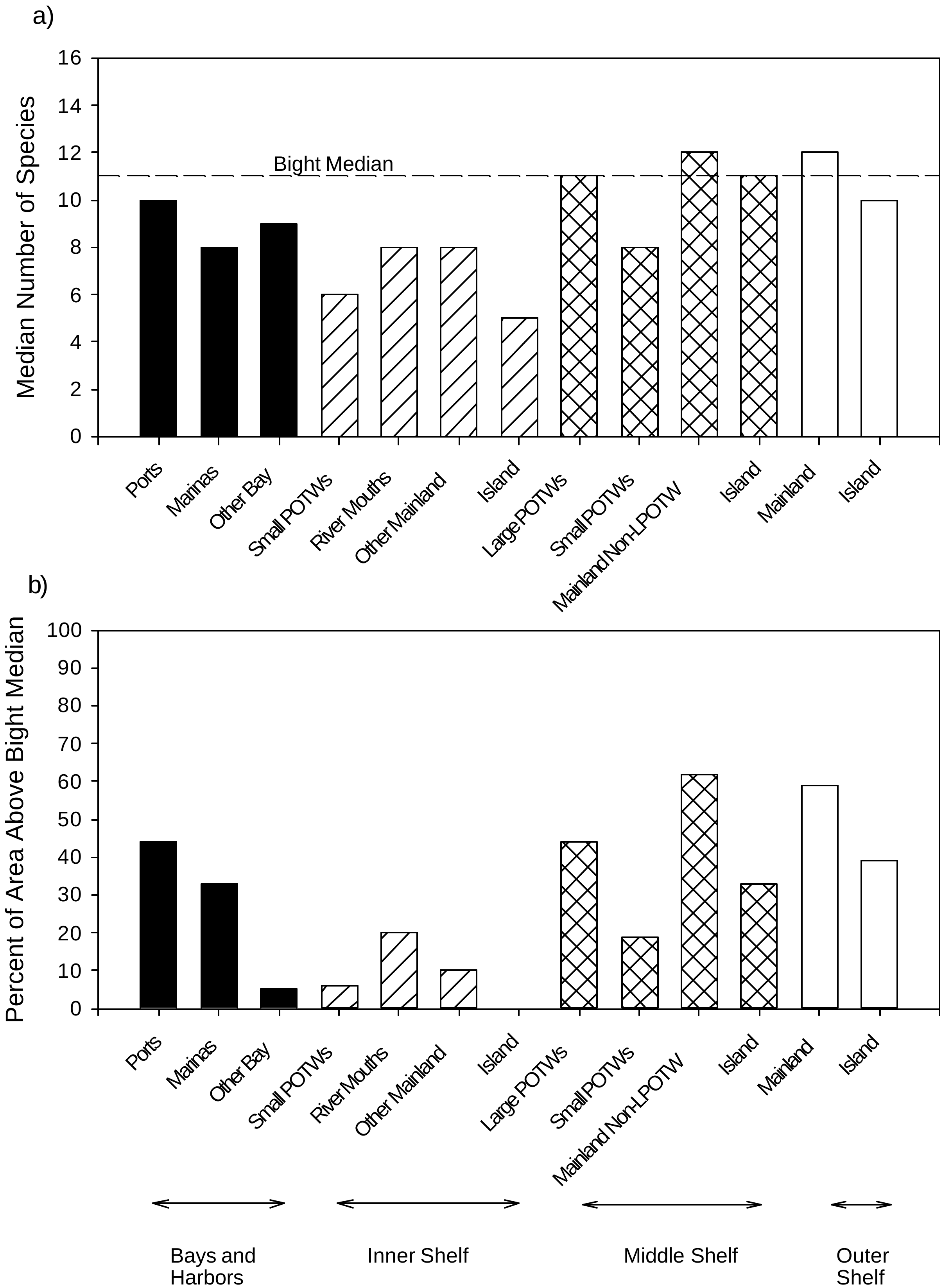
Appendix C5. Fish biomass per haul by shelf zone subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



Appendix C6. Fish biomass per haul by region within shelf zone subpopulations on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.

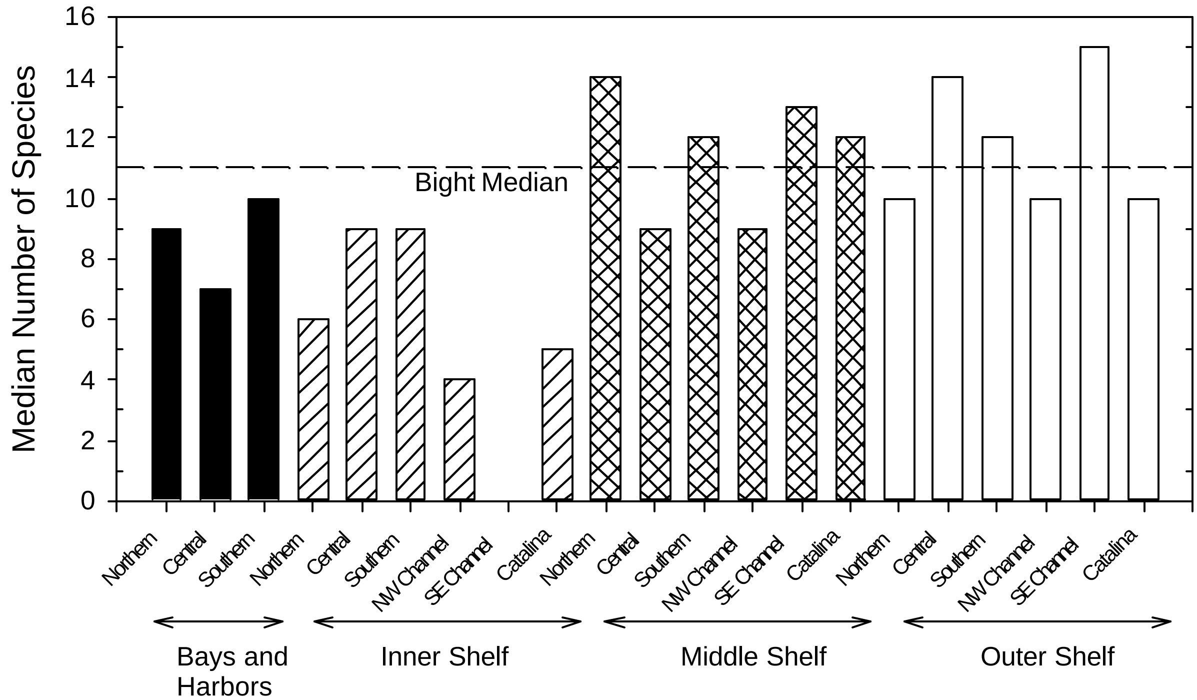


Appendix C7. Number of fish species per haul by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.

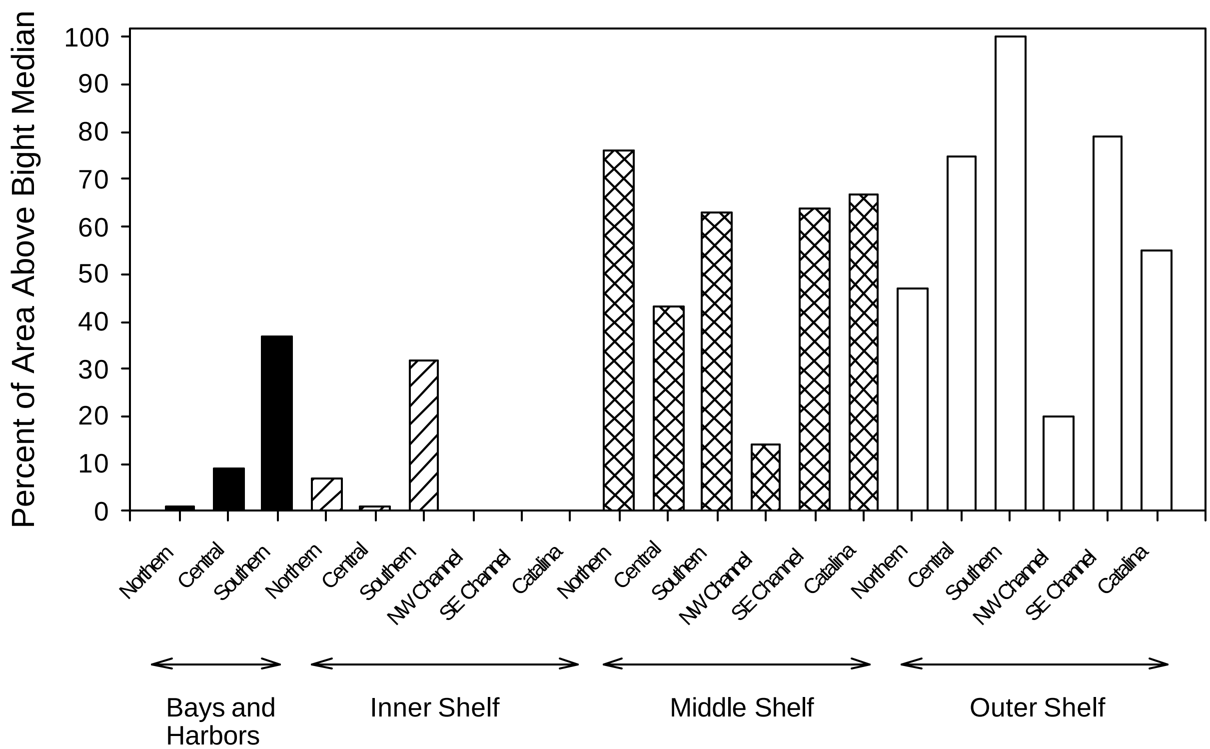


Appendix C8. Number of fish species per haul by shelf zone subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.

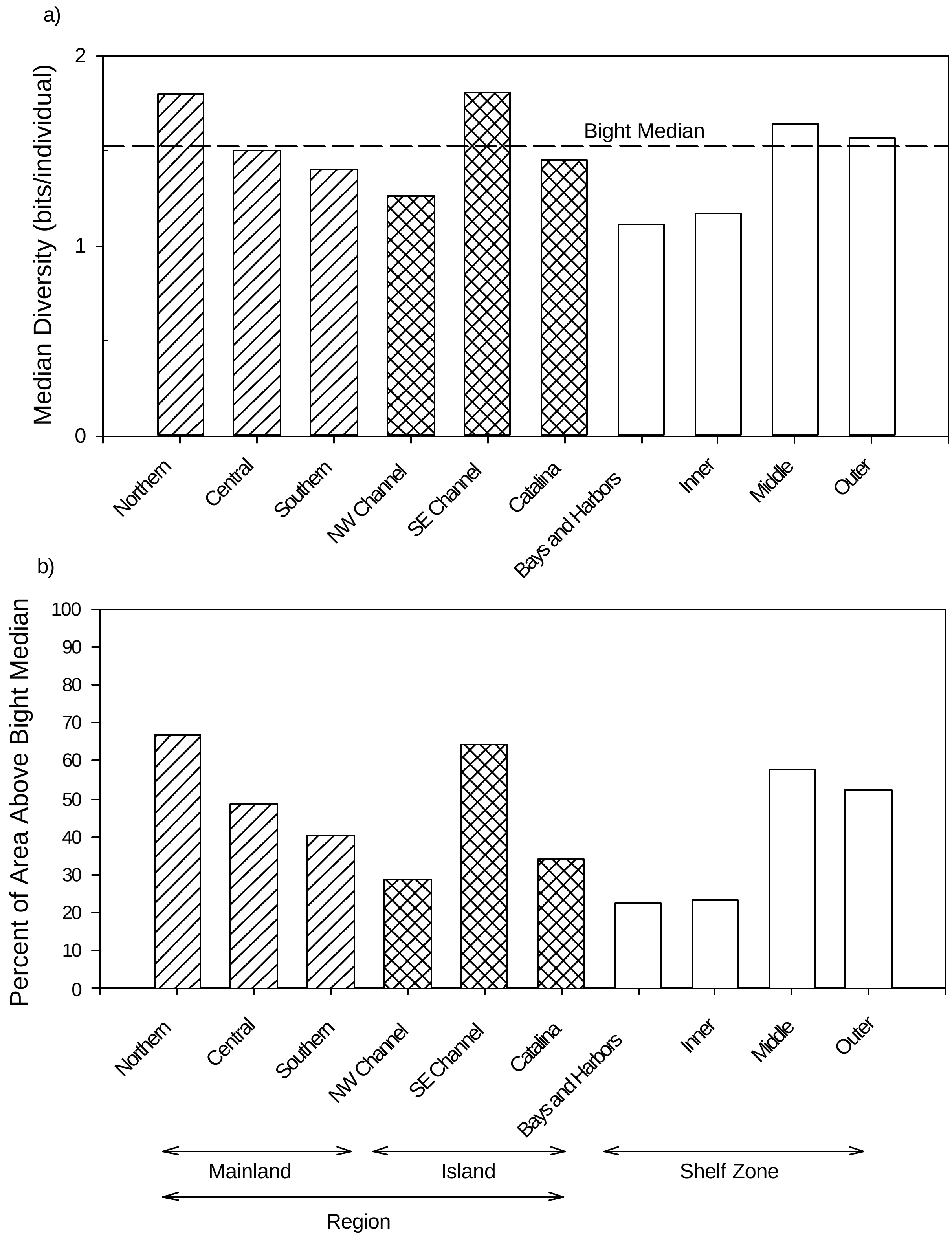
a)



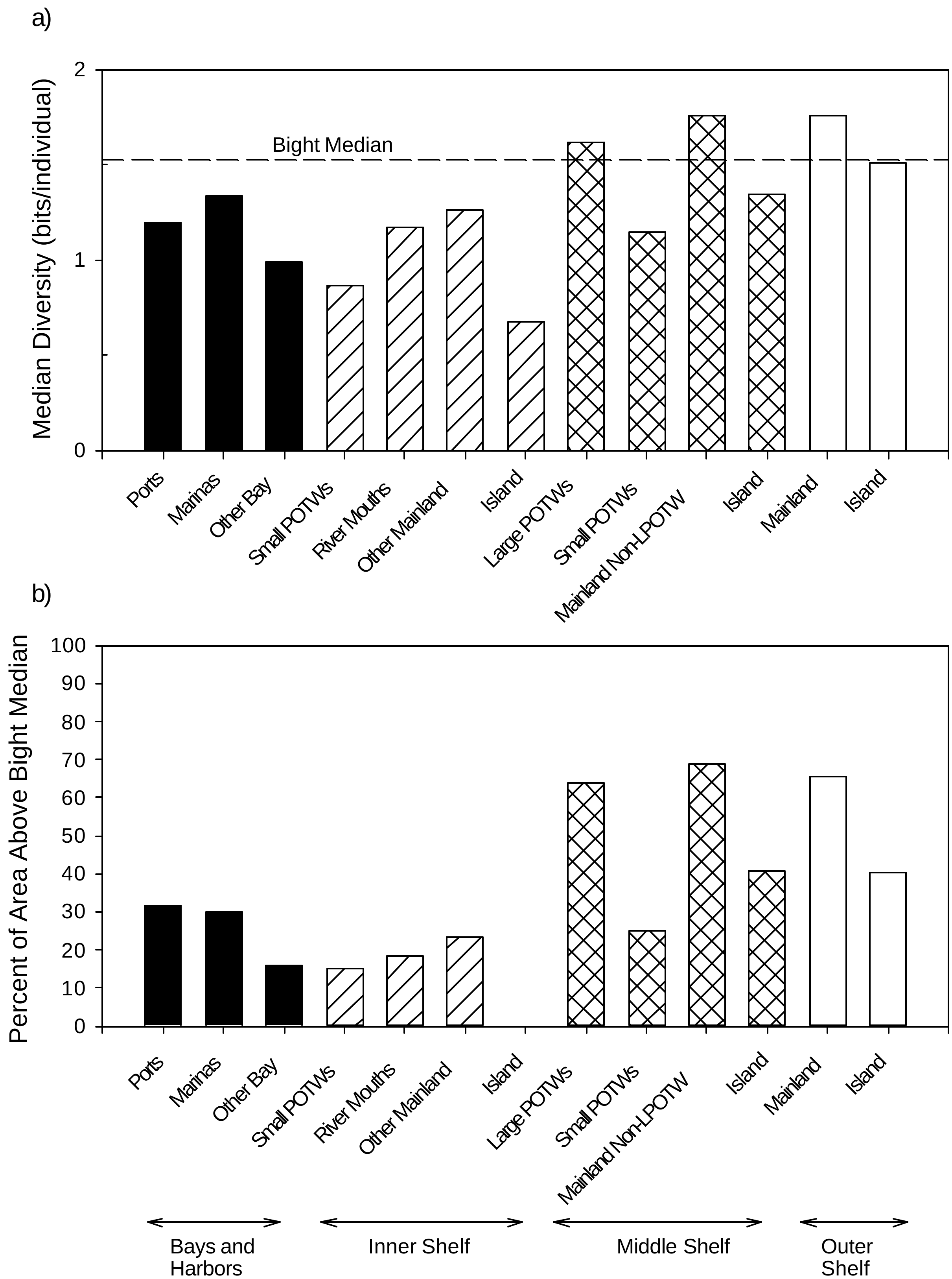
b)



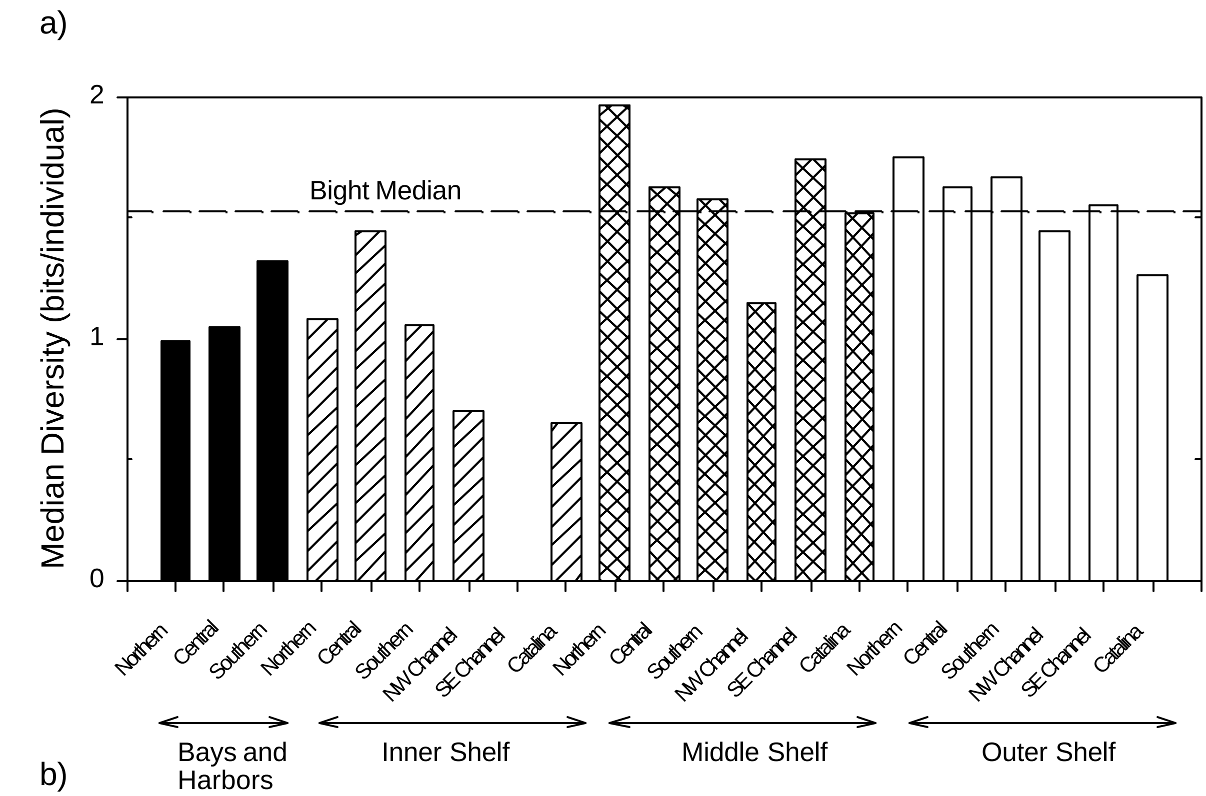
Appendix C9. Number of fish species per haul by region within shelf zone subpopulations on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.

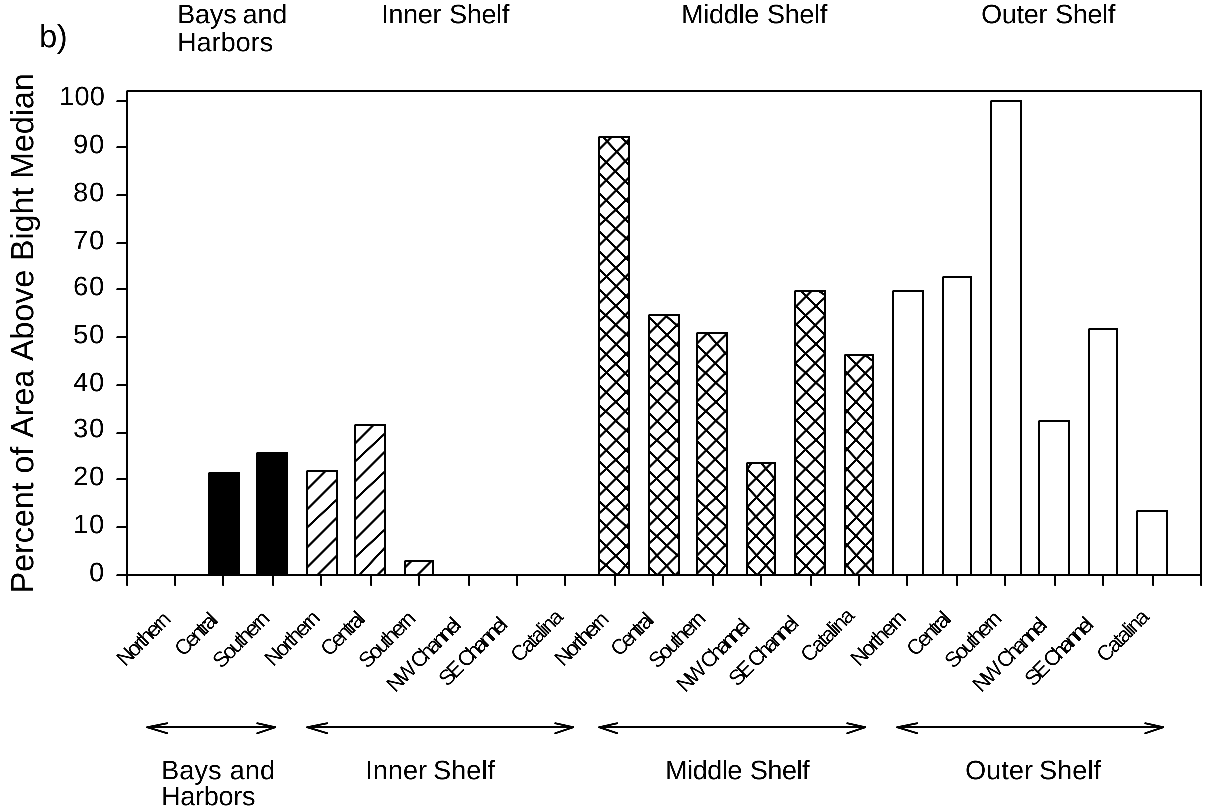


Appendix C10. Fish diversity (Shannon-Wiener) per haul by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



Appendix C11. Fish diversity (Shannon-Wiener) per haul by shelf zone subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.





Appendix C12. Fish diversity (Shannon-Wiener) per haul by region within shelf zone subpopulations on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.

Appendix C13. Taxonomic list of demersal fish species collected at depths of 2-202 m on the southern California shelf, July-September 1998.

Taxon/Species	Author	Common Name
MYXINI		HAGFISHES
-- MYXINIFORMES		
Myxinidae		HAGFISHES
Eptatretus stoutii	(Lockington 1878)	Pacific hagfish
ELASMOBRANCHII		ELASMOBRANCHS
-- CARCHARHINIFORMES		
Scyliorhinidae		CAT SHARKS
Cephaloscyllium ventriosum	(Garman 1880)	swell shark
Triakidae		HOUNDSHARKS
Mustelus californicus	Gill 1864	gray smoothhound
Mustelus henlei	(Gill 1862)	brown smoothhound
Triakis semifasciata	Girard 1854	leopard shark
-- SQUALIFORMES		
Squalidae		DOGFISH SHARKS
Squalus acanthias	Linnaeus 1758	spiny dogfish
-- SQUATINIFORMES		
Squatinidae		ANGEL SHARKS
Squatina californica	Ayres 1859	Pacific angel shark
-- TORPEDINIFORMES		
Torpedinidae		ELECTRIC RAYS
Torpedo californica	Ayres 1855	Pacific electric ray
-- RAJIFORMES		
Rhinobatidae		GUITARFISHES
Platyrhinoidis triseriata	(Jordan & Gilbert 1880)	thornback
Rhinobatos productus	(Ayres 1854)	shovelnose guitarfish
Rajidae		SKATES
Raja binoculata	Girard 1854	big skate
Raja inornata	Jordan & Gilbert 1881	California skate
Raja rhina	(Jordan & Gilbert 1880)	longnose skate
Raja stellulata	(Jordan & Gilbert 1880)	starry skate
Dasyatidae		STINGRAYS
Dasyatis dipterura	(Jordan and Gilbert 1880)	diamond stingray
Gymnuridae		BUTTERFLY RAYS
Gymnura marmorata	(Cooper 1864)	California butterfly ray
Myliobatidae		EAGLE RAYS
Myliobatis californica	Gill 1865	bat ray
Urolophidae		ROUND STINGRAYS
Urolophus halleri	Cooper 1863	round stingray
HOLOCEPHALI		HOLOCEPHALIANS
-- CHIMAERIFORMES		
Chimaeridae		CHIMAERAS
Hydrolagus colliei	(Lay & Bennett 1839)	spotted ratfish

Appendix C13 (continued)

Taxon/Species	Author	Common Name
ACTINOPTERYGII		RAY-FINNED FISHES
-- ALBULIFORMES		
Albulidae		BONEFISHES
Albula vulpes	Linnaeus 1758	bonefish
-- CLUPEIFORMES		
Clupeidae		HERRINGS
Clupea pallasii	Valenciennes 1847	Pacific herring
Sardinops sagax	(Jenyns 1842)	Pacific sardine
Engraulidae		ANCHOVIES
Anchoa compressa	(Girard 1858)	deepbody anchovy
Anchoa delicatissima	(Girard 1854)	slough anchovy
Engraulis mordax	Girard 1854	northern anchovy
-- OSMERIFORMES		
Argentinidae		ARGENTINES
Argentina sialis	Gilbert 1890	Pacific argentine
-- AULOPIFORMES		
Synodontidae		LIZARDFISHES
Synodus lucioceps	(Ayres 1855)	California lizardfish
-- GADIFORMES		
Moridae		CODLINGS
Physiculus rastrelliger	Gilbert 1890	hundred-fathom codling
Merlucciidae		MERLUCCID HAKES
Merluccius productus	(Ayres 1855)	Pacific hake
-- OPHIDIIFORMES		
Ophidiidae		CUSK-EELS
Chilara taylori	(Girard 1858)	spotted cusk-eel
Ophidion scrippsae	(Hubbs 1916)	basketweave cusk-eel
-- BATRACHOIDIFORMES		
Batrachoididae		TOADFISHES
Porichthys myriaster	Hubbs & Schultz 1939	specklefin midshipman
Porichthys notatus	Girard 1854	plainfin midshipman
-- ATHERINIFORMES		
Atherinidae		SILVERSIDES
Atherinops affinis	(Ayres 1860)	topsmelt
Atherinopsis californiensis	Girard 1854	jacksmelt
-- SYNGNATHIFORMES		
Centriscidae		SNIPEFISHES
Macroramphosus gracilis	(Lowe 1839)	slender snipefish
Syngnathidae		PIPEFISHES
Hippocampus ingens	Girard 1858	Pacific seahorse
Syngnathus californiensis	Storer 1845	kelp pipefish
Syngnathus exilis	(Osburn & Nichols 1916)	barcheek pipefish

Appendix C13 (continued)

Taxon/Species	Author	Common Name
-- SCORPAENIFORMES		
Sebastidae		ROCKFISHES
Sebastes atrovirens	(Jordan & Gilbert 1880)	kelp rockfish
Sebastes auriculatus	Girard 1854	brown rockfish
Sebastes caurinus	Richardson 1845	copper rockfish
Sebastes chlorostictus	(Jordan & Gilbert 1880)	greenspotted rockfish
Sebastes constellatus	(Jordan & Gilbert 1880)	starry rockfish
Sebastes dallii	(Eigenmann & Beeson 1894)	calico rockfish
Sebastes diploproa	(Gilbert 1890)	splitnose rockfish
Sebastes elongatus	Ayres 1859	greenstriped rockfish
Sebastes ensifer	Chen 1971	swordspine rockfish
Sebastes eos	(Eigenmann & Eigenmann 1890)	pink rockfish
Sebastes goodei	(Eigenmann & Eigenmann 1890)	chilipepper
Sebastes jordani	(Gilbert 1896)	shortbelly rockfish
Sebastes lentiginosus	Chen 1971	freckled rockfish
Sebastes levis	(Eigenmann & Eigenmann 1889)	cowcod
Sebastes macdonaldi	(Eigenmann & Beeson 1893)	Mexican rockfish
Sebastes miniatus	(Jordan & Gilbert 1880)	vermilion rockfish
Sebastes rosaceus	Girard 1854	rosy rockfish
Sebastes rosenblatti	Chen 1971	greenblotched rockfish
Sebastes rubrivinctus	(Jordan & Gilbert 1880)	flag rockfish
Sebastes saxicola	(Gilbert 1890)	stripetail rockfish
Sebastes semicinctus	(Gilbert 1897)	halfbanded rockfish
Sebastes simulator	Chen 1971	pinkrose rockfish
Sebastes umbrosus	(Jordan & Gilbert 1882)	honeycomb rockfish
Sebastolobus alascanus	Bean 1890	shortspine thornyhead
Scorpaenidae		SCORPIONFISHES
Scorpaena guttata	Girard 1854	California scorpionfish
Triglidae		SEAROBINS
Prionotus stephanophrys	Lockington 1881	lumptail searobin
Anoplopomatidae		SABLEFISHES
Anoplopoma fimbria	(Pallas 1814)	sablefish
Zaniolepididae		COMBFISHES
Zaniolepis frenata	(Eigenmann & Eigenmann 1889)	shortspine combfish
Zaniolepis latipinnis	Girard 1857	longspine combfish
Hexagrammidae		GREENLINGS
Ophiodon elongatus	Girard 1854	lingcod
Cottidae		SCULPINS
Chitonotus pugetensis	(Steindachner 1876)	roughback sculpin
Enophrys taurina	Gilbert 1914	bull sculpin
Icelinus cavifrons	Gilbert 1890	pit-head sculpin
Icelinus filamentosus	Gilbert 1890	threadfin sculpin
Icelinus quadriseriatus	(Lockington 1880)	yellowchin sculpin

Appendix C13 (continued)

Taxon/Species	Author	Common Name
Cottidae (continued)		
Icelinus tenuis	Gilbert 1890	spotfin sculpin
Radulinus asprellus	Gilbert 1890	slim sculpin
Agonidae		POACHERS
Agonopsis sterletus	(Gilbert 1898)	southern spearnose poacher
Odontopyxis trispinosa	Lockington 1880	pygmy poacher
Xeneretmus latifrons	(Gilbert 1890)	blacktip poacher
Xeneretmus triacanthus	(Gilbert 1890)	bluespotted poacher
-- PERCIFORMES		
Polyprionidae		GIANT SEA BASSES
Stereolepis gigas	Ayres 1859	giant sea bass
Serranidae		SEA BASSES
Paralabrax clathratus	(Girard 1854)	kelp bass
Paralabrax maculatofasciatus	(Steindachner 1868)	spotted sand bass
Paralabrax nebulifer	(Girard 1854)	barred sand bass
Malacanthidae		TILEFISHES
Caulolatilus princeps	(Jenyns 1842)	ocean whitefish
Carangidae		JACKS
Trachurus symmetricus	(Ayres 1855)	jack mackerel
Haemulidae		GRUNTS
Anisotremus davidsonii	(Steindachner 1875)	sargo
Sciaenidae		DRUMS
Atractoscion nobilis	(Ayres 1860)	white seabass
Cheilotrema saturnum	(Girard 1858)	black croaker
Genyonemus lineatus	(Ayres 1855)	white croaker
Menticirrhus undulatus	(Girard 1854)	California corbina
Roncador stearnsii	(Steindachner 1875)	spotfin croaker
Seriphus politus	Ayres 1860	queenfish
Umbrina roncador	Jordan & Gilbert 1882	yellowfin croaker
Embiotocidae		SURFPERCHES
Amphistichus argenteus	Agassiz 1854	barred surfperch
Cymatogaster aggregata	Gibbons 1854	shiner perch
Embiotoca jacksoni	Agassiz 1853	black perch
Hyperprosopon argenteum	Gibbons 1854	walleye surfperch
Phanerodon furcatus	Girard 1854	white seaperch
Rhacochilus vacca	(Girard 1855)	pile perch
Zalembius rosaceus	(Jordan & Gilbert 1880)	pink seaperch
Labridae		WRASSES
Semicossyphus pulcher	(Ayres 1854)	California sheephead
Bathymasteridae		RONQUILS
Rathbunella alleni	Gilbert 1904	stripedfin ronquil [1]
Rathbunella hypoplecta	(Gilbert 1890)	bluebanded ronquil [1]

Appendix C13 (continued)

Taxon/Species	Author	Common Name
Zoarcidae		EELPOUTS
Lycodes cortezianus	(Gilbert 1890)	bigfin eelpout
Lycodes pacificus [2]		
(=*Lycodopsis pacifica*)	Collett 1879	blackbelly eelpout
Lyconema barbatum	Gilbert 1896	bearded eelpout
Stichaeidae		PRICKLEBACKS
Plectobranchus evides	Gilbert 1890	bluebarred prickleback
Uranoscopidae		STARGAZERS
Kathetostoma averruncus	Jordan & Bollman 1890	smooth stargazer
Labrisomidae		LABRISOMIDS
Cryptotrema corallinum	Gilbert 1890	deepwater blenny
Clinidae		CLINIDS
Heterostichus rostratus	Girard 1854	giant kelpfish
Chaenopsidae		PIKE BLENNIES
Neoclinus blanchardi	Girard 1858	sarcastic fringehead
Blenniidae		COMBTOOTH BLENNIES
Hypsoblennius jenkinsi	(Jordan & Evermann 1896)	mussel blenny
Callionymidae		DRAGONETS
Synchiropus atrilabiatus	(Garman 1899)	blacklip dragonet
Gobiidae		GOBIES
Acanthogobius flavimanus	(Temminck & Schlegel 1845)	yellowfin goby
Coryphopterus nicholsii	(Bean 1882)	blackeye goby
Ilypnus gilberti	(Eigenmann & Eigenmann 1889)	cheekspot goby
Lepidogobius lepidus	(Girard 1858)	bay goby
Lythrypnus dalli	(Gilbert 1890)	bluebanded goby
Lythrypnus zebra	(Gilbert 1890)	zebra goby
Trichiuridae		SNAKE MACKERELS
Trichiurus lepturus [2] (=*nitens*)	Linnaeus 1758	cutlassfish[3]
Stromateidae		BUTTERFISHES
Peprilus simillimus	(Ayres 1860)	Pacific pompano
-- PLEURONECTIFORMES		
Paralichthyidae		SAND FLOUNDERS
Citharichthys fragilis	Gilbert 1890	gulf sanddab
Citharichthys sordidus	(Girard 1854)	Pacific sanddab
Citharichthys stigmaeus	Jordan & Gilbert 1882	speckled sanddab
Citharichthys xanthostigma	Gilbert 1890	longfin sanddab
Hippoglossina stomata	Eigenmann & Eigenmann 1890	bigmouth sole
Paralichthys californicus	(Ayres 1859)	California halibut
Xystreurys liolepis	Jordan & Gilbert 1880	fantail sole
Bothidae		LEFTEYE FLOUNDERS
Engyophrys sanctilaurentii	Jordan & Bollman 1890	speckletail flounder

Appendix C13 (continued)

Taxon/Species	Author	Common Name
Pleuronectidae		RIGHTEYE FLOUNDERS
Eopsetta jordani	(Lockington 1879)	petrale sole
Glyptocephalus[4] (=*Errex*) *zachirus*	Lockington 1879	rex sole
Lepidopsetta bilineata[4] (=*Pleuronectes bilineatus*)	(Ayres 1855)	rock sole
Lyopsetta[4] (=*Eopsetta*) *exilis*	(Jordan & Gilbert 1880)	slender sole
Microstomus pacificus	(Lockington 1879)	Dover sole
Parophrys[4] (=*Pleuronectes*) *vetulus*[5] (=*vetula*)	Girard 1854	English sole
Pleuronichthys coenosus	Girard 1854	C-O sole
Pleuronichthys decurrens	Jordan & Gilbert 1880	curlfin sole
Pleuronichthys guttulatus[4] (=*Hypsopsetta guttulata*)	Girard 1856	diamond turbot
Pleuronichthys ritteri	Starks & Morris 1907	spotted turbot
Pleuronichthys verticalis	Jordan & Gilbert 1880	hornyhead turbot
Cynoglossidae		TONGUEFISHES
Symphurus atricaudus[6] (=*atricauda*)	(Jordan & Gilbert 1880)	California tonguefish

Taxonomic arrangement and scientific names (Eschmeyer 1998) except that flatfish names are updated from Cooper and Chapleau (1998). Common names generally from Robins *et al*. (1991).
(...=.....) means 'current valid name (=database name)'

1 *Rathbunella alleni* was called 'rough ronquil' and *Rathbunella hypoplecta* was called 'stripedfin ronquil' in Allen *et al.* (1998). The names shown in this list follow those of Matarese (1991).

2 Scientific name from Eschmeyer (1998).

3 Common name from Allen and Robertson (1994)

4 Scientific name from Cooper and Chapleau (1998)

5 We follow Orr and Materese (2000) in using *vetulus* instead of *vetula*.

6 We follow Jordan and Evermann (1896-1900), Munroe and Nizinski (1990), and Eschmeyer (1998) in using *atricaudus.*

Appendix C14. Percent of area of demersal fish species by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	Percent of Area										
	Region										
	Mainland			Island			Shelf Zone				
Species*	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Citharichthys sordidus	55	34	46	98	98	85	-	6	77	91	65
Synodus lucioceps	68	80	72	1	34	31	36	75	56	4	50
Porichthys notatus	48	16	46	72	72	46	2	-	56	81	49
Hippoglossina stomata	32	61	61	31	51	73	-	15	64	14	45
Symphurus atricaudus	62	72	65	11	-	12	49	53	54	-	44
Pleuronichthys verticalis	44	68	46	22	48	19	8	53	54	2	44
Zalembius rosaceus	46	20	58	52	41	65	-	0	58	41	44
Microstomus pacificus	41	12	22	66	74	62	-	-	41	94	42
Zaniolepis latipinnis	55	25	48	36	62	12	-	0	59	28	42
Parophrys vetulus	56	29	25	46	57	8	-	33	41	60	42
Icelinus quadriseriatus	47	47	65	10	43	31	-	6	61	1	39
Citharichthys stigmaeus	49	43	9	44	17	12	2	79	35	-	37
Sebastes saxicola	49	16	36	31	44	46	-	-	40	59	35
Citharichthys xanthostigma	29	67	73	-	-	31	-	27	45	2	33
Zaniolepis frenata	23	6	11	45	83	58	-	-	26	82	30
Paralichthys californicus	30	45	21	-	-	4	66	73	10	-	21
Chitonotus pugetensis	7	5	9	43	43	23	-	1	31	-	20
Lyopsetta exilis	31	6	13	10	29	46	-	-	8	75	18
Xystreurys liolepis	23	45	10	-	-	12	20	34	18	-	18
Genyonemus lineatus	22	26	41	-	-	-	62	41	13	-	17
Pleuronichthys decurrens	-	-	-	52	37	4	-	-	25	5	17
Porichthys myriaster	28	29	12	1	-	8	38	19	19	-	16
Scorpaena guttata	4	32	29	-	17	38	1	6	21	3	15
Sebastes semicinctus	5	1	8	31	33	4	-	-	13	32	14
Icelinus tenuis	1	0	7	31	28	50	-	-	14	26	13
Argentina sialis	7	6	16	10	43	31	-	-	17	14	13
Odontopyxis trispinosa	23	10	2	10	17	4	-	-	20	-	13
Lepidogobius lepidus	11	10	26	10	-	38	6	0	20	1	13
Chilara taylori	2	3	1	20	48	31	-	-	10	33	12
Citharichthys fragilis	7	8	49	-	5	19	-	-	15	14	12
Seriphus politus	14	17	17	-	-	-	45	32	5	0	10
Sebastes chlorostictus	4	1	17	15	20	4	-	-	9	20	9
Sebastes rosenblatti	15	5	3	5	9	31	-	-	9	17	9
Raja inornata	6	28	3	-	2	-	6	6	10	7	8
Sebastes eos	20	3	12	-	-	8	-	-	8	16	8
Lycodes pacificus	13	5	3	5	5	19	-	-	2	36	7
Xeneretmus latifrons	12	3	-	10	10	-	-	-	-	42	7
Xeneretmus triacanthus	4	-	1	20	7	8	-	-	5	24	7
Sebastes caurinus	15	-	2	10	-	-	-	6	9	2	7
Pleuronichthys ritteri	-	19	17	-	-	-	32	27	2	-	7
Lepidopsetta bilineata	-	-	-	26	-	-	-	-	8	7	6
Paralabrax nebulifer	0	16	15	-	-	-	59	14	3	-	6
Glyptocephalus zachirus	8	3	-	5	7	15	-	-	-	31	5
Prionotus stephanophrys	-	0	35	-	-	-	-	-	7	2	5
Sebastes elongatus	5	1	10	-	11	23	-	-	3	16	5
Phanerodon furcatus	9	2	13	1	-	-	27	23	-	-	5

Appendix C14 (continued)

	Percent of Area										
	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Cephaloscyllium ventriosum	-	-	-	10	20	-	-	-	7	-	4
Agonopsis sterletus	7	-	7	-	9	15	-	-	7	-	4
Merluccius productus	9	4	2	-	-	15	-	-	2	18	4
Sebastes miniatus	11	1	0	-	9	4	-	-	7	-	4
Engraulis mordax	2	11	9	-	-	-	28	16	0	2	4
Enophrys taurina	2	-	-	10	9	-	-	3	5	-	4
Raja stellulata	-	-	-	5	26	-	-	-	3	12	4
Sebastes jordani	2	-	-	10	2	4	-	-	4	5	4
Sebastes diploproa	7	6	-	-	2	4	-	-	-	21	4
Platyrhinoidis triseriata	0	8	12	-	-	-	-	19	-	-	3
Cymatogaster aggregata	7	1	9	-	-	-	14	16	0	-	3
Plectobranchus evides	2	1	0	5	7	4	-	-	-	18	3
Sebastes dallii	11	-	-	-	-	-	1	-	5	-	3
Coryphopterus nicholsii	-	5	-	-	17	8	-	-	5	-	3
Pleuronichthys coenosus	-	-	0	12	-	-	-	2	4	-	3
Sebastes ensifer	-	-	2	10	-	-	-	-	-	16	3
Neoclinus blanchardi	-	-	-	10	-	-	-	-	4	-	3
Hydrolagus colliei	1	-	0	5	5	12	-	-	0	13	2
Menticirrhus undulatus	2	3	9	-	-	-	-	13	-	-	2
Sebastes rubrivinctus	-	0	2	5	2	4	-	-	0	10	2
Rathbunella hypoplecta	-	-	7	-	9	4	-	-	3	-	2
Eopsetta jordani	1	-	-	5	-	12	-	-	0	10	2
Sebastes goodei	2	-	-	5	-	-	-	-	-	11	2
Lyconema barbatum	4	1	-	-	5	-	-	-	-	10	2
Raja rhina	1	-	-	5	2	-	-	-	-	10	2
Embiotoca jacksoni	2	-	8	-	-	-	5	9	-	-	2
Rhinobatos productus	-	3	8	-	-	-	2	9	-	-	2
Trichiurus lepturus	0	5	4	-	-	-	1	3	2	-	2
Sardinops sagax	2	4	0	-	-	-	17	7	0	-	2
Syngnathus exilis	1	0	8	-	-	4	-	7	-	2	2
Urolophus halleri	-	0	10	-	-	-	14	6	-	-	1
Cryptotrema corallinum	-	-	-	-	9	12	-	-	2	-	1
Sebastes macdonaldi	4	-	-	-	2	-	-	-	0	6	1
Icelinus filamentosus	-	-	-	5	-	-	-	-	-	7	1
Radulinus asprellus	-	-	-	5	-	-	-	-	-	7	1
Hyperprosopon argenteum	0	0	8	-	-	-	-	7	-	-	1
Ophiodon elongatus	1	-	-	-	9	-	-	-	1	2	1
Caulolatilus princeps	-	5	-	-	-	-	-	-	2	-	1
Sebastes levis	-	-	-	-	11	-	-	-	2	-	1
Mustelus henlei	4	-	-	-	-	-	-	0	2	-	1
Clupea pallasii	4	-	-	-	-	-	-	-	2	-	1
Sebastes simulator	-	-	7	-	-	-	-	-	2	-	1
Trachurus symmetricus	4	-	-	-	-	- -	-	-	2	-	1
Sebastes lentiginosus	-	-	-	-	9	4	-	-	2	-	1
Pleuronichthys guttulatus	-	3	2	-	-	-	18	3	-	-	1
Peprilus simillimus	0	4	-	-	-	-	10	4	-	-	1
Rathbunella alleni	-	-	-	-	9	-	-	-	1	-	1
Myliobatis californica	0	3	0	-	-	-	10	3	-	-	1
Cheilotrema saturnum	-	0	5	-	-	-	10	3	-	-	1
Umbrina roncador	0	0	4	-	-	-	5	3	-	-	1
Anchoa delicatissima	-	0	4	-	-	-	8	3	-	-	1

Appendix C14 (continued)

	Percent of Area										
	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Sebastes sp.	-	-	5	-	-	-	-	-	1	2	1
Heterostichus rostratus	2	-	0	-	-	-	1	3	-	-	1
Lycodes cortezianus	-	1	-	-	2	-	-	-	-	3	1
Atherinopsis californiensis	-	3	-	-	-	-	-	3	-	-	1
Sebastes auriculatus	2	-	-	-	-	-	-	3	-	-	1
Squalus acanthias	-	2	-	-	-	-	-	3	-	-	1
Syngnathus californiensis	-	-	4	-	-	-	-	3	-	-	1
Paralabrax clathratus	-	1	1	-	-	8	4	0	1	-	1
Eptatretus stoutii	-	2	-	-	-	-	-	-	0	2	0
Paralabrax	-	0	3	-	-	-	21	0	-	-	0
Anoplopoma fimbria	1	-	-	-	-	-	-	-	-	2	0
Physiculus rastrelliger	-	1	-	-	-	-	-	-	-	2	0
Raja binoculata	-	1	-	-	-	-	-	-	-	2	0
Sebastolobus alascanus	-	1	-	-	-	-	-	-	-	2	0
Anchoa compressa	-	1	1	-	-	-	12	1	-	-	0
Macroramphosus gracilis	-	-	0	-	-	8	-	-	0	-	0
Icelinus cavifrons	-	-	-	-	-	8	-	-	0	-	0
Torpedo californica	-	1	-	-	-	-	-	-	0	-	0
Sebastes atrovirens	-	-	-	1	-	-	-	1	-	-	0
Lythrypnus dalli	-	-	-	-	-	4	-	-	0	-	0
Lythrypnus zebra	-	-	-	-	-	4	-	-	0	-	0
Semicossyphus pulcher	-	-	-	-	-	4	-	-	0	-	0
Synchiropus atrilabiatus	-	-	-	-	-	4	-	-	0	-	0
Ophidion scrippsae	-	0	-	-	-	-	3	0	-	-	0
Roncador stearnsii	-	0	1	-	-	-	4	0	-	-	0
Kathetostoma averruncus	-	0	0	-	-	-	-	-	0	0	0
Sebastes constellatus	-	0	0	-	-	-	-	-	0	-	0
Rhacochilus vacca	-	0	0	-	-	-	2	0	0	-	0
Sebastes umbrosus	-	0	-	-	-	-	-	-	0	-	0
Squatina californica	-	0	0	-	-	-	2	-	0	-	0
Atractoscion nobilis	-	0	0	-	-	-	1	0	-	-	0
Mustelus californicus	-	0	-	-	-	-	3	-	-	-	0
Dasyatis dipterura	-	-	0	-	-	-	2	-	-	-	0
Anisotremus davidsonii	-	0	-	-	-	-	1	0	-	-	0
Amphistichus argenteus	-	0	0	-	-	-	-	0	-	-	0
Hippocampus ingens	-	-	0	-	-	-	2	-	-	-	0
Engyophrys sanctilaurentii	-	-	0	-	-	-	-	-	0	-	0
Sebastes rosaceus	-	-	0	-	-	-	-	-	-	0	0
Gymnura marmorata	-	-	0	-	-	-	1	-	-	-	0
Acanthogobius flavimanus	0	-	-	-	-	-	1	-	-	-	0
Atherinops affinis	-	0	-	-	-	-	1	-	-	-	0
Hypsoblennius jenkinsi	-	0	-	-	-	-	1	-	-	-	0
Albula vulpes	-	0	-	-	-	-	1	-	-	-	0
Ilypnus gilberti	-	0	-	-	-	-	1	-	-	-	0
Stereolepis gigas	-	0	-	-	-	-	-	0	-	-	0
Triakis semifasciata	-	-	0	-	-	-	-	0	-	-	0

N = Northern; C = Central; S = Southern; NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; CAT = Santa Catalina Island; B&H = Bays and harbors; IS = Inner shelf; MS = Middle shelf; OS = Outer shelf; SCB = Southern California Bight; sp. = Species

0 = Present in less than 0.5% of area; See Glossary G2 for common nams of fish species

Appendix C15. Abundance (number of individuals) of demersal fish species by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	Region										
	Mainland			Island			Shelf Zone				
Species*	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Genyonemus lineatus	2,482	12,893	2,067	-	-	-	8,627	8,291	524	-	17,442
Citharichthys sordidus	1,366	639	399	817	983	2,246	-	73	3,666	2,711	6,450
Synodus lucioceps	618	2,276	2,616	19	14	30	115	1,085	4,361	12	5,573
Seriphus politus	1,726	1,808	320	-	-	-	878	2,876	98	2	3,854
Citharichthys xanthostigma	59	1,543	1,776	-	-	201	-	62	3,469	48	3,579
Engraulis mordax	11	3,024	70	-	-	-	2,846	237	21	1	3,105
Lyopsetta exilis	722	606	103	137	426	955	-	-	30	2,919	2,949
Symphurus atricaudus	236	1,429	182	5	-	10	494	206	1,162	-	1,862
Icelinus quadriseriatus	351	377	351	74	204	390	-	5	1,735	7	1,747
Microstomus pacificus	332	211	251	71	387	383	-	-	665	970	1,635
Porichthys notatus	232	72	740	83	186	146	2	-	1,068	389	1,459
Citharichthys stigmaeus	309	218	81	348	66	83	2	570	533	-	1,105
Sebastes saxicola	190	245	138	14	149	86	-	-	365	457	822
Zaniolepis frenata	131	25	13	245	273	87	-	-	158	616	774
Zaniolepis latipinnis	189	187	237	49	93	4	-	2	680	77	759
Zalembius rosaceus	119	114	186	16	9	94	-	9	449	80	538
Anchoa compressa	-	81	439	-	-	-	482	38	-	-	520
Lepidogobius lepidus	21	6	39	9	-	405	2	1	460	17	480
Paralichthys californicus	30	286	155	-	-	3	283	131	60	-	474
Paralabrax nebulifer	1	304	135	-	-	-	382	42	16	-	440
Cymatogaster aggregata	147	168	90	-	-	-	192	166	47	-	405
Parophrys vetulus	187	94	52	15	47	2	-	50	182	165	397
Hippoglossina stomata	50	189	70	6	12	69	-	9	356	31	396
Pleuronichthys verticalis	61	251	53	6	14	8	10	139	242	2	393
Argentina sialis	4	24	91	5	52	185	-	-	308	53	361
Sardinops sagax	29	289	1	-	-	-	268	49	2	-	319
Lycodes pacificus	53	116	19	30	28	71	-	-	9	308	317
Phanerodon furcatus	141	86	73	2	-	-	153	149	-	-	302
Icelinus tenuis	1	1	2	96	25	172	-	-	182	115	297
Xeneretmus latifrons	92	28	-	96	43	-	-	-	-	259	259
Urolophus halleri	-	2	199	-	-	-	196	5	-	-	201
Porichthys myriaster	26	143	24	1	-	2	116	24	56	-	196
Sebastes diploproa	51	132	-	-	8	1	-	-	-	192	192
Sebastes semicinctus	28	1	5	25	93	9	-	-	113	48	161
Citharichthys fragilis	33	22	82	-	2	17	-	-	70	86	156
Pleuronichthys ritteri	-	85	61	-	-	-	88	52	6	-	146
Paralabrax maculatofasciatus	-	1	132	-	-	-	131	2	-	-	133
Chitonotus pugetensis	3	3	11	11	48	42	-	1	117	-	118
Scorpaena guttata	1	49	47	-	2	17	2	6	104	4	116
Xystreurys liolepis	18	65	14	-	-	13	17	44	49	-	110
Anchoa delicatissima	-	34	75	-	-	-	64	45	-	-	109
Pleuronichthys guttulatus	-	59	33	-	-	-	84	8	-	-	92
Sebastes dallii	80	-	-	-	-	-	2	-	78	-	80
Hyperprosopon argenteum	2	6	69	-	-	-	-	77	-	-	77
Chilara taylori	5	6	2	6	42	14	-	-	19	56	75
Roncador stearnsii	-	6	67	-	-	-	52	21	-	-	73
Glyptocephalus zachirus	21	10	-	4	6	26	-	-	-	67	67

Appendix C15 (continued)

Species	Region						Shelf Zone				SCB
	Mainland			Island							
	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	
Pleuronichthys decurrens	-	-	-	47	10	3	-	-	57	3	60
Cheilotrema saturnum	-	30	29	-	-	-	33	26	-	-	59
Cryptotrema corallinum	-	-	-	-	6	49	-	-	55	-	55
Umbrina roncador	6	31	16	-	-	-	36	17	-	-	53
Sebastes rosenblatti	6	9	3	1	1	30	-	-	39	11	50
Odontopyxis trispinosa	28	6	3	2	4	2	-	-	45	-	45
Raja inornata	5	29	9	-	1	-	4	5	31	4	44
Prionotus stephanophrys	-	2	41	-	-	-	-	-	40	3	43
Sebastes elongatus	10	2	2	-	2	24	-	-	7	33	40
Merluccius productus	14	17	1	-	-	6	-	-	2	36	38
Menticirrhus undulatus	1	18	18	-	-	-	-	37	-	-	37
Embiotoca jacksoni	3	-	31	-	-	-	12	22	-	-	34
Peprilus simillimus	1	31	-	-	-	-	16	16	-	-	32
Xeneretmus triacanthus	4	-	2	13	11	2	-	-	8	24	32
Myliobatis californica	10	19	1	-	-	-	24	6	-	-	30
Sebastes chlorostictus	5	2	6	2	8	1	-	-	15	9	24
Lyconema barbatum	14	1	-	-	8	-	-	-	-	23	23
Coryphopterus nicholsii	-	5	-	-	13	4	-	-	22	-	22
Sebastes eos	10	6	3	-	-	2	-	-	10	11	21
Trichiurus lepturus	1	9	11	-	-	-	4	16	1	-	21
Platyrhinoidis triseriata	1	12	7	-	-	-	-	20	-	-	20
Paralabrax clathratus	-	9	7	-	-	3	12	2	5	-	19
Plectobranchus evides	4	1	1	2	9	1	-	-	-	18	18
Hydrolagus colliei	1	-	1	1	2	13	-	-	2	16	18
Rhinobatos productus	-	3	12	-	-	-	4	11	-	-	15
Sebastes ensifer	-	-	2	12	-	-	-	-	-	14	14
Rhacochilus vacca	-	2	12	-	-	-	2	3	9	-	14
Lythrypnus dalli	-	-	-	-	-	13	-	-	13	-	13
Syngnathus exilis	1	1	9	-	-	1	-	11	-	1	12
Physiculus rastrelliger	-	11	-	-	-	-	-	-	-	11	11
Sebastes caurinus	8	-	1	1	-	-	-	4	5	1	10
Sebastes miniatus	4	2	1	-	1	2	-	-	10	-	10
Hypsoblennius jenkinsi	-	8	-	-	-	-	8	-	-	-	8
Macroramphosus gracilis	-	-	1	-	-	7	-	-	8	-	8
Agonopsis sterletus	2	-	1	-	1	4	-	-	8	-	8
Pleuronichthys coenosus	-	-	1	7	-	-	-	5	3	-	8
Ophidion scrippsae	-	8	-	-	-	-	1	7	-	-	8
Sebastes sp.	-	-	8	-	-	-	-	-	7	1	8
Sebastes rosaceus	-	-	7	-	-	-	-	-	-	7	7
Sebastes jordani	2	-	-	2	2	1	-	-	4	3	7
Cephaloscyllium ventriosum	-	-	-	1	5	-	-	-	6	-	6
Lycodes cortezianus	-	3	-	-	3	-	-	-	-	6	6
Heterostichus rostratus	1	-	5	-	-	-	2	4	-	-	6
Rathbunella hypoplecta	-	-	1	-	4	1	-	-	6	-	6
Sebastes rubrivinctus	-	1	1	1	1	1	-	-	2	3	5
Squatina californica	-	4	1	-	-	-	4	-	1	-	5
Eopsetta jordani	1	-	-	1	-	3	-	-	2	3	5
Raja stellulata	-	-	-	1	3	-	-	-	2	2	4
Sebastes goodei	3	-	-	1	-	-	-	-	-	4	4

Appendix C15 (continued)

Species	Region						Shelf Zone				SCB
	Mainland			Island							
	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	
Sebastolobus alascanus	-	4	-	-	-	-	-	-	-	4	4
Rathbunella alleni	-	-	-	-	4	-	-	-	4	-	4
Dasyatis dipterura	-	-	4	-	-	-	4	-	-	-	4
Atractoscion nobilis	-	1	3	-	-	-	2	2	-	-	4
Mustelus henlei	4	-	-	-	-	-	-	2	2	-	4
Lepidopsetta bilineata	-	-	-	4	-	-	-	-	3	1	4
Sebastes macdonaldi	3	-	-	-	1	-	-	-	1	3	4
Syngnathus californiensis	-	-	4	-	-	-	-	4	-	-	4
Atherinops affinis	-	4	-	-	-	-	4	-	-	-	4
Raja rhina	1	-	-	2	1	-	-	-	-	4	4
Hippocampus ingens	-	-	4	-	-	-	4	-	-	-	4
Enophrys taurina	1	-	-	1	1	-	-	1	2	-	3
Torpedo californica	-	3	-	-	-	-	-	-	3	-	3
Amphistichus argenteus	-	2	1	-	-	-	-	3	-	-	3
Anisotremus davidsonii	-	3	-	-	-	-	2	1	-	-	3
Atherinopsis californiensis	-	3	-	-	-	-	-	3	-	-	3
Sebastes constellatus	-	2	1	-	-	-	-	-	3	-	3
Sebastes lentiginosus	-	-	-	-	1	1	-	-	2	-	2
Acanthogobius flavimanus	2	-	-	-	-	-	2	-	-	-	2
Albula vulpes	-	2	-	-	-	-	2	-	-	-	2
Ophiodon elongatus	1	-	-	-	1	-	-	-	1	1	2
Kathetostoma averruncus	-	1	1	-	-	-	-	-	1	1	2
Ilypnus gilberti	-	2	-	-	-	-	2	-	-	-	2
Sebastes auriculatus	2	-	-	-	-	-	-	2	-	-	2
Icelinus cavifrons	-	-	-	-	-	2	-	-	2	-	2
Eptatretus stoutii	-	2	-	-	-	-	-	-	1	1	2
Gymnura marmorata	-	-	2	-	-	-	2	-	-	-	2
Sebastes levis	-	-	-	-	2	-	-	-	2	-	2
Caulolatilus princeps	-	2	-	-	-	-	-	-	2	-	2
Sebastes simulator	-	-	1	-	-	-	-	-	1	-	1
Anoplopoma fimbria	1	-	-	-	-	-	-	-	-	1	1
Raja binoculata	-	1	-	-	-	-	-	-	-	1	1
Radulinus asprellus	-	-	-	1	-	-	-	-	-	1	1
Mustelus californicus	-	1	-	-	-	-	1	-	-	-	1
Neoclinus blanchardi	-	-	-	1	-	-	-	-	1	-	1
Lythrypnus zebra	-	-	-	-	-	1	-	-	1	-	1
Stereolepis gigas	-	1	-	-	-	-	-	1	-	-	1
Synchiropus atrilabiatus	-	-	-	-	-	1	-	-	1	-	1
Engyophrys sanctilaurentii	-	-	1	-	-	-	-	-	1	-	1
Icelinus filamentosus	-	-	-	1	-	-	-	-	-	1	1
Clupea pallasii	1	-	-	-	-	-	-	-	1	-	1
Squalus acanthias	-	1	-	-	-	-	-	1	-	-	1
Semicossyphus pulcher	-	-	-	-	-	1	-	-	1	-	1
Trachurus symmetricus	1	-	-	-	-	-	-	-	1	-	1
Triakis semifasciata	-	-	1	-	-	-	-	1	-	-	1
Sebastes umbrosus	-	1	-	-	-	-	-	-	1	-	1
Sebastes atrovirens	-	-	-	1	-	-	-	1	-	-	1
Total	10,321	28,532	11,848	2,296	3,318	5,950	15,675	14,709	21,923	9,958	62,265

Appendix C15 (continued)

N = Northern; C = Central; S = Southern; NWI = Northwest Channel Islands; SEI = Southwest Channel Islands; Santa Catalina Island; B&H = Bays and harbors; IS = Inner shelf; MS = Middle shelf; OS = Outer shelf; SCB = Southern California Bight; sp = species

*See Glossary G2 for common names of fish species.

Appendix C16. Biomass (kg) of demersal fish species by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	Region						Shelf Zone				
	Mainland			Island							
Species*	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Genyonemus lineatus	103.7	311.2	79.5	-	-	-	176.6	277.8	40.0	-	494.4
Citharichthys sordidus	43.9	9.0	6.6	46.0	27.2	71.8	-	1.1	83.3	120.0	204.4
Paralichthys californicus	13.5	102.5	38.2	-	-	2.2	45.8	57.4	53.2	-	156.4
Citharichthys xanthostigma	1.7	39.1	37.7	-	-	4.9	-	2.6	78.8	2.0	83.4
Seriphus politus	24.3	37.5	5.4	-	-	-	15.3	47.9	3.9	0.1	67.2
Synodus lucioceps	7.0	30.3	22.8	0.3	0.3	0.2	1.3	9.5	50.1	0.0	60.9
Urolophus halleri	-	0.4	50.2	-	-	-	49.9	0.7	-	-	50.6
Squatina californica	-	50.2	0.1	-	-	-	50.2	-	0.1	-	50.3
Lyopsetta exilis	10.2	10.7	2.3	2.2	5.9	16.8	-	-	0.5	47.5	48.0
Paralabrax nebulifer	0.4	26.3	15.7	-	-	-	26.3	6.9	9.3	-	42.5
Parophrys vetulus	12.6	16.1	6.3	2.5	3.9	0.0	-	3.0	21.9	16.6	41.4
Paralabrax maculatofasciatus	-	0.5	37.4	-	-	-	36.9	1.0	-	-	37.9
Pleuronichthys verticalis	2.6	27.1	5.2	0.2	1.5	0.5	0.2	11.7	24.9	0.3	37.1
Myliobatis californica	11.4	23.2	1.5	-	-	-	27.6	8.5	-	-	36.1
Microstomus pacificus	6.4	7.5	3.0	3.6	4.7	5.0	-	-	9.6	20.6	30.2
Porichthys notatus	7.5	1.8	9.8	2.4	3.5	2.4	0.0	-	17.0	10.3	27.4
Raja inornata	0.3	19.8	6.5	-	0.0	-	4.2	3.7	17.3	1.4	26.6
Hippoglossina stomata	1.3	14.1	6.3	0.4	0.5	3.3	-	0.9	21.7	3.2	25.8
Symphurus atricaudus	2.2	19.9	2.3	0.0	-	0.1	5.1	2.5	17.0	-	24.6
Dasyatis dipterura	-	-	24.0	-	-	-	24.0	-	-	-	24.0
Scorpaena guttata	0.4	9.9	10.6	-	0.9	1.6	0.0	0.9	21.8	0.7	23.4
Phanerodon furcatus	9.4	6.3	4.3	0.0	-	-	12.2	7.8	0.0	-	20.0
Xystreurys liolepis	2.3	12.4	2.2	-	-	3.0	4.4	5.4	10.0	-	19.9
Zaniolepis latipinnis	3.3	5.2	7.0	1.0	0.3	0.0	-	0.0	15.0	1.8	16.8
Sebastes saxicola	3.7	7.5	1.6	0.2	2.6	1.2	-	-	4.5	12.3	16.8
Pleuronichthys guttulatus	-	9.9	6.4	-	-	-	14.2	2.1	-	-	16.3
Zaniolepis frenata	2.1	0.7	0.6	6.0	4.0	2.3	-	-	3.1	12.6	15.7
Porichthys myriaster	0.7	9.5	4.1	0.0	-	0.0	9.1	1.6	3.6	-	14.3
Pleuronichthys ritteri	-	8.1	3.8	-	-	-	6.2	5.1	0.6	-	11.9
Cheilotrema saturnum	-	2.6	7.5	-	-	-	7.4	2.7	-	-	10.1
Citharichthys stigmaeus	2.4	1.6	0.8	3.5	1.0	0.2	0.0	4.9	4.5	-	9.4
Torpedo californica	-	9.1	-	-	-	-	-	-	9.1	-	9.1
Zalembius rosaceus	1.4	2.4	3.6	0.2	0.0	1.1	-	0.0	7.8	0.8	8.5
Sardinops sagax	1.2	6.3	0.0	-	-	-	4.0	3.5	0.0	-	7.5
Roncador stearnsii	-	1.4	5.9	-	-	-	5.4	1.9	-	-	7.3
Lycodes pacificus	0.6	4.3	0.5	0.6	0.1	1.0	-	-	0.3	6.9	7.2
Cymatogaster aggregata	3.0	3.3	0.7	-	-	-	3.1	2.4	1.5	-	7.0
Umbrina roncador	0.2	5.2	1.1	-	-	-	5.4	1.1	-	-	6.5
Rhinobatos productus	-	1.7	4.8	-	-	-	3.7	2.8	-	-	6.5
Icelinus quadriseriatus	1.7	0.7	0.9	0.4	1.1	1.2	-	0.0	5.9	0.0	5.9
Menticirrhus undulatus	0.1	3.3	2.4	-	-	-	-	5.8	-	-	5.8
Engraulis mordax	0.0	5.7	0.0	-	-	-	5.4	0.3	0.0	0.0	5.7
Merluccius productus	0.7	4.7	0.1	-	-	0.0	-	-	0.1	5.4	5.5
Platyrhinoidis triseriata	0.4	3.0	1.6	-	-	-	-	5.0	-	-	5.0
Eopsetta jordani	0.3	-	-	0.5	-	4.2	-	-	2.6	2.4	5.0
Mustelus henlei	4.5	-	-	-	-	-	-	2.5	2.0	-	4.5
Anchoa compressa	-	0.8	3.0	-	-	-	3.4	0.4	-	-	3.8

Appendix C16 (continued)

	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Gymnura marmorata	-	-	3.6	-	-	-	3.6	-	-	-	3.6
Paralabrax clathratus	-	2.3	0.4	-	-	0.3	0.4	0.3	2.3	-	3.0
Citharichthys fragilis	1.4	0.5	0.8	-	0.0	0.1	-	-	0.5	2.3	2.8
Cephaloscyllium ventriosum	-	-	-	2.3	0.3	-	-	-	2.6	-	2.6
Icelinus tenuis	0.0	0.0	0.0	1.5	0.2	0.9	-	-	1.7	0.9	2.6
Xeneretmus latifrons	0.6	0.2	-	1.1	0.4	-	-	-	-	2.3	2.3
Pleuronichthys decurrens	-	-	-	1.7	0.3	0.3	-	-	2.3	0.0	2.3
Glyptocephalus zachirus	0.6	0.5	-	0.3	0.1	0.7	-	-	-	2.2	2.2
Sebastes elongatus	0.9	0.2	0.0	-	0.0	0.9	-	-	0.0	2.0	2.0
Hyperprosopon argenteum	0.0	0.5	1.3	-	-	-	-	1.8	-	-	1.8
Embiotoca jacksoni	0.0	-	1.8	-	-	-	0.8	1.0	-	-	1.8
Prionotus stephanophrys	-	0.2	1.5	-	-	-	-	-	1.6	0.1	1.7
Anisotremus davidsonii	-	1.6	-	-	-	-	1.6	0.0	-	-	1.6
Hydrolagus colliei	0.1	-	0.5	0.0	0.1	0.9	-	-	0.9	0.7	1.6
Sebastes semicinctus	0.8	0.0	0.1	0.1	0.1	0.4	-	-	0.3	1.2	1.5
Raja binoculata	-	1.4	-	-	-	-	-	-	-	1.4	1.4
Sebastes goodei	0.7	-	-	0.4	-	-	-	-	-	1.1	1.1
Squalus acanthias	-	1.1	-	-	-	-	-	1.1	-	-	1.1
Chilara taylori	0.0	0.4	0.0	0.0	0.7	0.0	-	-	0.1	1.0	1.1
Trichiurus lepturus	0.0	0.4	0.6	-	-	-	0.4	0.6	0.0	-	1.0
Raja rhina	0.4	-	-	0.3	0.3	-	-	-	-	1.0	1.0
Rhacochilus vacca	-	0.4	0.6	-	-	-	0.4	0.2	0.4	-	1.0
Sebastes ensifer	-	-	0.3	0.7	-	-	-	-	-	1.0	1.0
Mustelus californicus	-	0.8	-	-	-	-	0.8	-	-	-	0.8
Lepidopsetta bilineata	-	-	-	0.8	-	-	-	-	0.4	0.4	0.8
Pleuronichthys coenosus	-	-	0.1	0.7	-	-	-	0.7	0.1	-	0.8
Amphistichus argenteus	-	0.2	0.5	-	-	-	-	0.7	-	-	0.7
Lepidogobius lepidus	0.0	0.0	0.0	0.0	-	0.7	0.0	0.0	0.7	0.0	0.7
Atherinopsis californiensis	-	0.6	-	-	-	-	-	0.6	-	-	0.6
Sebastes chlorostictus	0.2	0.0	0.4	0.0	0.0	0.0	-	-	0.2	0.4	0.6
Kathetostoma averruncus	-	0.5	0.0	-	-	-	-	-	0.5	0.0	0.5
Eptatretus stoutii	-	0.4	-	-	-	-	-	-	0.3	0.1	0.4
Sebastolobus alascanus	-	0.4	-	-	-	-	-	-	-	0.4	0.4
Sebastes auriculatus	0.4	-	-	-	-	-	-	0.4	-	-	0.4
Chitonotus pugetensis	0.0	0.0	0.1	0.0	0.3	0.0	-	0.0	0.4	-	0.4
Sebastes diploproa	0.1	0.2	-	-	0.0	0.0	-	-	-	0.3	0.3
Sebastes miniatus	0.0	0.2	0.0	-	0.0	0.1	-	-	0.3	-	0.3
Atractoscion nobilis	-	0.3	0.0	-	-	-	0.0	0.3	-	-	0.3
Sebastes rubrivinctus	-	0.0	0.3	0.0	0.0	0.0	-	-	0.0	0.3	0.3
Sebastes rosenblatti	0.0	0.3	0.0	0.0	0.0	0.0	-	-	0.3	0.0	0.3
Sebastes eos	0.2	0.1	0.0	-	-	0.0	-	-	0.0	0.3	0.3
Cryptotrema corallinum	-	-	-	-	0.1	0.2	-	-	0.3	-	0.3
Sebastes dallii	0.2	-	-	-	-	-	0.0	-	0.2	-	0.2
Hippocampus ingens	-	-	0.2	-	-	-	0.2	-	-	-	0.2
Physiculus rastrelliger	-	0.2	-	-	-	-	-	-	-	0.2	0.2
Sebastes umbrosus	-	0.2	-	-	-	-	-	-	0.2	-	0.2
Triakis semifasciata	-	-	0.2	-	-	-	-	0.2	-	-	0.2
Argentina sialis	0.0	0.0	0.2	0.0	0.0	0.0	-	-	0.2	0.0	0.2
Sebastes jordani	0.1	-	-	0.0	0.0	0.0	-	-	0.0	0.1	0.1

Appendix C16 (continued)

	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Icelinus filamentosus	-	-	-	0.1	-	-	-	-	-	0.1	0.1
Anchoa delicatissima	-	0.0	0.1	-	-	-	0.0	0.1	-	-	0.1
Peprilus simillimus	0.0	0.1	-	-	-	-	0.0	0.1	-	-	0.1
Lyconema barbatum	0.1	0.0	-	-	0.0	-	-	-	-	0.1	0.1
Caulolatilus princeps	-	0.1	-	-	-	-	-	-	0.1	-	0.1
Anoplopoma fimbria	0.1	-	-	-	-	-	-	-	-	0.1	0.1
Enophrys taurina	0.0	-	-	0.1	0.0	-	-	0.0	0.1	-	0.1
Agonopsis sterletus	0.0	-	0.0	-	0	0	-	-	0.0	-	0.0
Sebastes macdonaldi	0.0	-	-	-	0	-	-	-	0.0	0.0	0.0
Xeneretmus triacanthus	0.0	-	0.0	0	0	0	-	-	0.0	0.0	0.0
Coryphopterus nicholsii	-	0.0	-	-	0	0	-	-	0.0	-	0.0
Clupea pallasii	0.0	-	-	-	-	-	-	-	0.0	-	0.0
Sebastes levis	-	-	-	-	0	-	-	-	0.0	-	0.0
Atherinops affinis	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Sebastes rosaceus	-	-	0.0	-	-	-	-	-	-	0.0	0.0
Sebastes simulator	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Albula vulpes	-	0.0	-	-	-	-	0.0	-	-	-	0.0
SEBASTES SP	-	-	0.0	-	-	-	-	-	0.0	0.0	0.0
Sebastes lentiginosus	-	-	-	-	0	0	-	-	0.0	-	0.0
Lycodes cortezianus	-	0.0	-	-	0	-	-	-	-	0.0	0.0
Acanthogobius flavimanus	0.0	-	-	-	-	-	0.0	-	-	-	0.0
Syngnathus exilis	0.0	0.0	0.0	-	-	0	-	0.0	-	0.0	0.0
Plectobranchus evides	0.0	0.0	0.0	0	0	0	-	-	-	0.0	0.0
Ophiodon elongatus	0.0	-	-	-	0	-	-	-	0.0	0.0	0.0
Ophidion scrippsae	-	0.0	-	-	-	-	0.0	0.0	-	-	0.0
Odontopyxis trispinosa	0.0	0.0	0.0	0	0	0	-	-	0.0	-	0.0
Neoclinus blanchardi	-	-	-	0	-	-	-	-	0.0	-	0.0
Trachurus symmetricus	0.0	-	-	-	-	-	-	-	0.0	-	0.0
Synchiropus atrilabiatus	-	-	-	-	-	0	-	-	0.0	-	0.0
Macroramphosus gracilis	-	-	0.0	-	-	0	-	-	0.0	-	0.0
Lythrypnus zebra	-	-	-	-	-	0	-	-	0.0	-	0.0
Sebastes caurinus	0.0	-	0.0	0	-	-	-	0.0	0.0	0.0	0.0
Stereolepis gigas	-	0.0	-	-	-	-	-	0.0	-	-	0.0
Engyophrys sanctilaurentii	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Ilypnus gilberti	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Radulinus asprellus	-	-	-	0	-	-	-	-	-	0.0	0.0
Semicossyphus pulcher	-	-	-	-	-	0	-	-	0.0	-	0.0
Icelinus cavifrons	-	-	-	-	-	0	-	-	0.0	-	0.0
Raja stellulata	-	-	-	0	0	-	-	-	0.0	0.0	0.0
Hypsoblennius jenkinsi	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Rathbunella alleni	-	-	-	-	0	-	-	-	0.0	-	0.0
Rathbunella hypoplecta	-	-	0.0	-	0	0	-	-	0.0	-	0.0
Heterostichus rostratus	0.0	-	0.0	-	-	-	0.0	0.0	-	-	0.0
Syngnathus californiensis	-	-	0.0	-	-	-	-	0.0	-	-	0.0
Sebastes atrovirens	-	-	-	0	-	-	-	0.0	-	-	0.0
Sebastes constellatus	-	0.0	0.0	-	-	-	-	-	0.0	-	0.0
Lythrypnus dalli	-	-	-	-	-	0	-	-	0.0	-	0.0
Total	293.9	887.1	448.1	79.7	60.2	128.1	555.4	499.3	557.9	284.4	1897.1

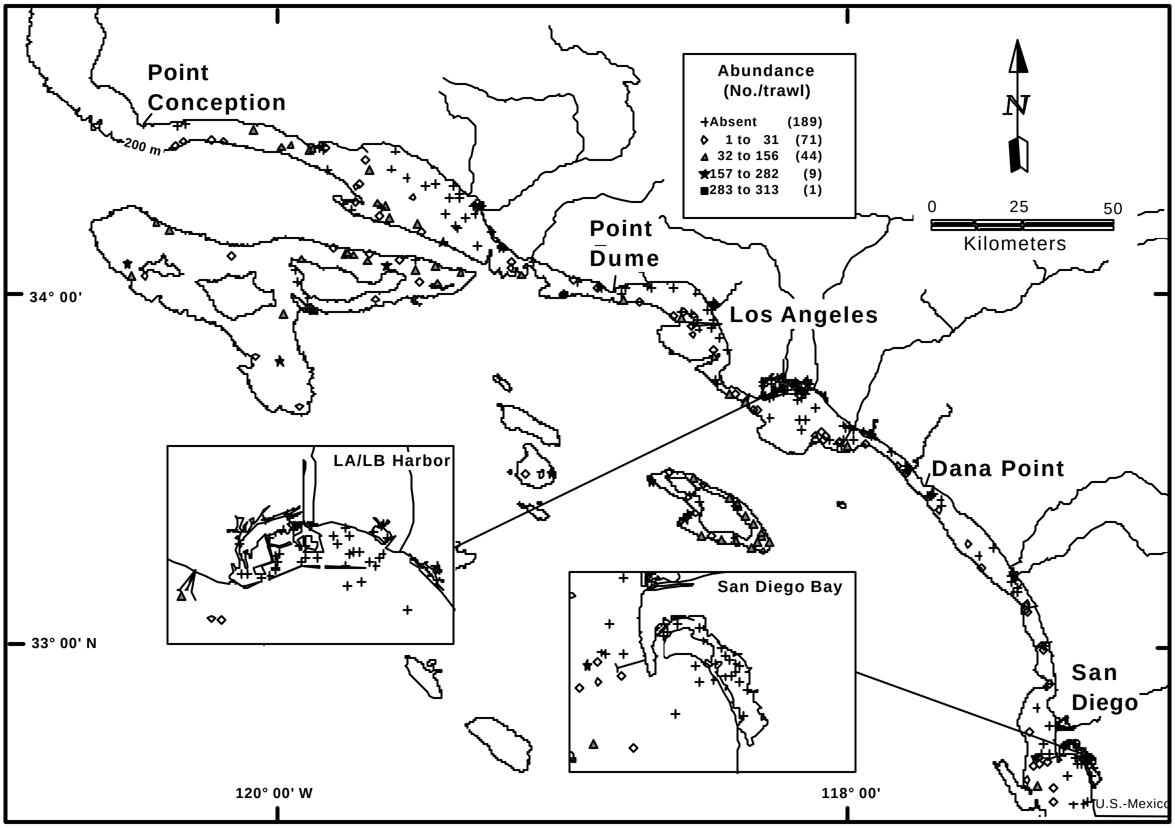
Appendix C16 (continued)

N = Northern; C = Central; S = Southern; NWI = Northwest Islands; SEI = Southwest Islands; CAT = Santa Catalina island; B&H = Bays and harbors; IS = Inner shelf; MS = Middle shelf; OS = Outer shelf; SCB = Southern California Bight; sp = species.

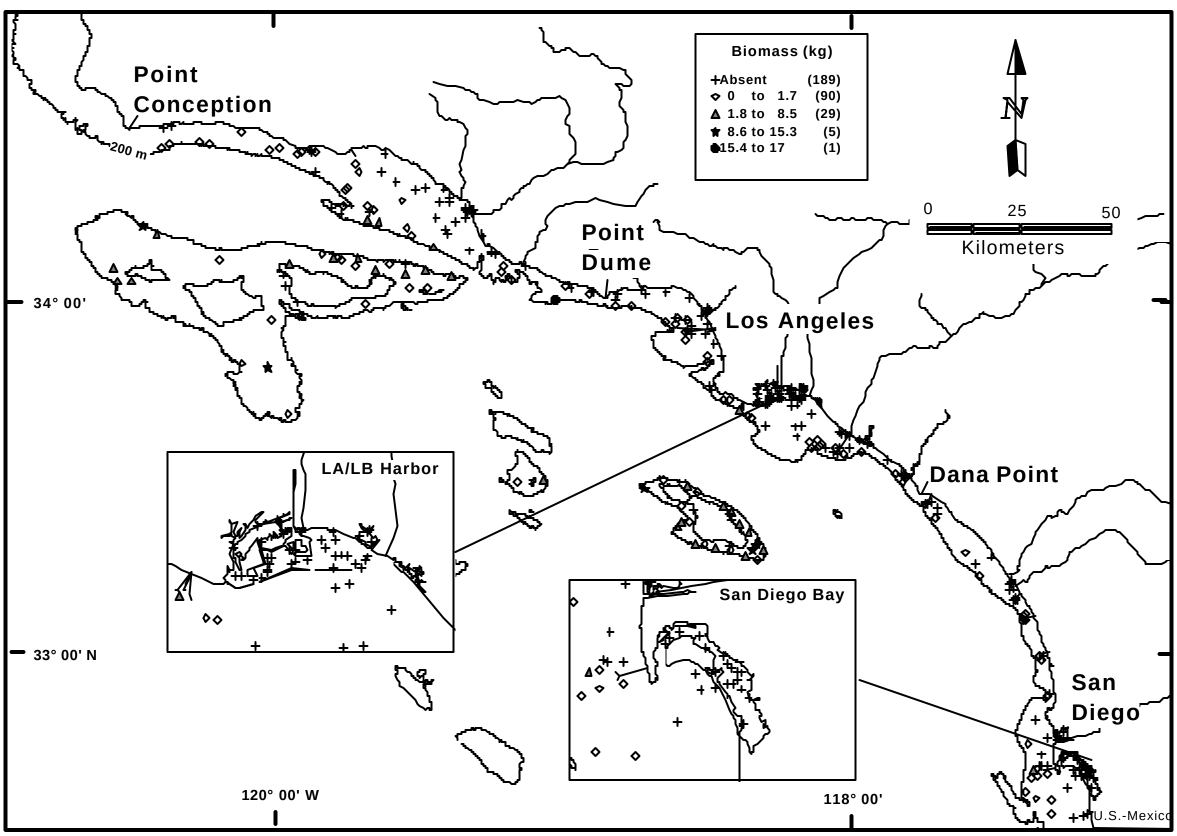
0.0 = less than 0.05 kg

*See Glossary G2 for common names of fish species.

a)

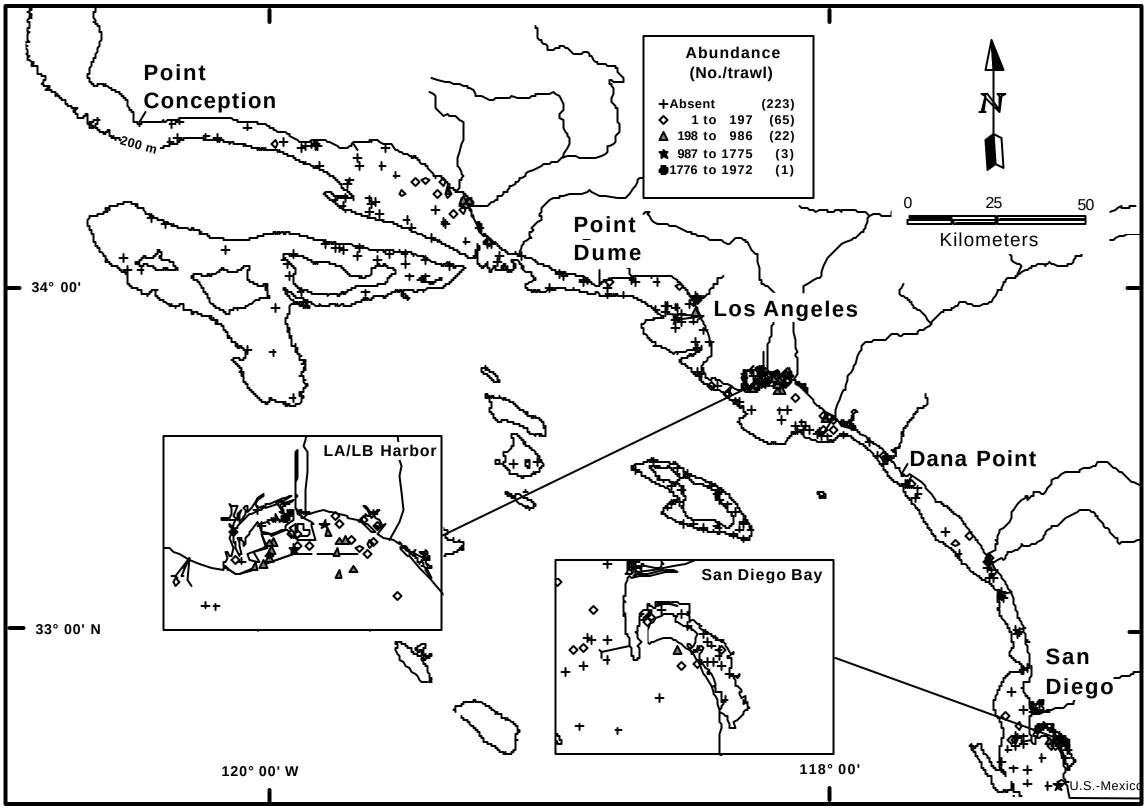


b)

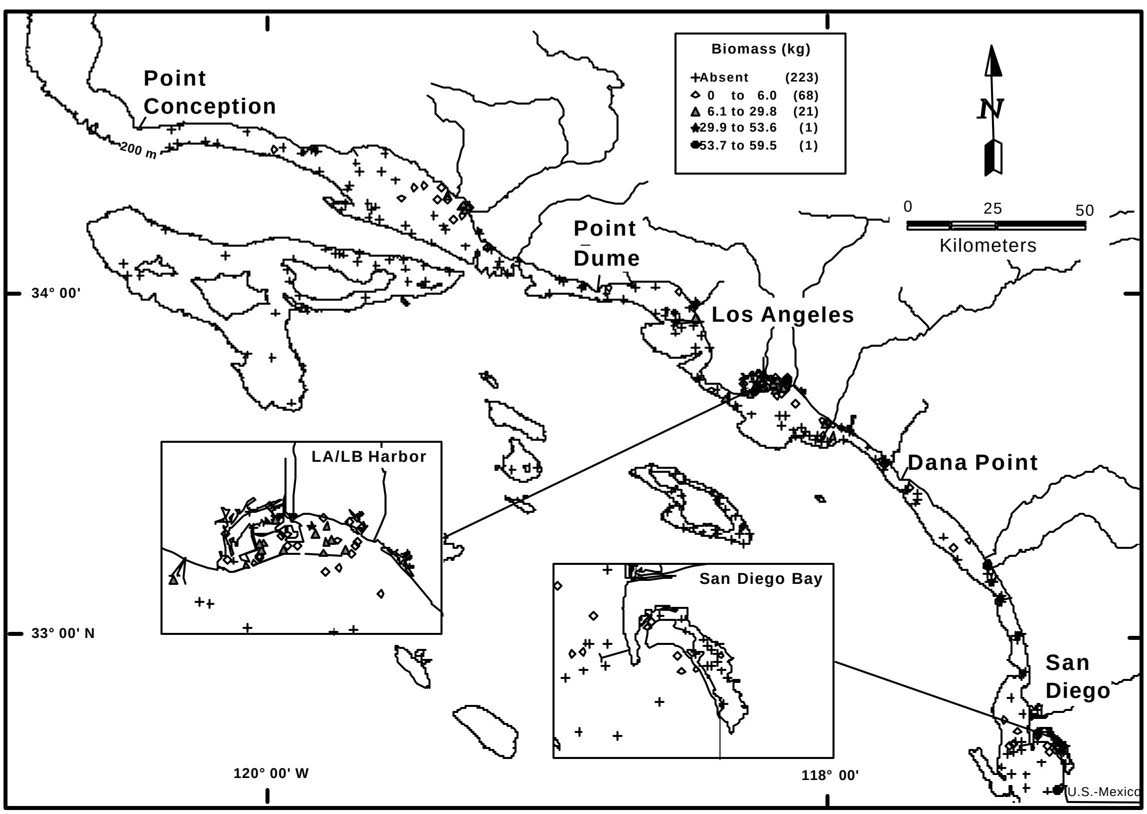


Appendix C17. Distribution of Pacific sanddab (*Citharichthys sordidus*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

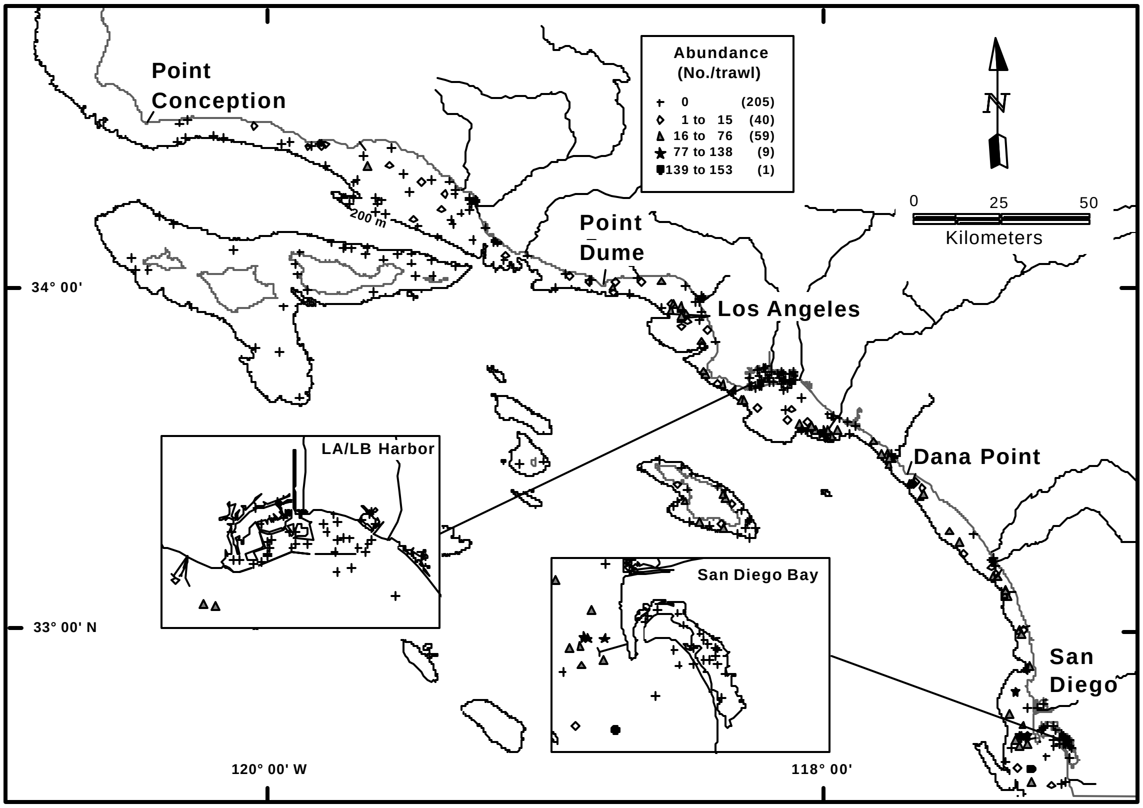


b)

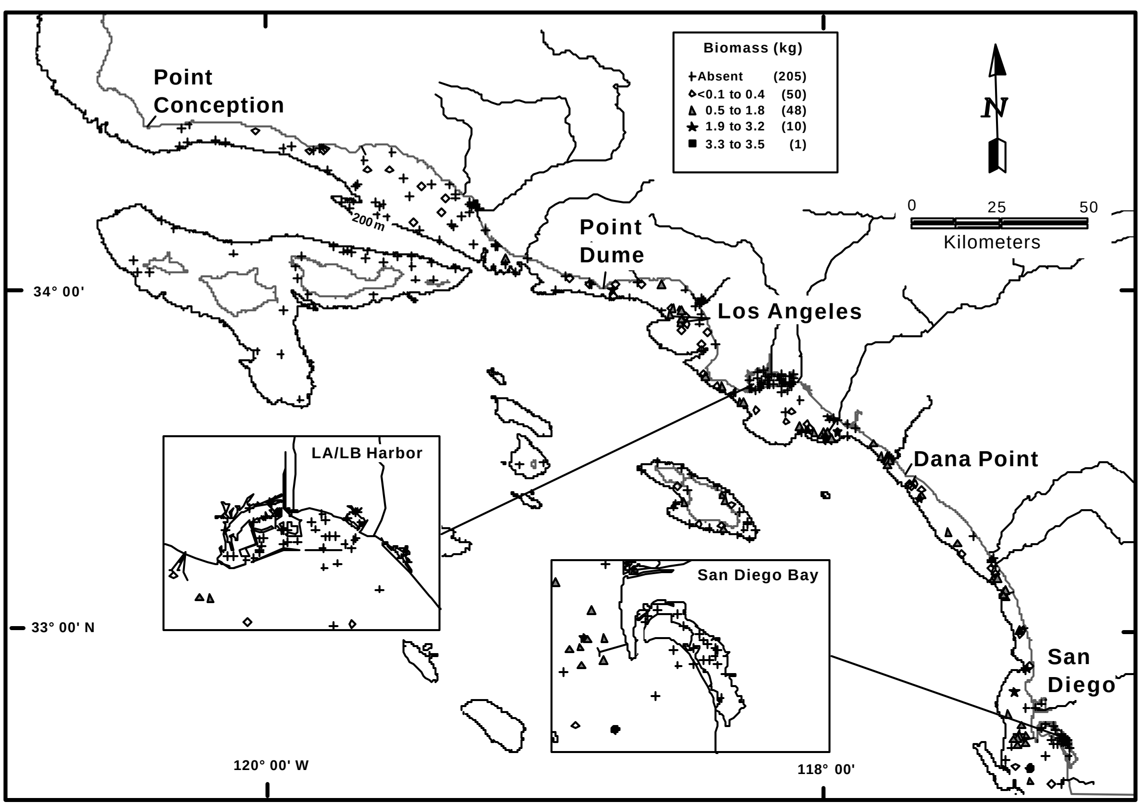


Appendix C18. Distribution of white croaker (*Genyonemus lineatus*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

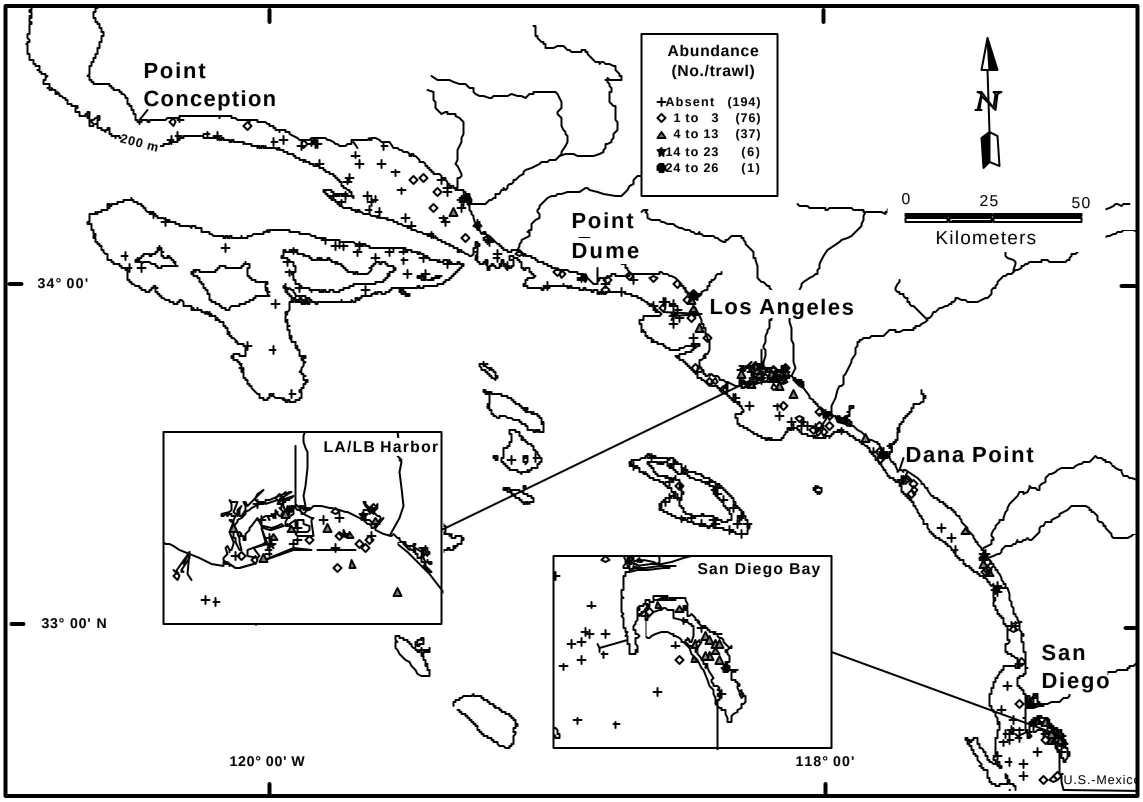


b)

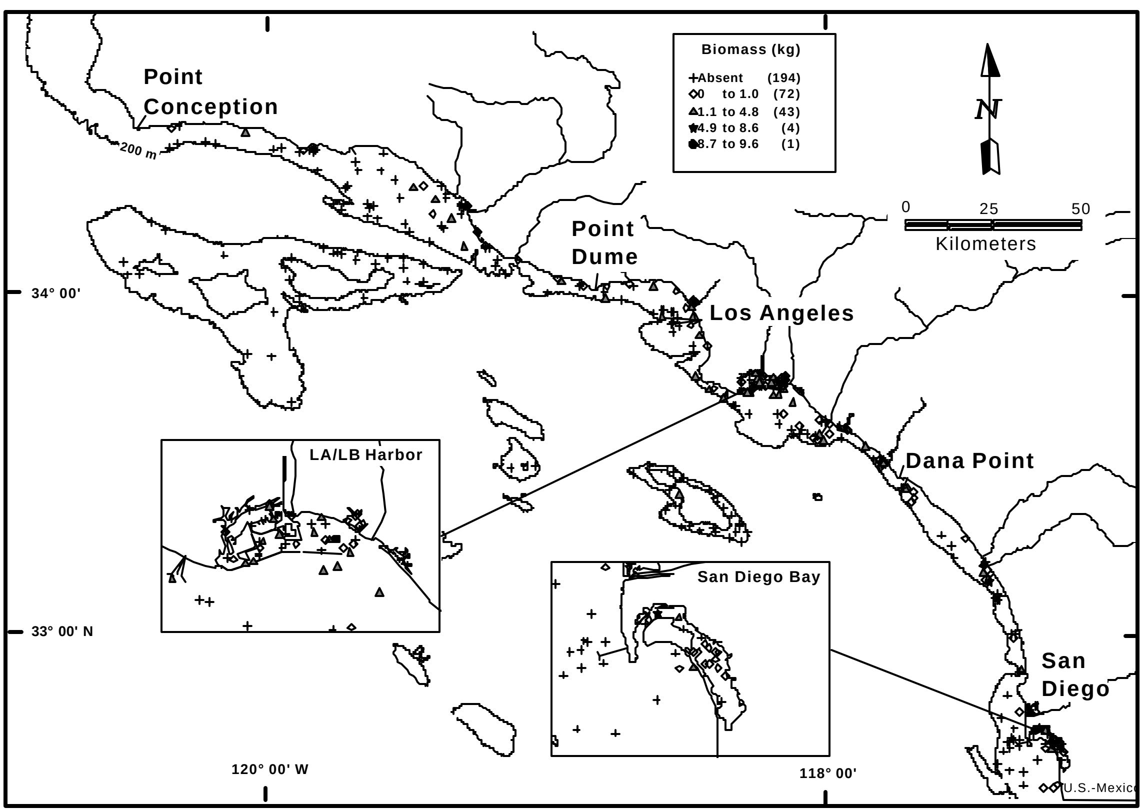


Appendix C19. Distribution of longfin sanddab (*Citharichthys xanthostigma*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

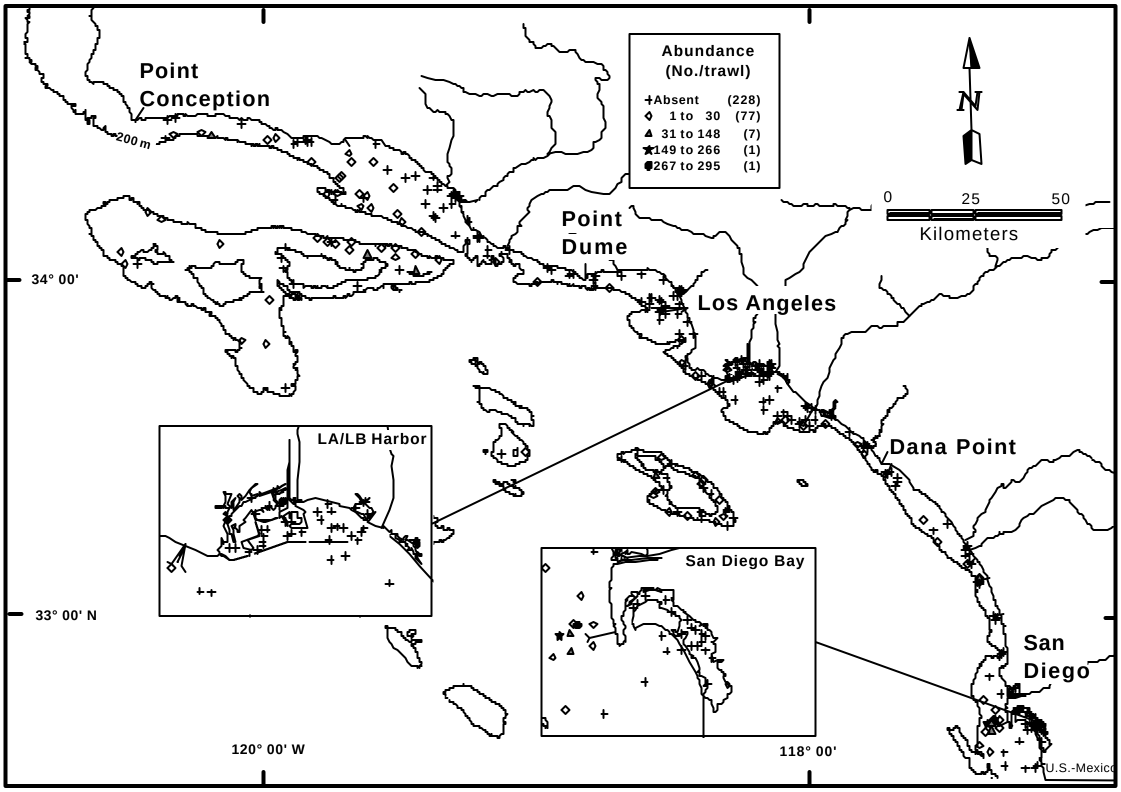


b)

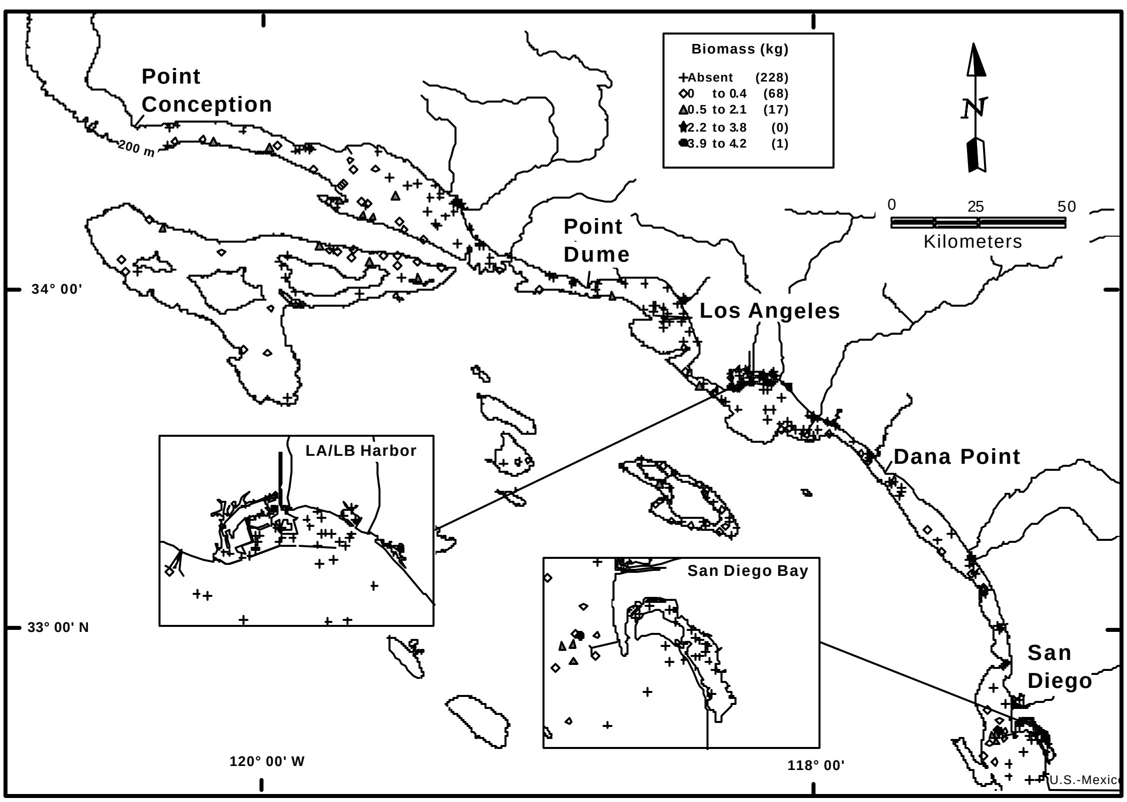


Appendix C20. Distribution of California halibut (*Paralichthys californicus*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

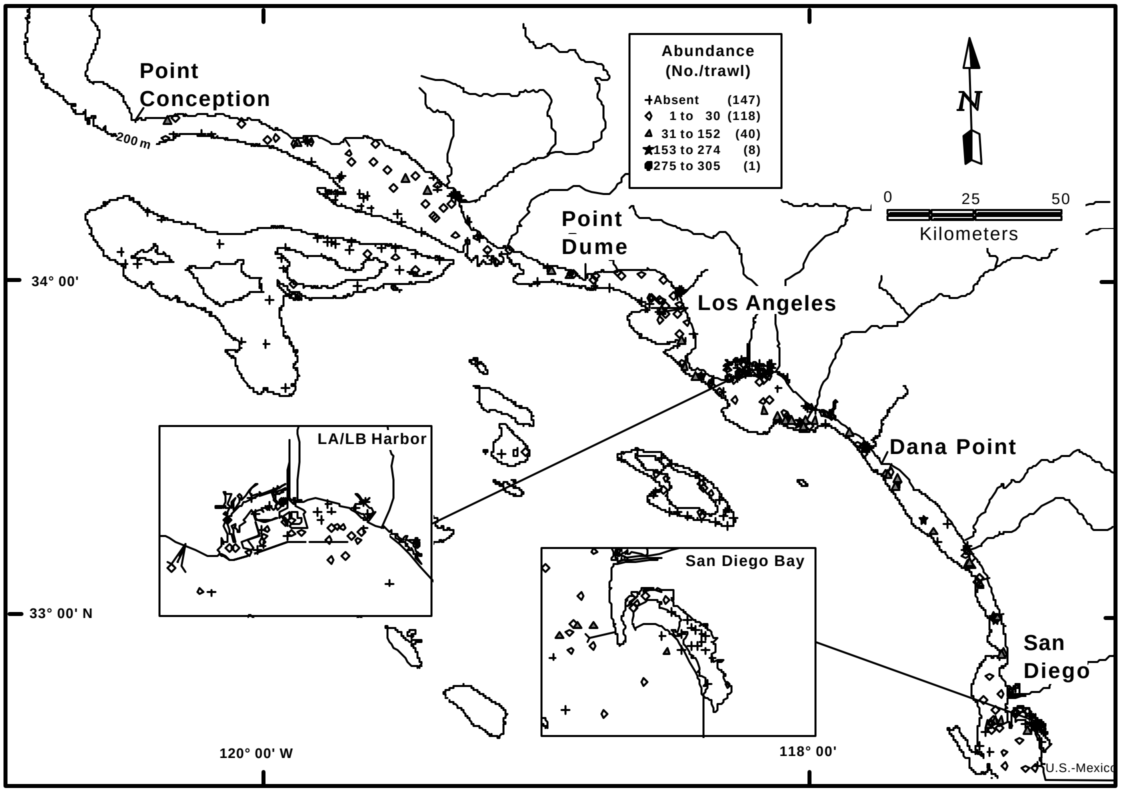


b)

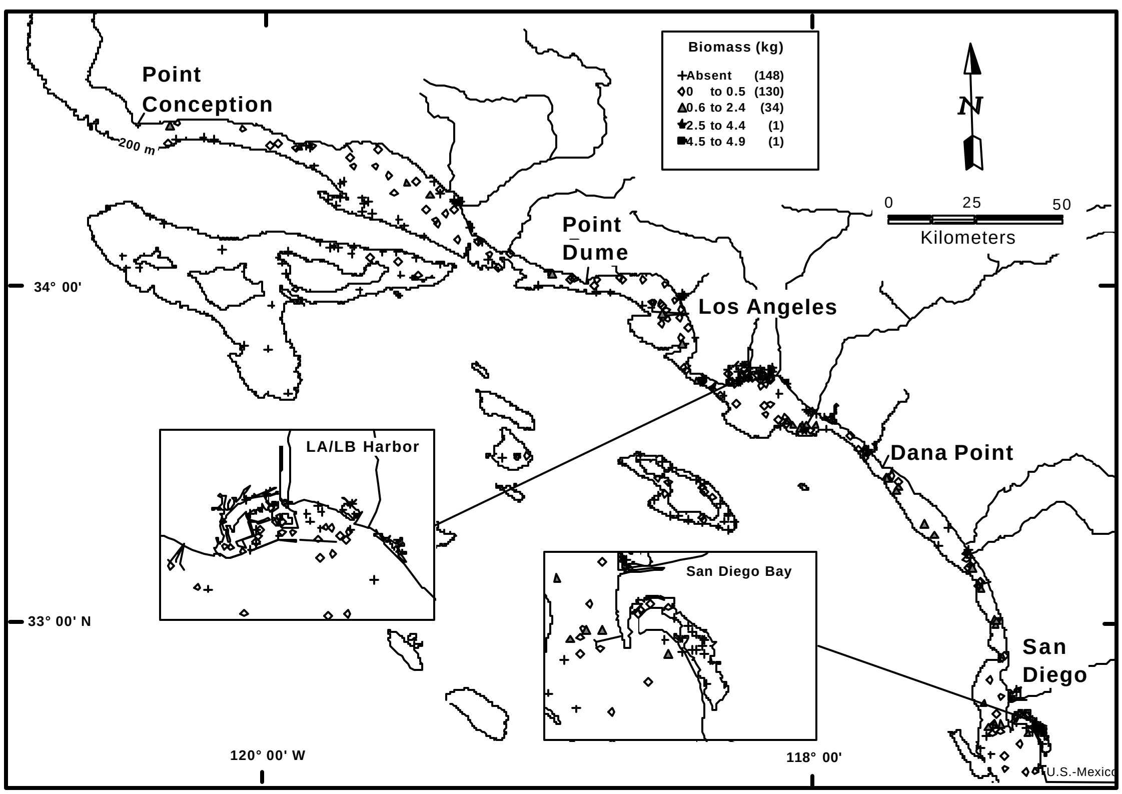


Appendix C21. Distribution of plainfin midshipman (*Porichthys notatus*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

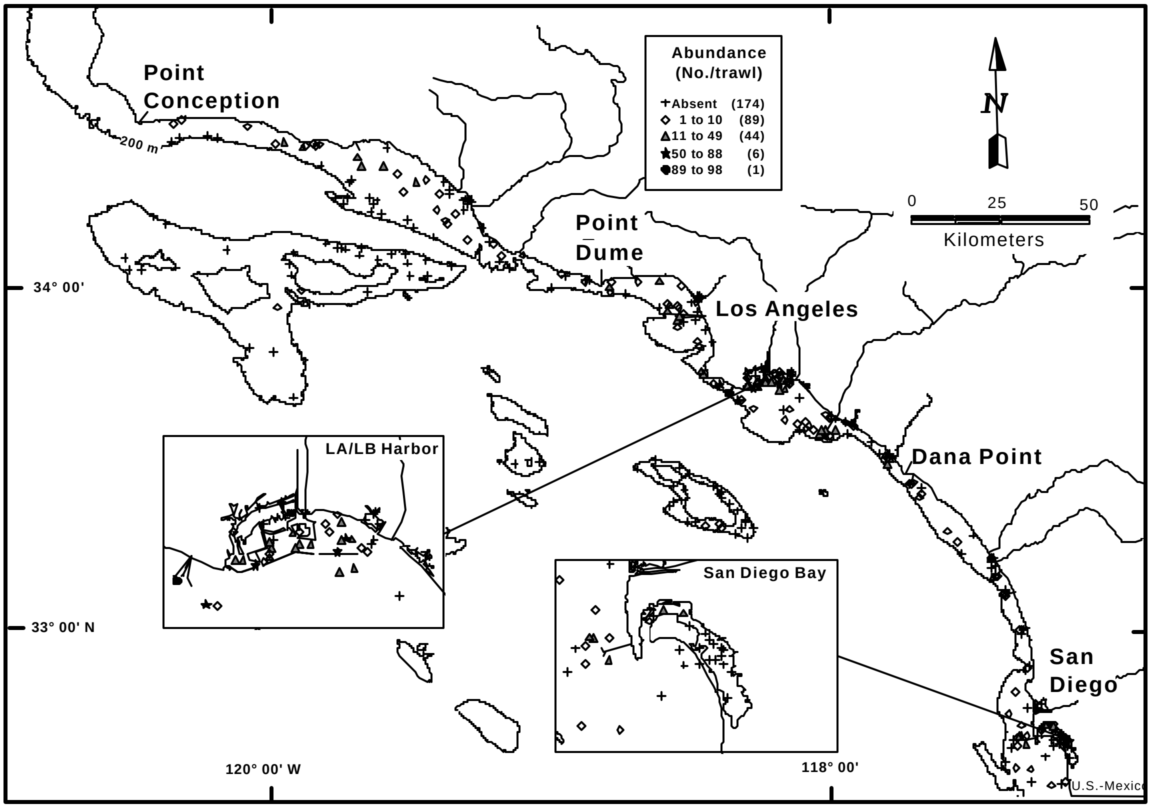


b)

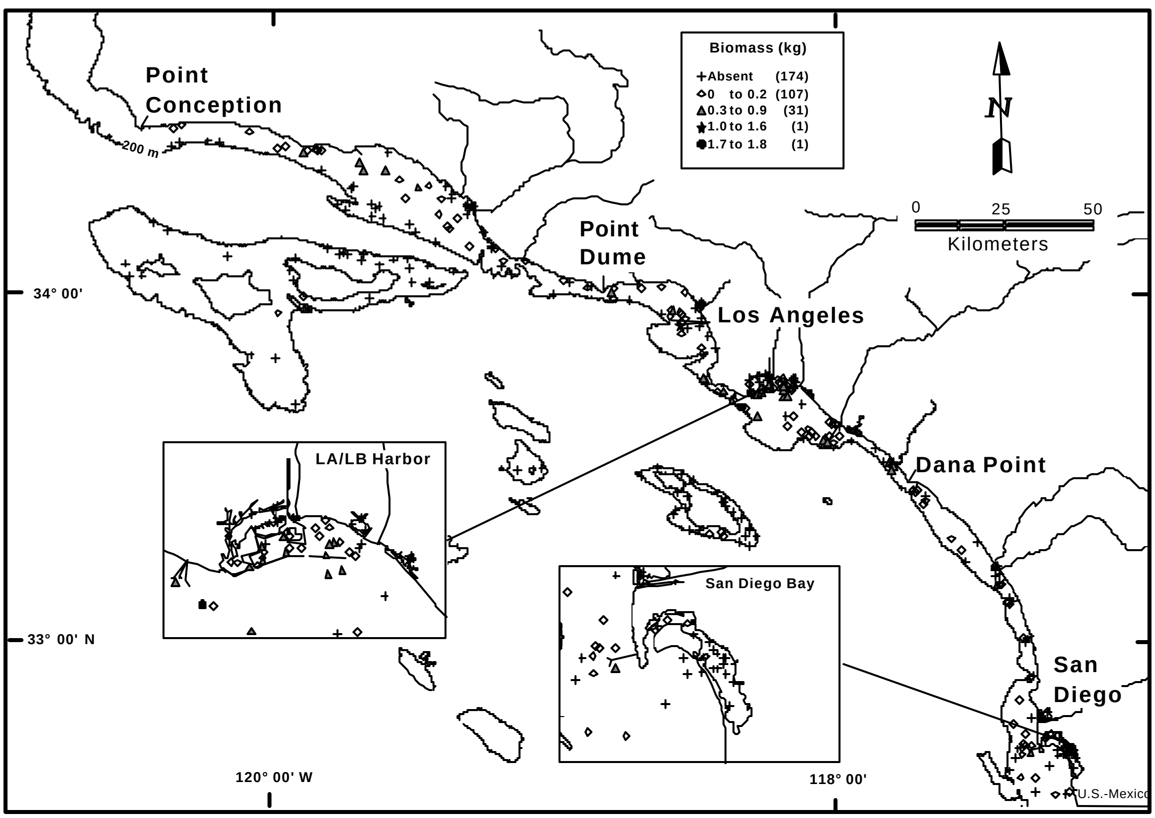


Appendix C22. Distribution of California lizardfish (*Synodus lucioceps*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

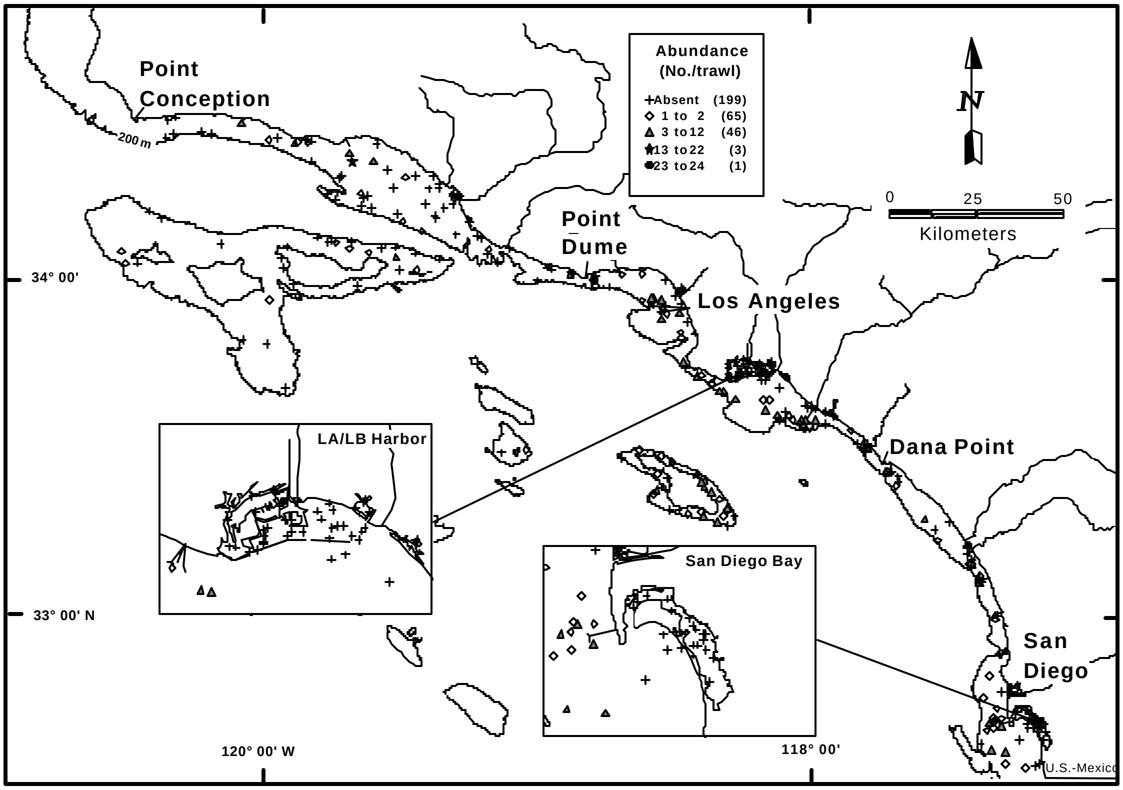


b)

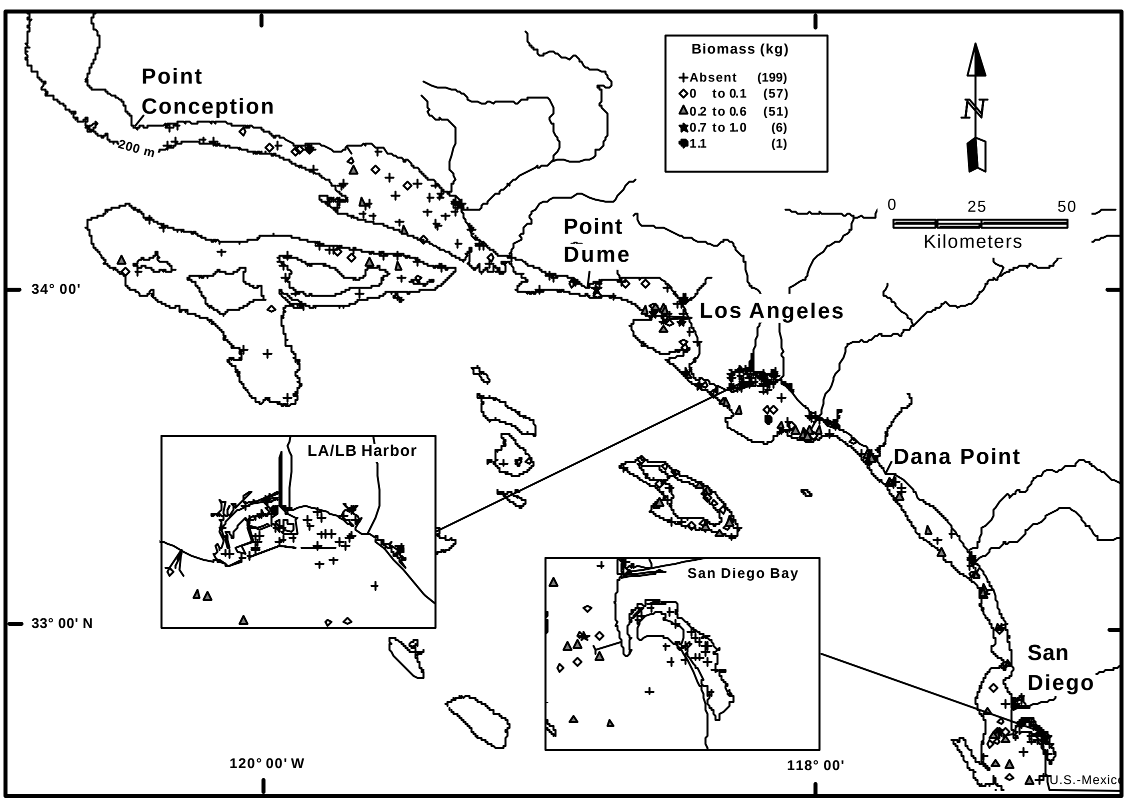


Appendix C23. Distribution of California tonguefish (*Symphurus atricaudus*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

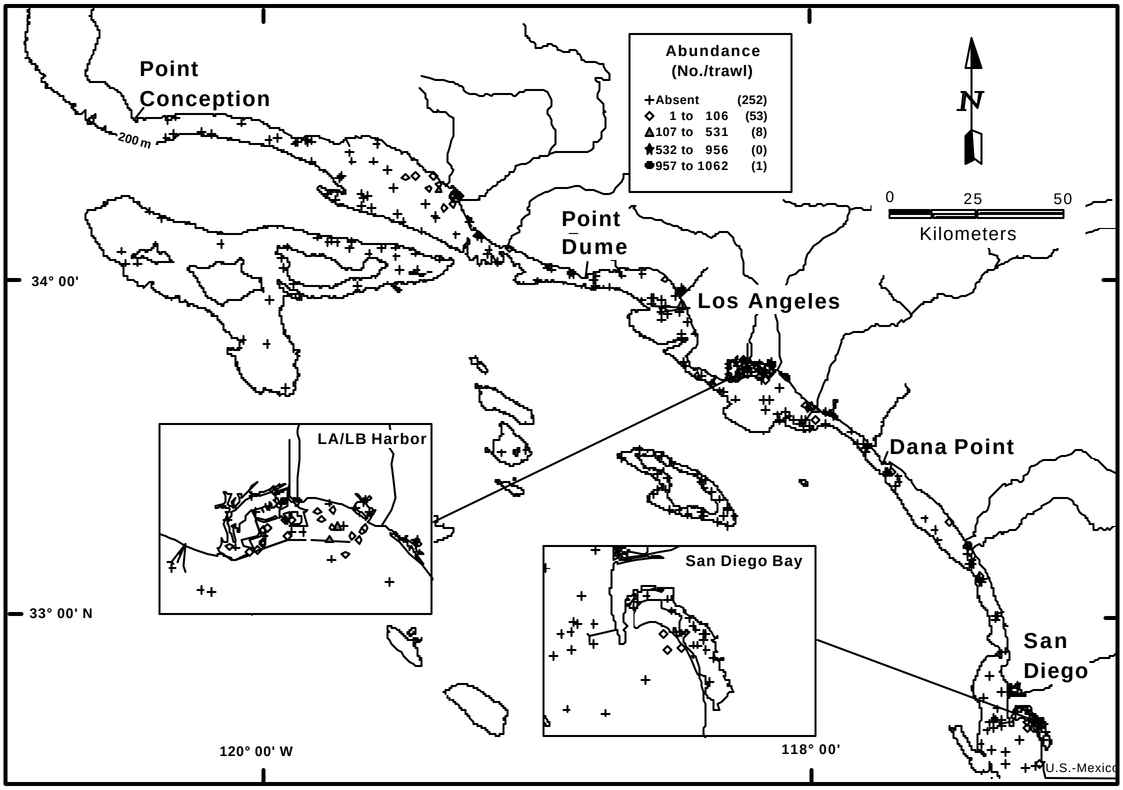


b)

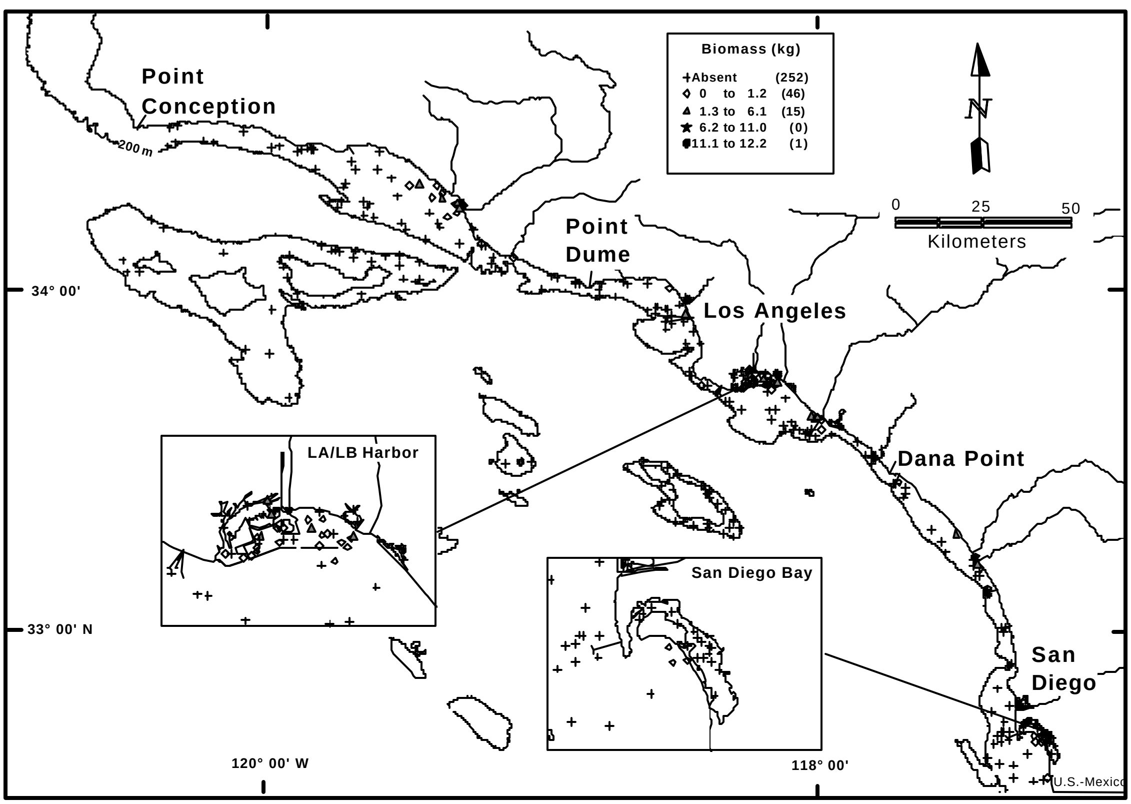


Appendix C24. Distribution of bigmouth sole (*Hippoglossina stomata*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

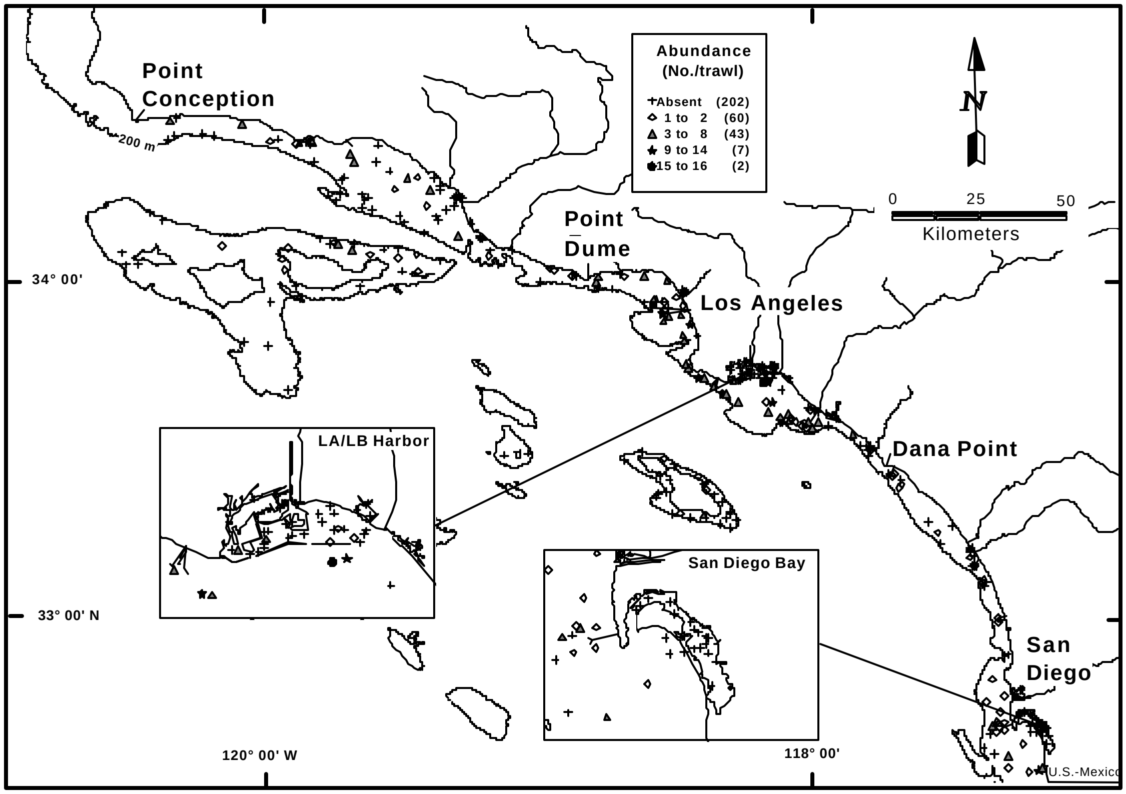


b)

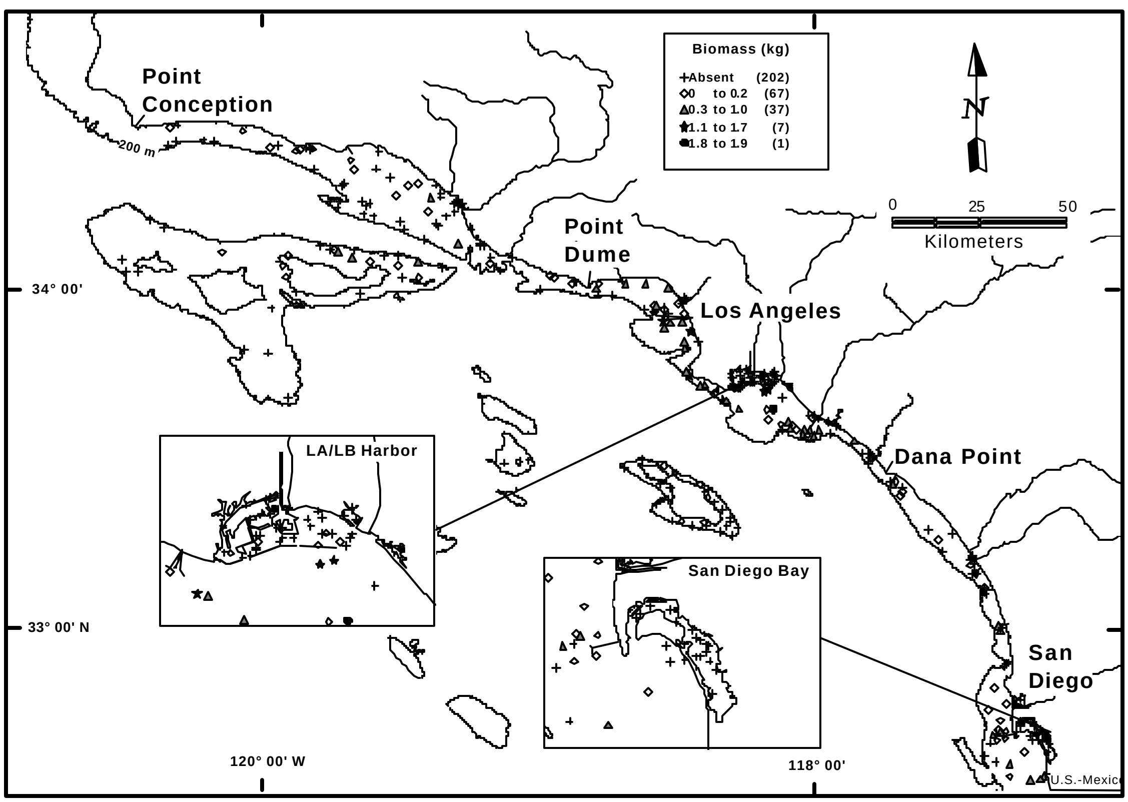


Appendix C25. Distribution of queenfish (*Seriphus politus*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

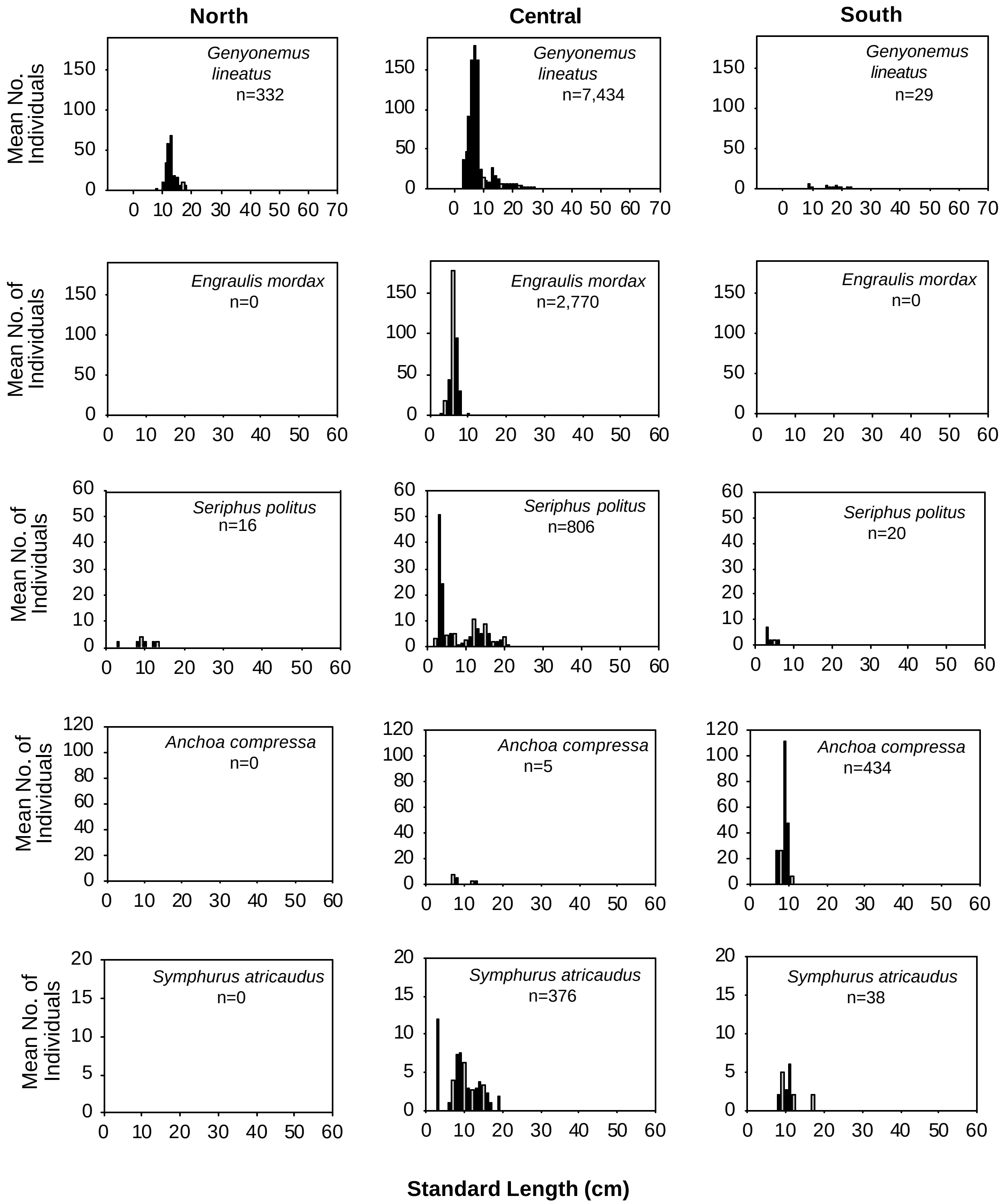
a)



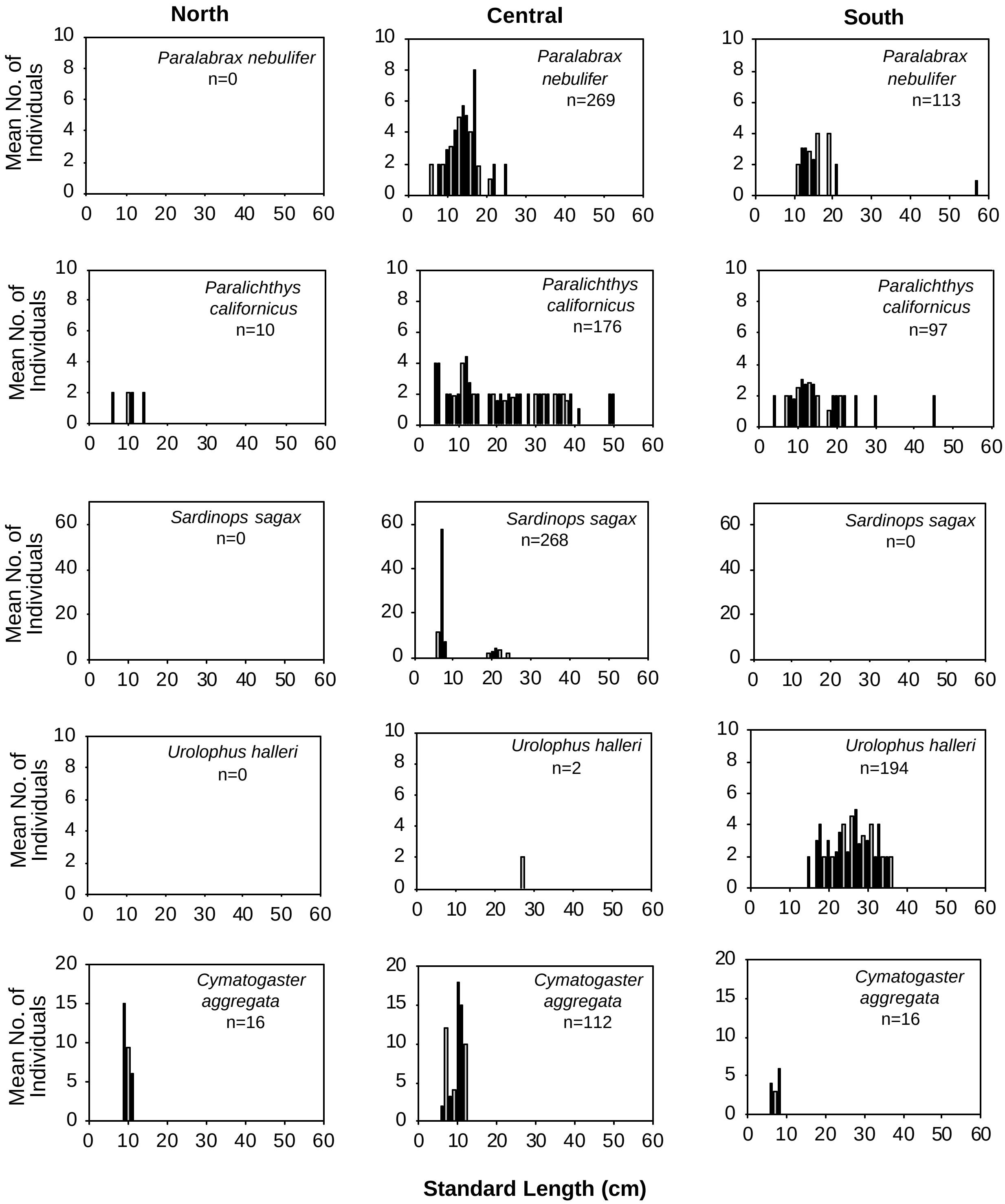
b)



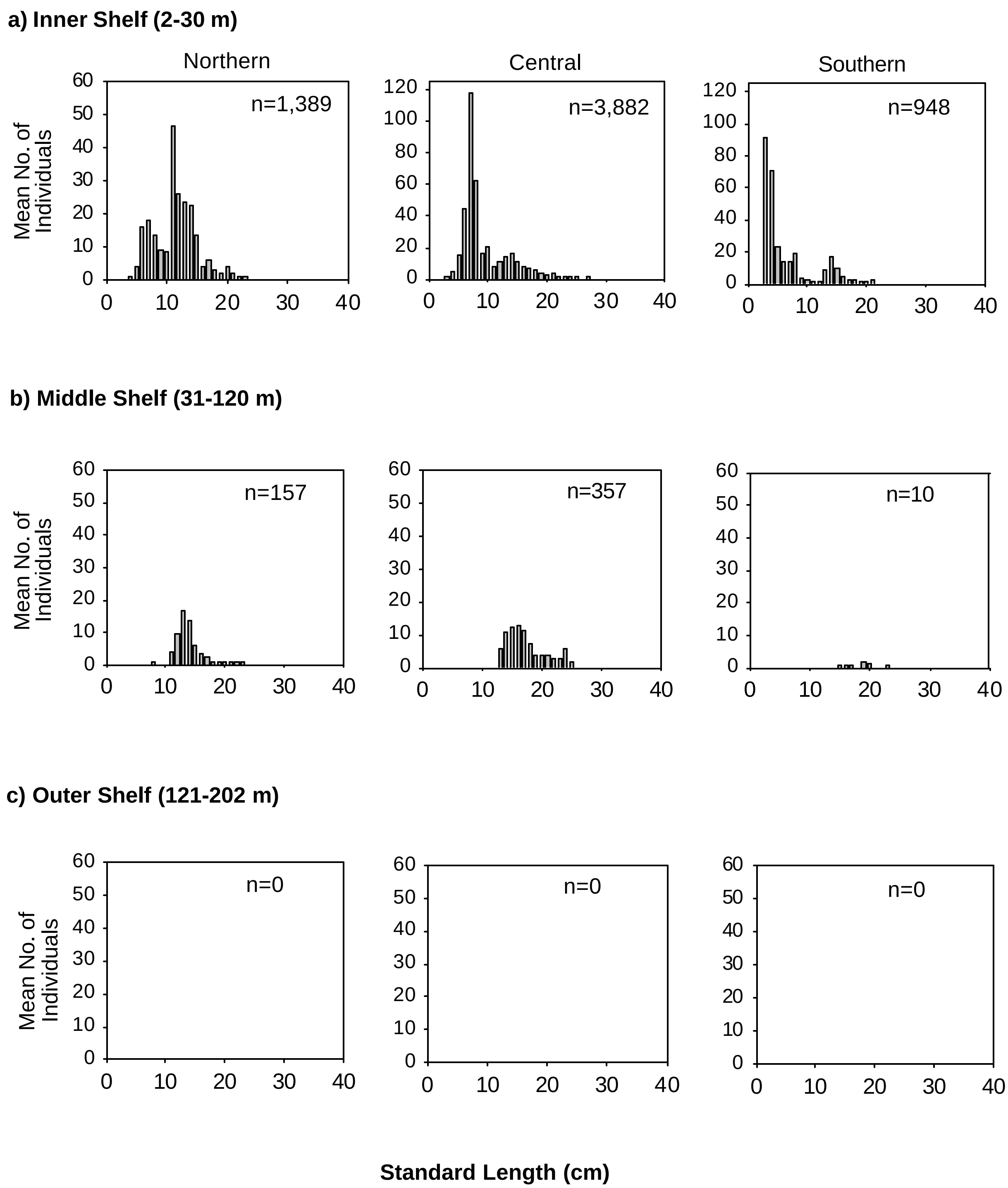
Appendix C26. Distribution of hornyhead turbot (*Pleuronichthys verticalis*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.



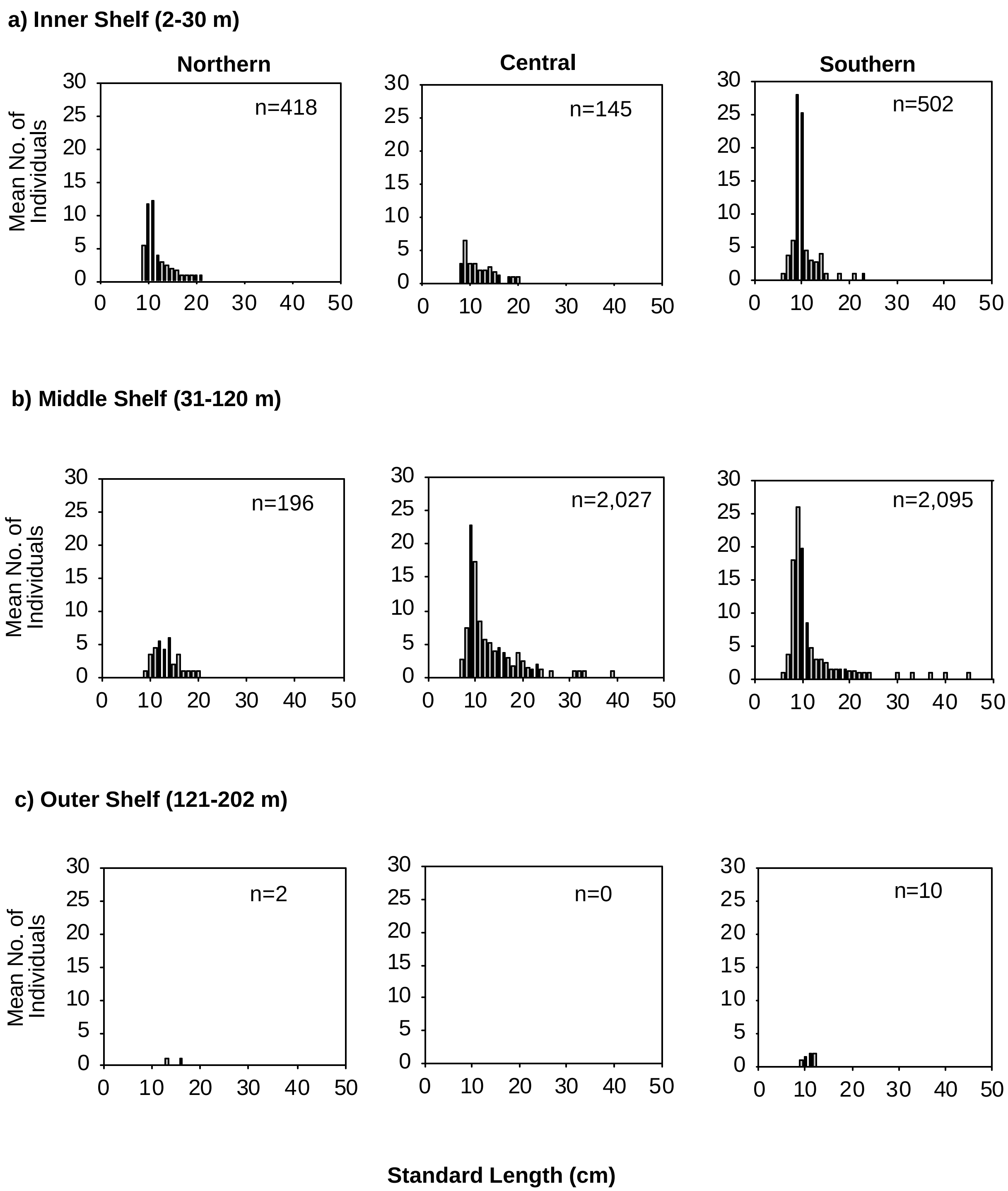
Appendix C27. Length-frequency distribution (mean number of fish per size class) of the 10 most abundant species collected in southern California bays and harbors (2-30 m) by region, July-September 1998. n = Number of fish measured.



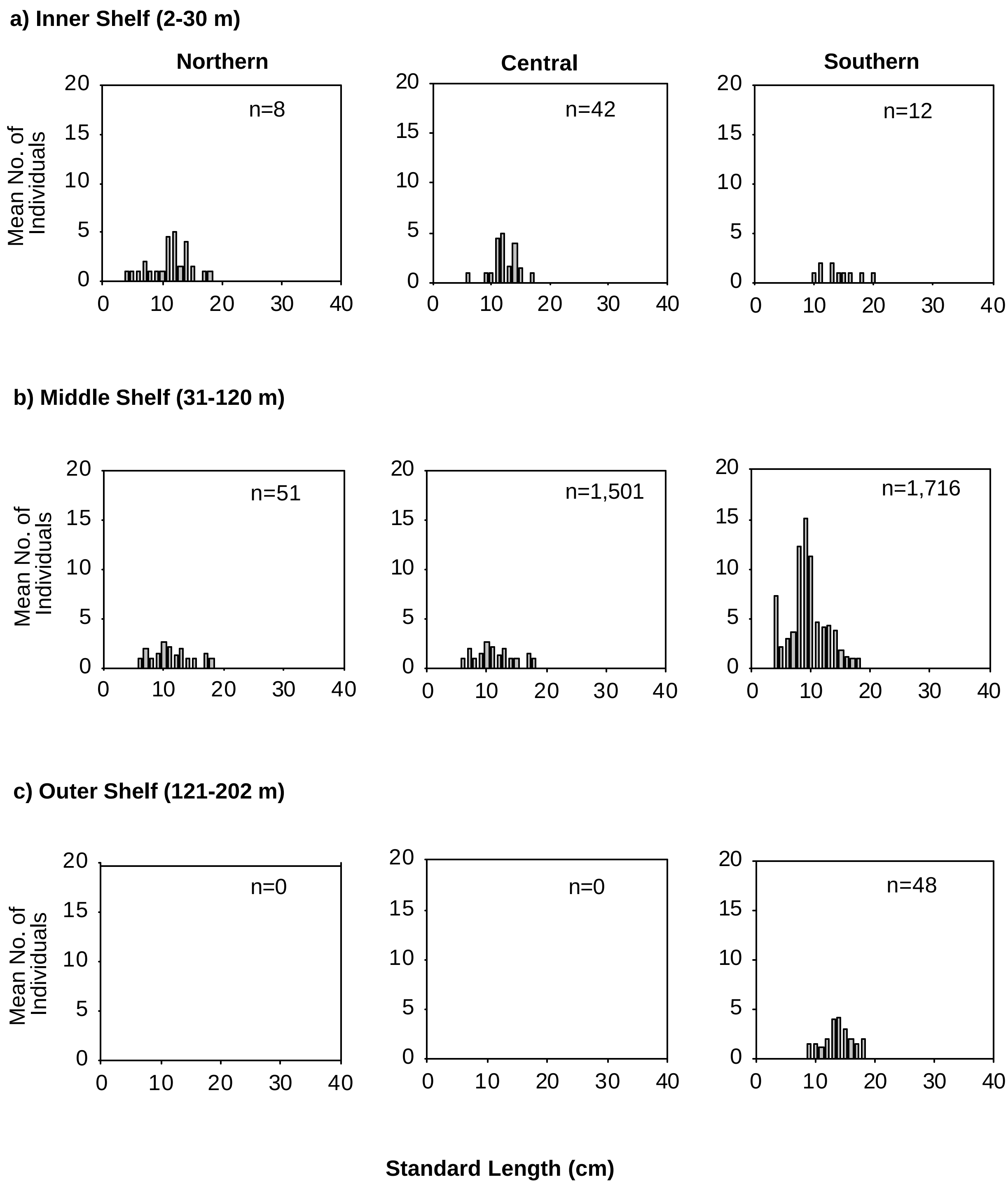
Appendix C27 (continued).



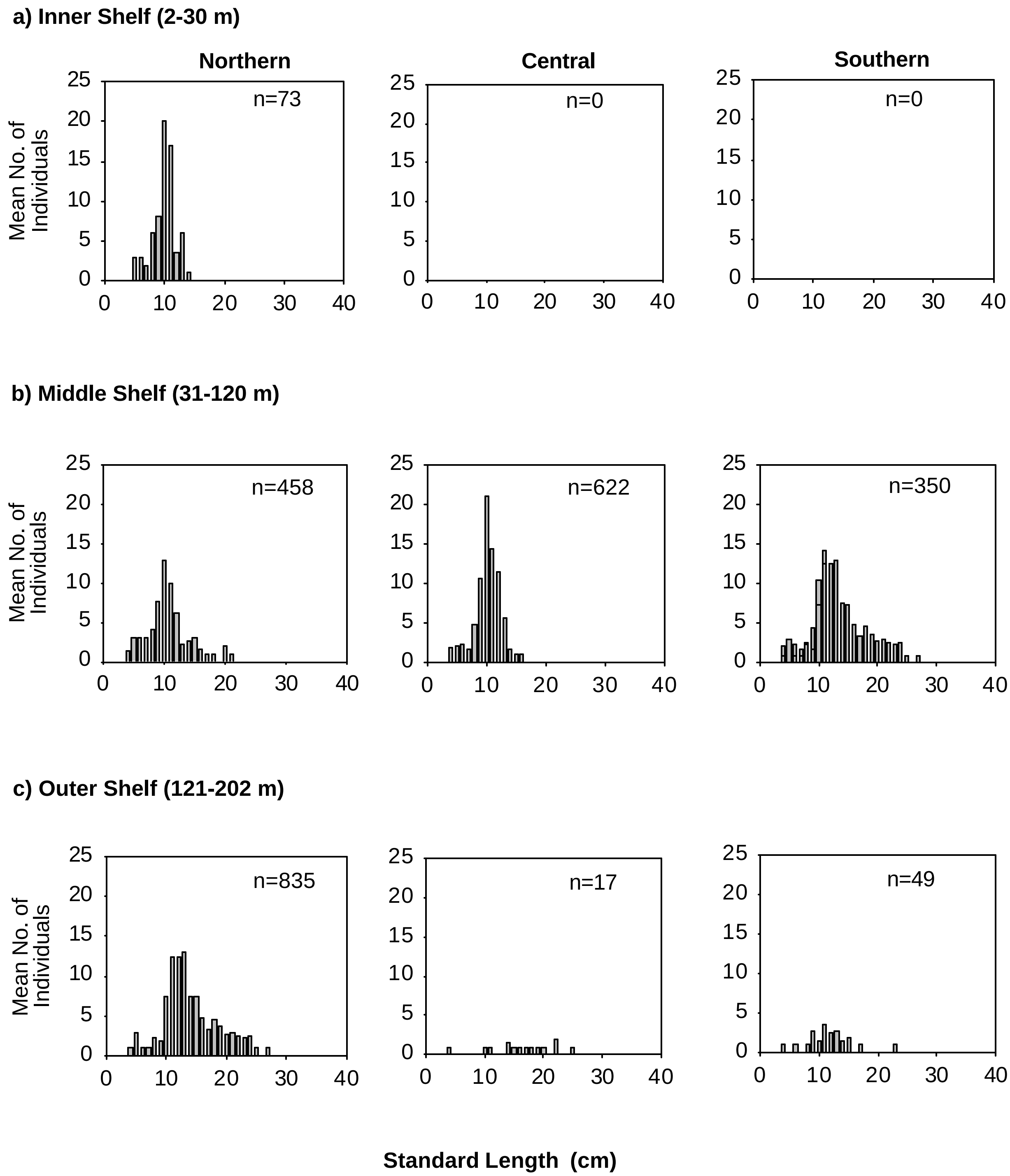
Appendix C28. Length-frequency distribution (mean number of fish per size class) of white croaker (*Genyonemus lineatus*) collected on the mainland shelf of southern California by depth and regional subpopulation, July-September 1998. n = Number of fish measured.



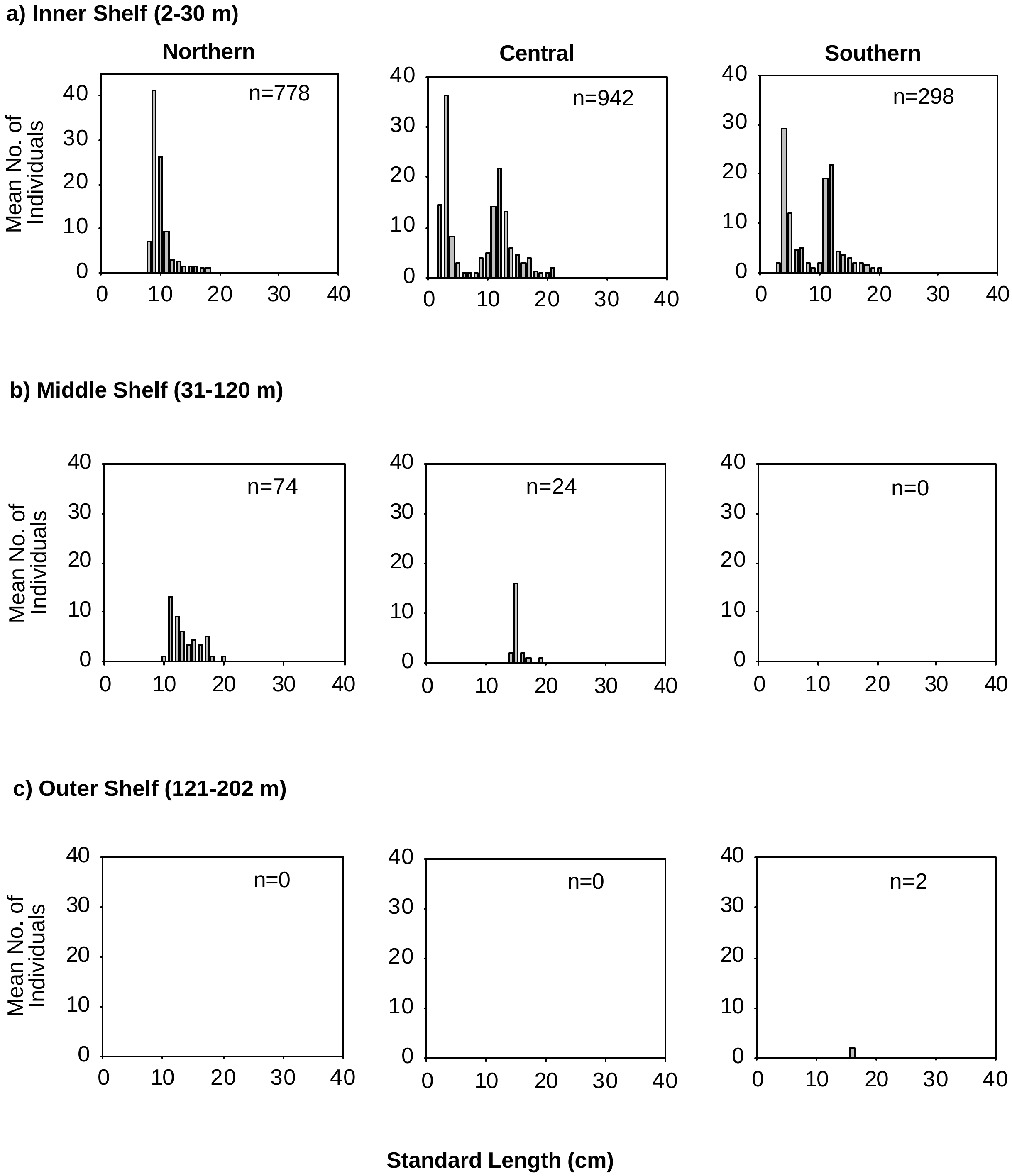
Appendix C29. Length-frequency distribution (mean number of fish per size class) of California lizardfish (*Synodus lucioceps*) collected on the mainland shelf of southern California by depth and regional subpopulation, July-September 1998. n = Number of fish measured.



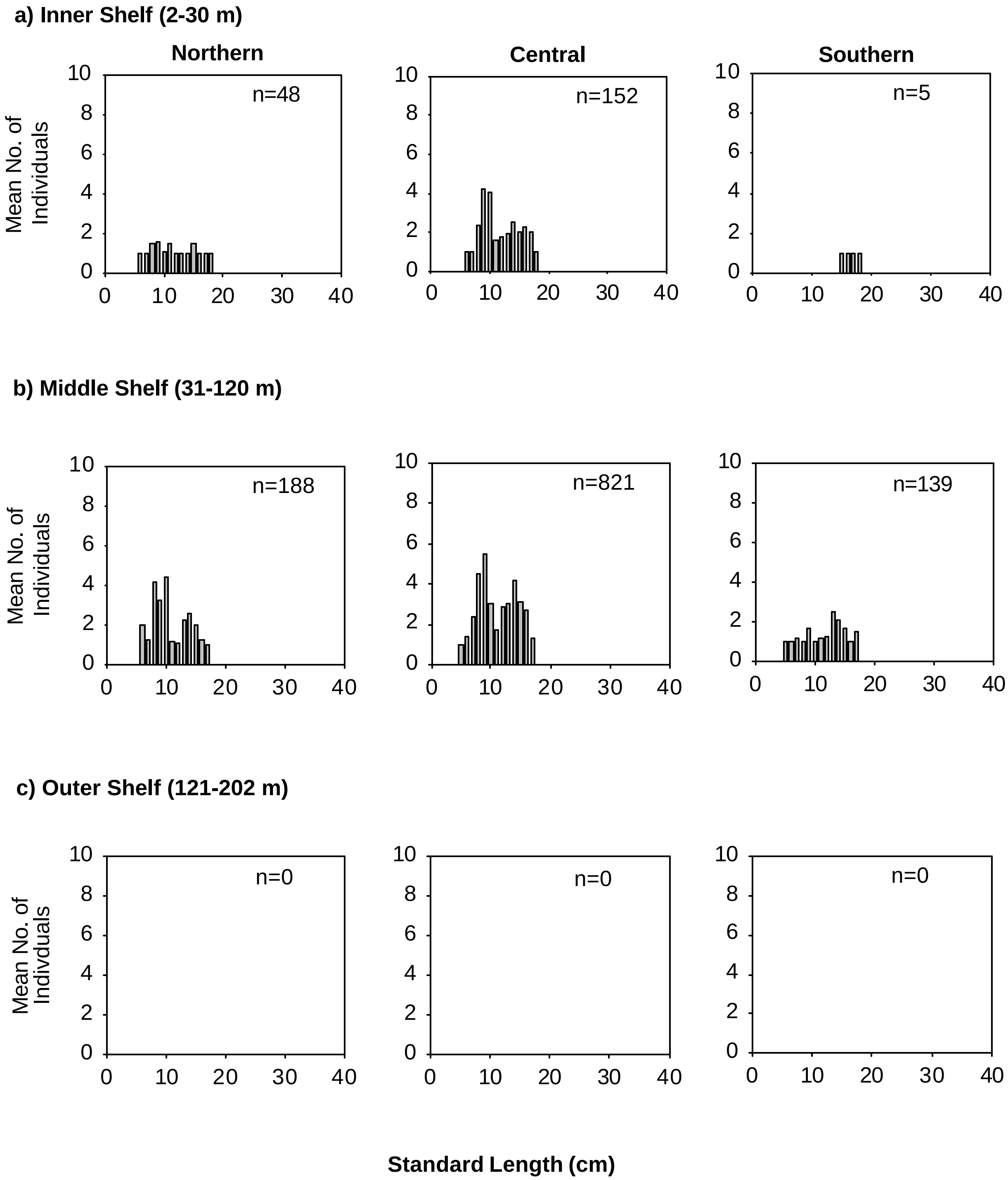
Appendix C30. Length-frequency distribution (mean number of fish per size class) of longfin sanddab (*Citharichthys xanthostigma*) collected on the mainland shelf of southern California by depth and regional subpopulation, July-September 1998. n = Number of fish measured.



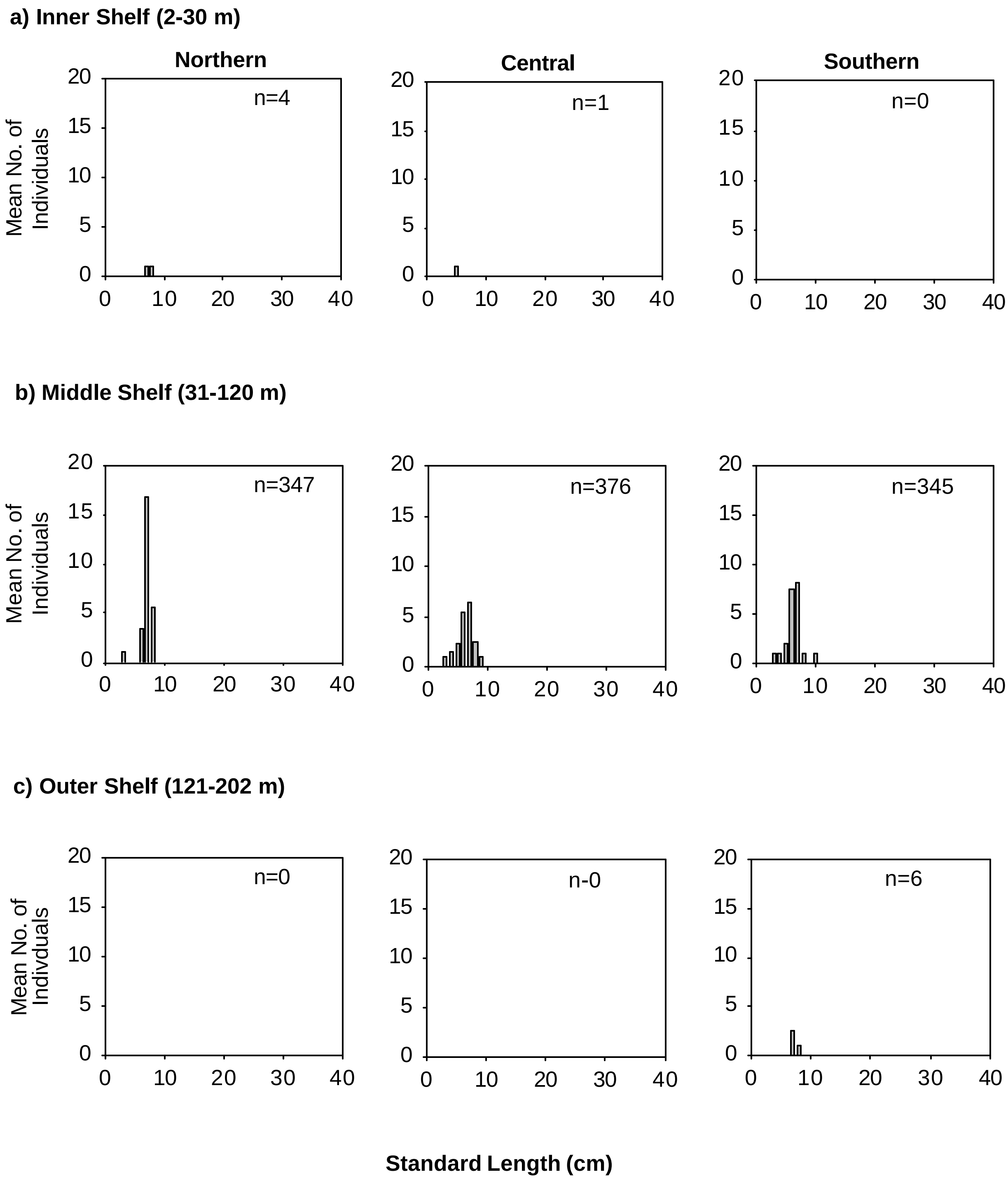
Appendix C31. Length-frequency distribution (mean number of fish per size class) of Pacific sanddab (*Citharichthys sordidus*) collected on the mainland shelf of southern California by depth and regional subpopulation, July-September 1998. n = Number of fish measured.



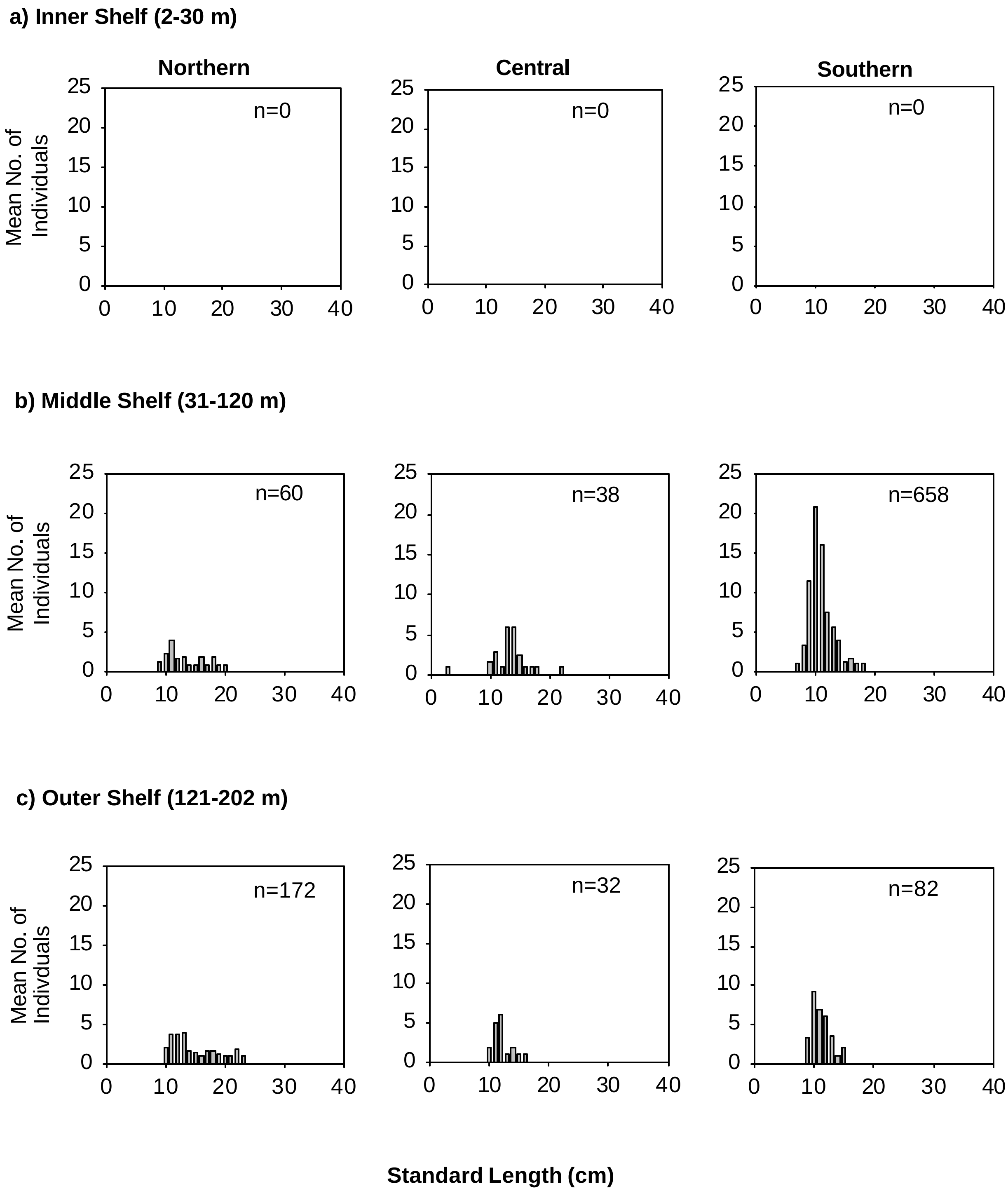
Appendix C32. Length-frequency distribution (mean number of fish per size class) of queenfish (*Seriphus politus*) collected on the mainland shelf of southern California by depth and regional subpopulation, July-September 1998. n = Number of fish measured.



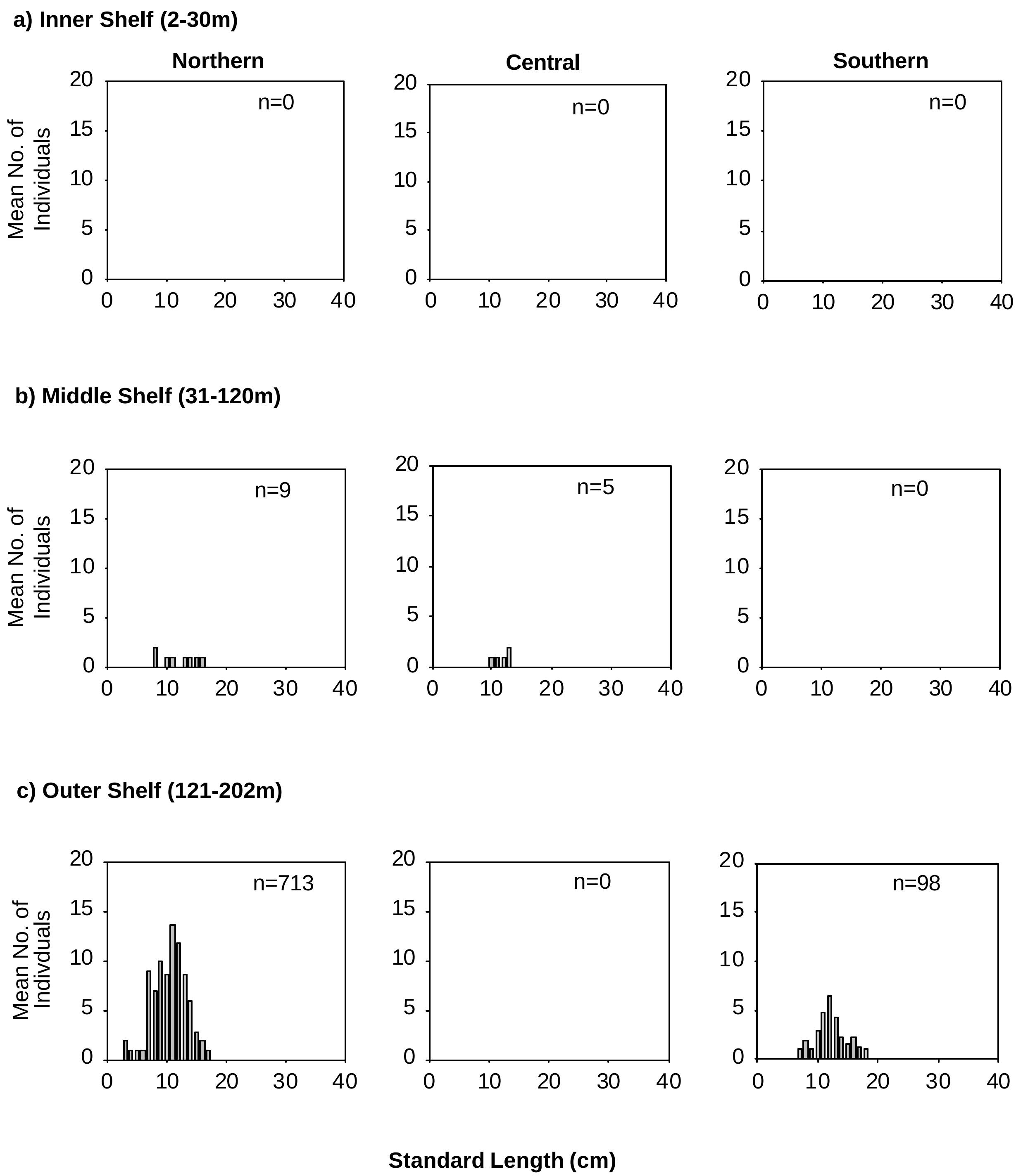
Appendix C33. Length-frequency distribution (mean number of fish per size class) of California tonguefish (*Symphurus atricaudus*) collected on the mainland shelf of southern California by depth and regional subpopulation, July-September 1998. n = Number of fish measured.



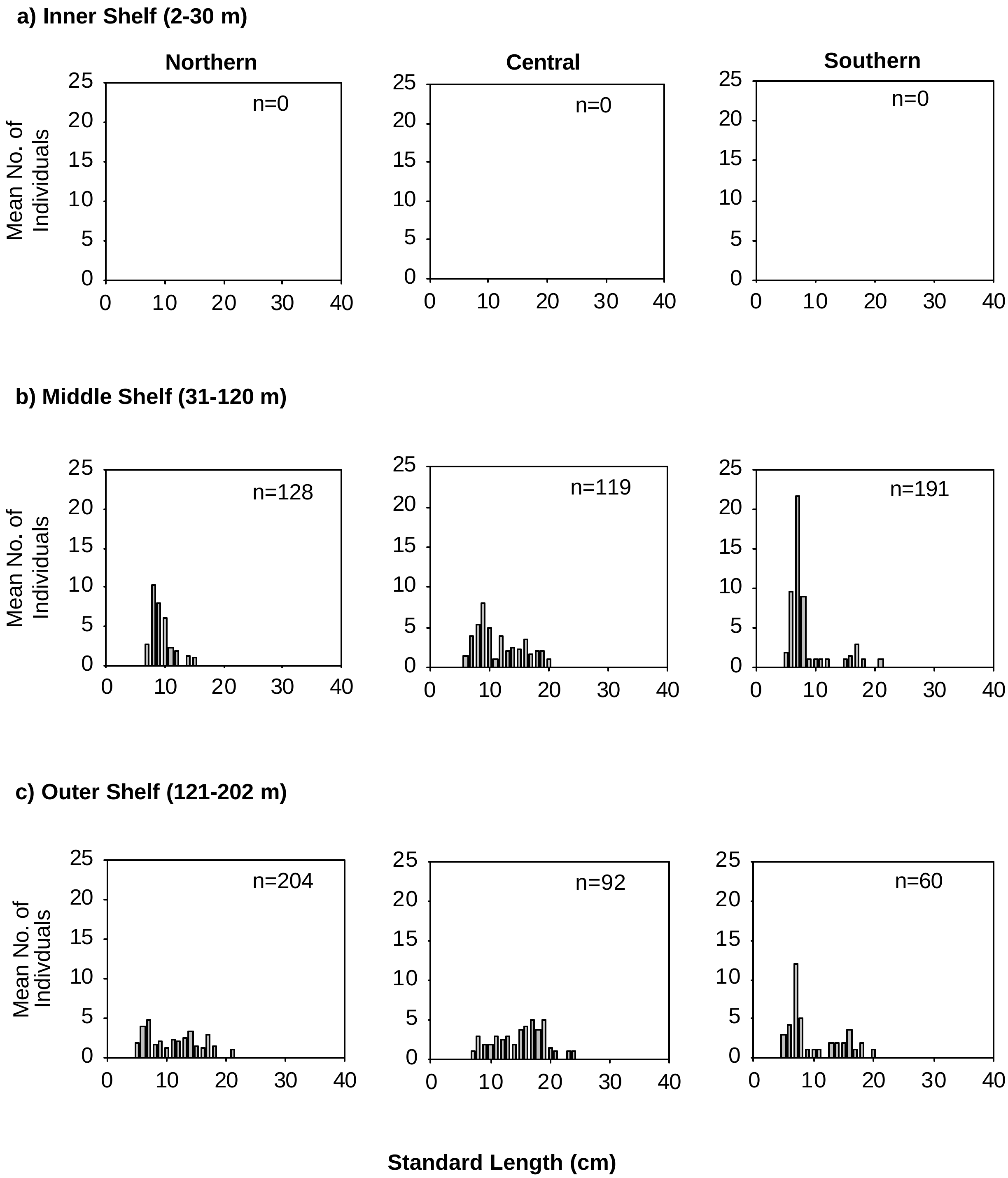
Appendix C34. Length-frequency distribution (mean number of fish per size class) of yellowchin sculpin (*Icelinus quadriseriatus*) collected on the mainland shelf of southern California by depth and regional subpopulation, July-September 1998. N = number of fish measured.



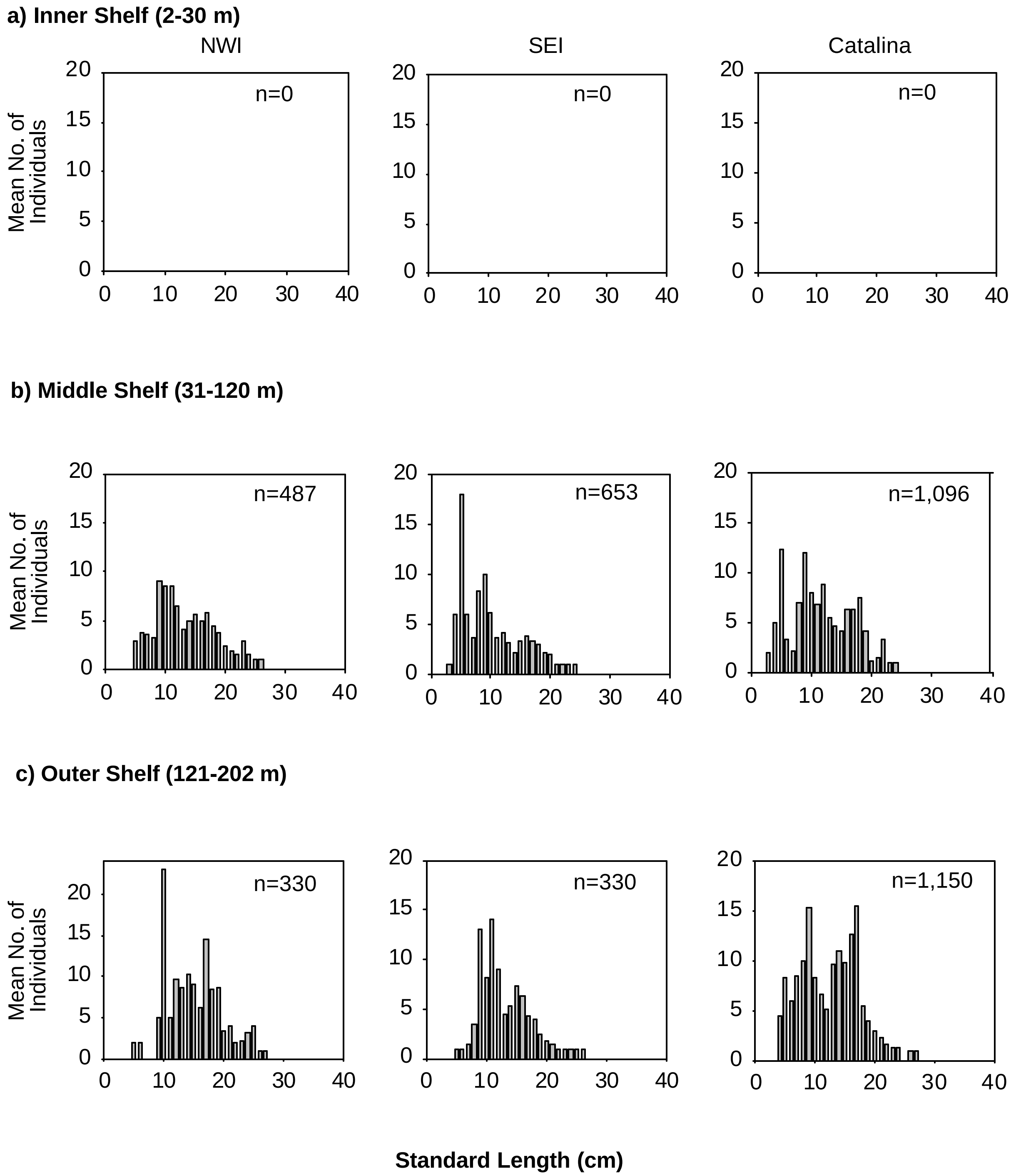
Appendix C35. Length-frequency distribution (mean number of fish per size class) of plainfin midshipman (*Porichthys notatus*) collected on the mainland shelf of southern California by depth and regional subpopulation, July-September 1998. n = Number of fish measured.



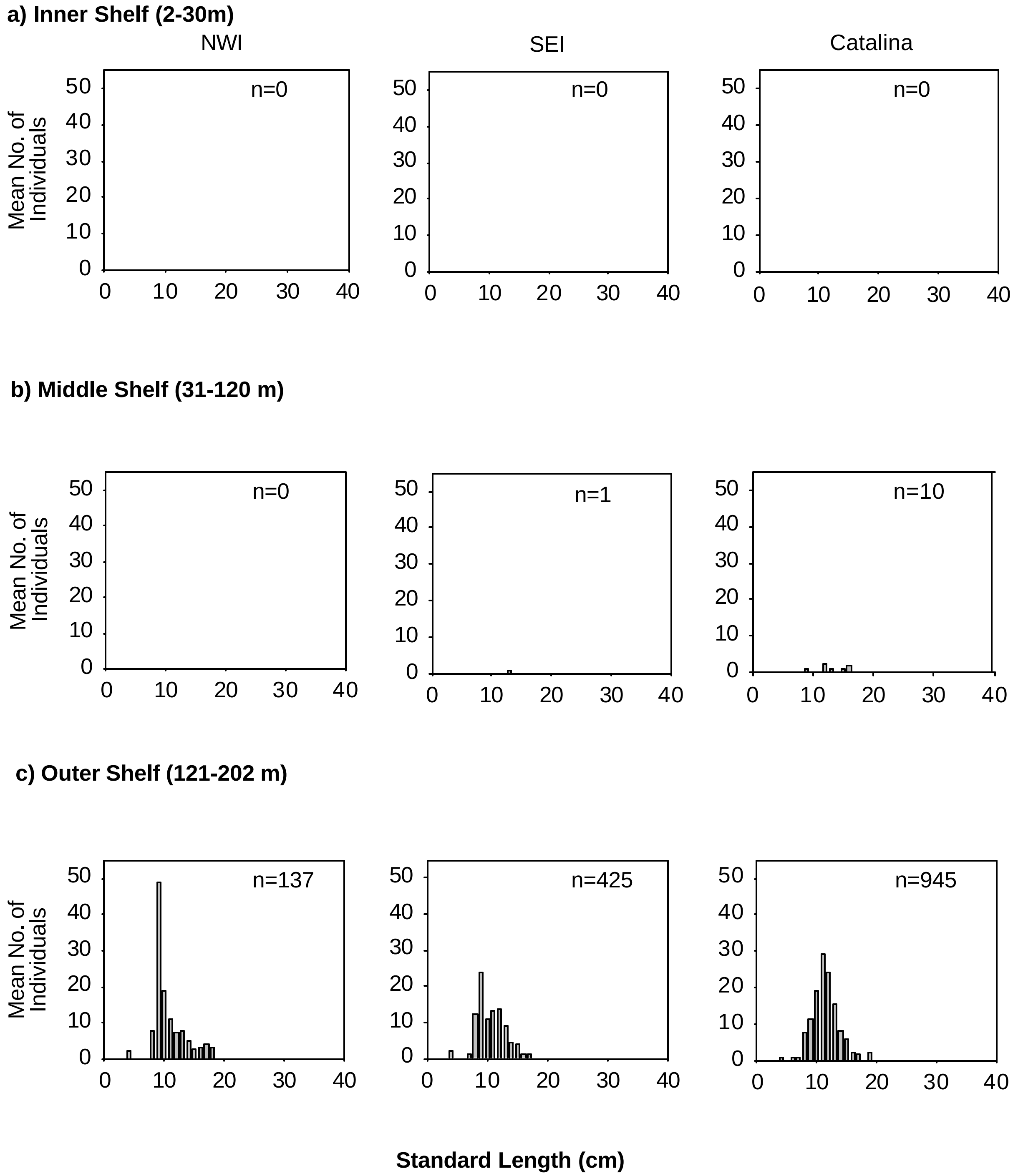
Appendix C36. Length-frequency distribution (mean number of fish per size class) of slender sole (*Lyopsetta exilis*) collected on the mainland shelf of southern California by depth and regional subpopulation, July-September 1998. n = Number of fish measured.



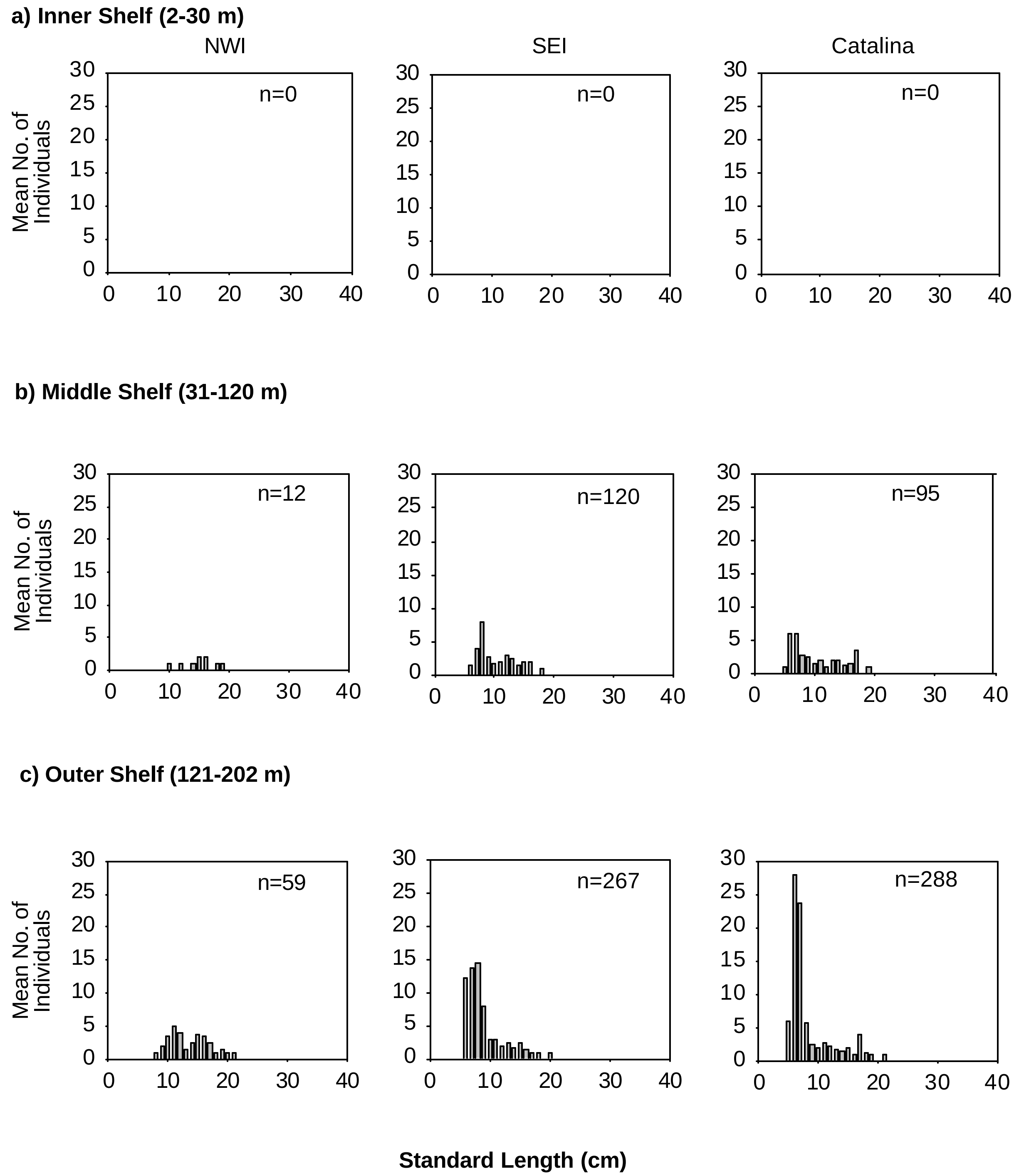
Appendix C37. Length-frequency distribution (mean number of fish per size class) of Dover sole (*Microstomus pacificus*) collected on the mainland shelf of southern California by depth and regional subpopulation, July-September 1998. n = Number of fish measured.



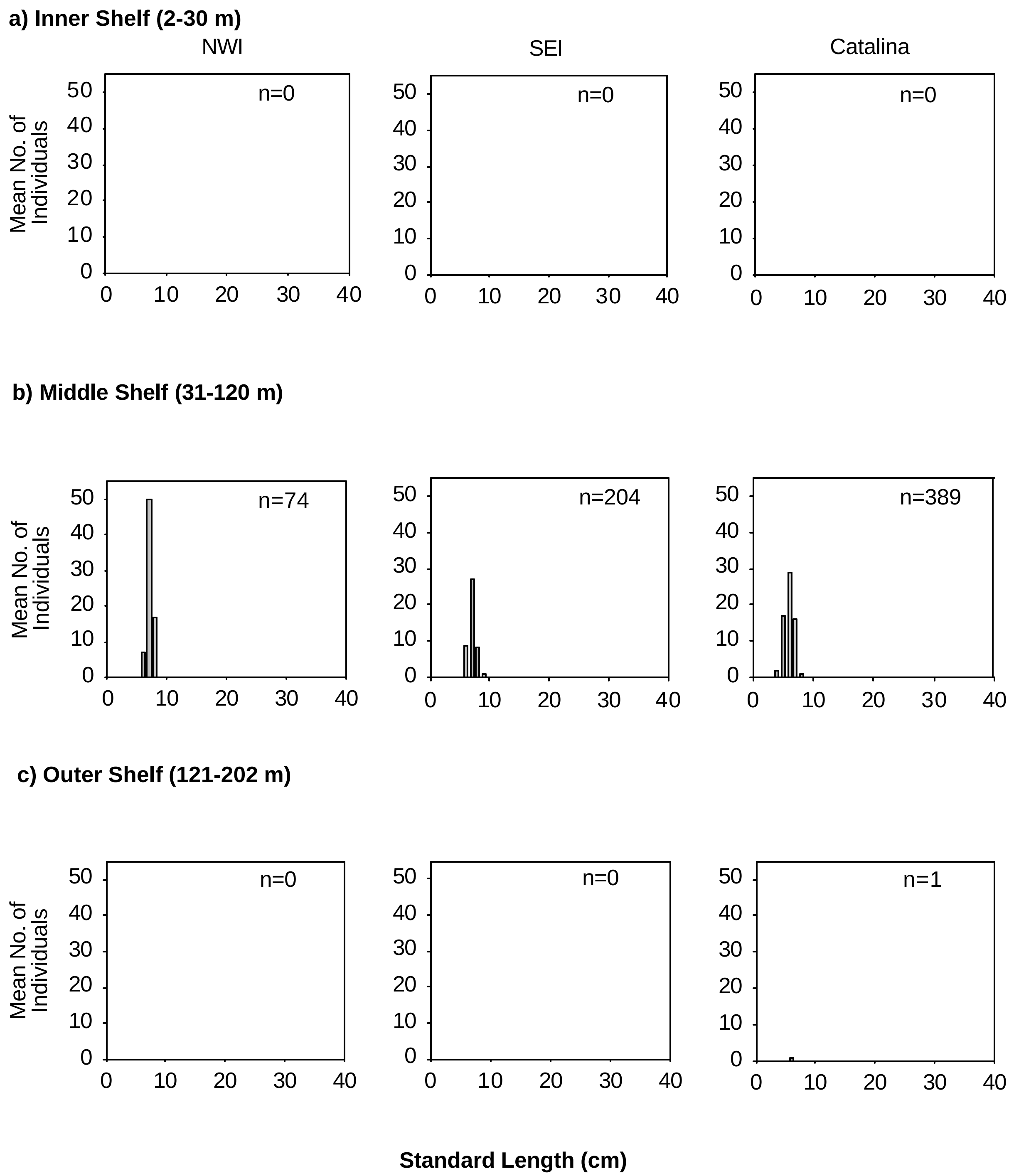
Appendix C38. Length-frequency distribution (mean number of fish per size class) of Pacific sanddab (*Citharichthys sordidus*) collected at southern California islands by depth and regional subpopulation, July-September 1998. n = Number of fish measured. NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; Catalina = Santa Catalina Island.



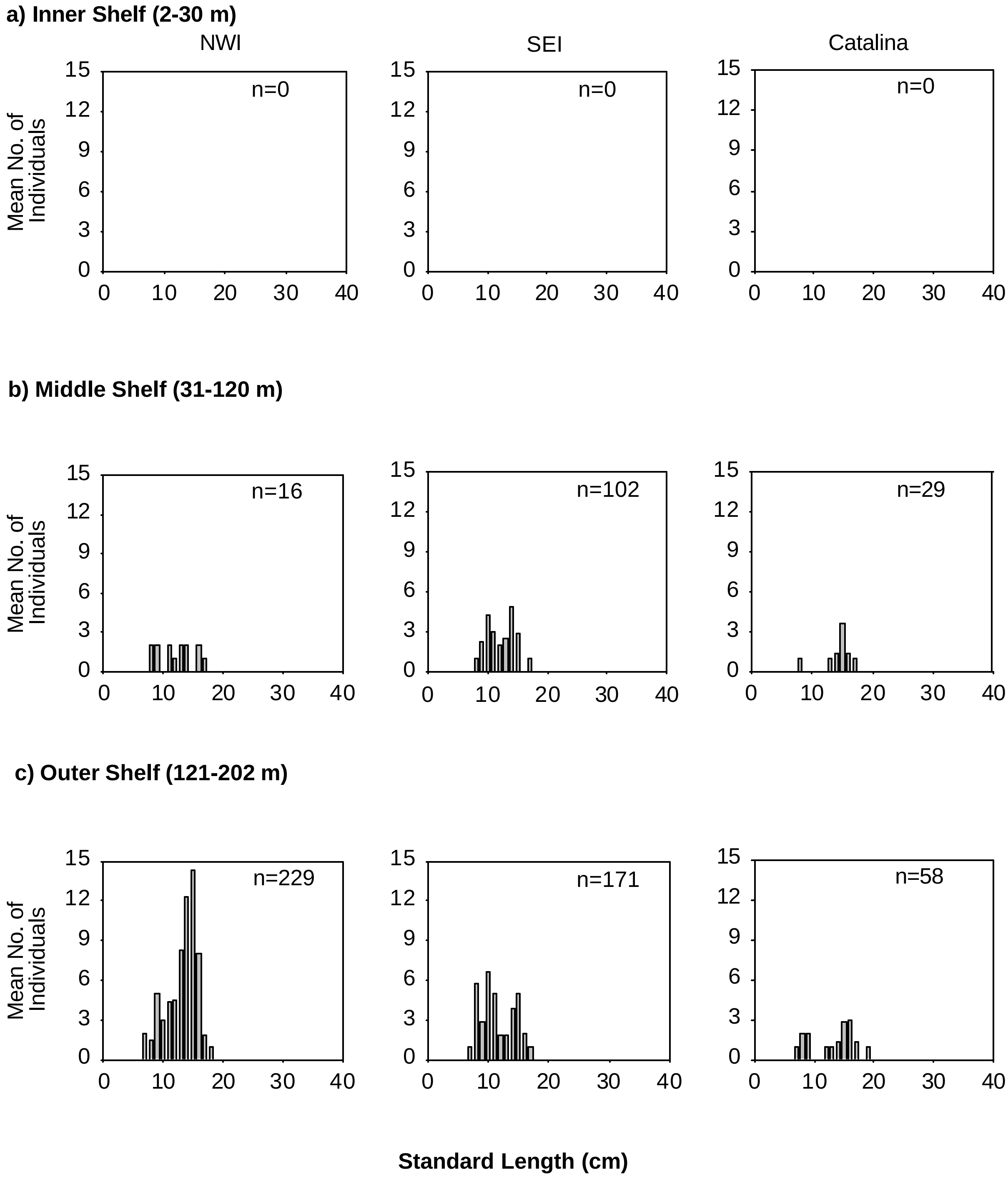
Appendix C39. Length-frequency distribution (mean number of fish per size class) of slender sole (*Lyopsetta exilis*) collected at southern California islands by depth and regional subpopulation, July-September 1998. n = Number of fish measured. NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; Catalina = Santa Catalina Island.



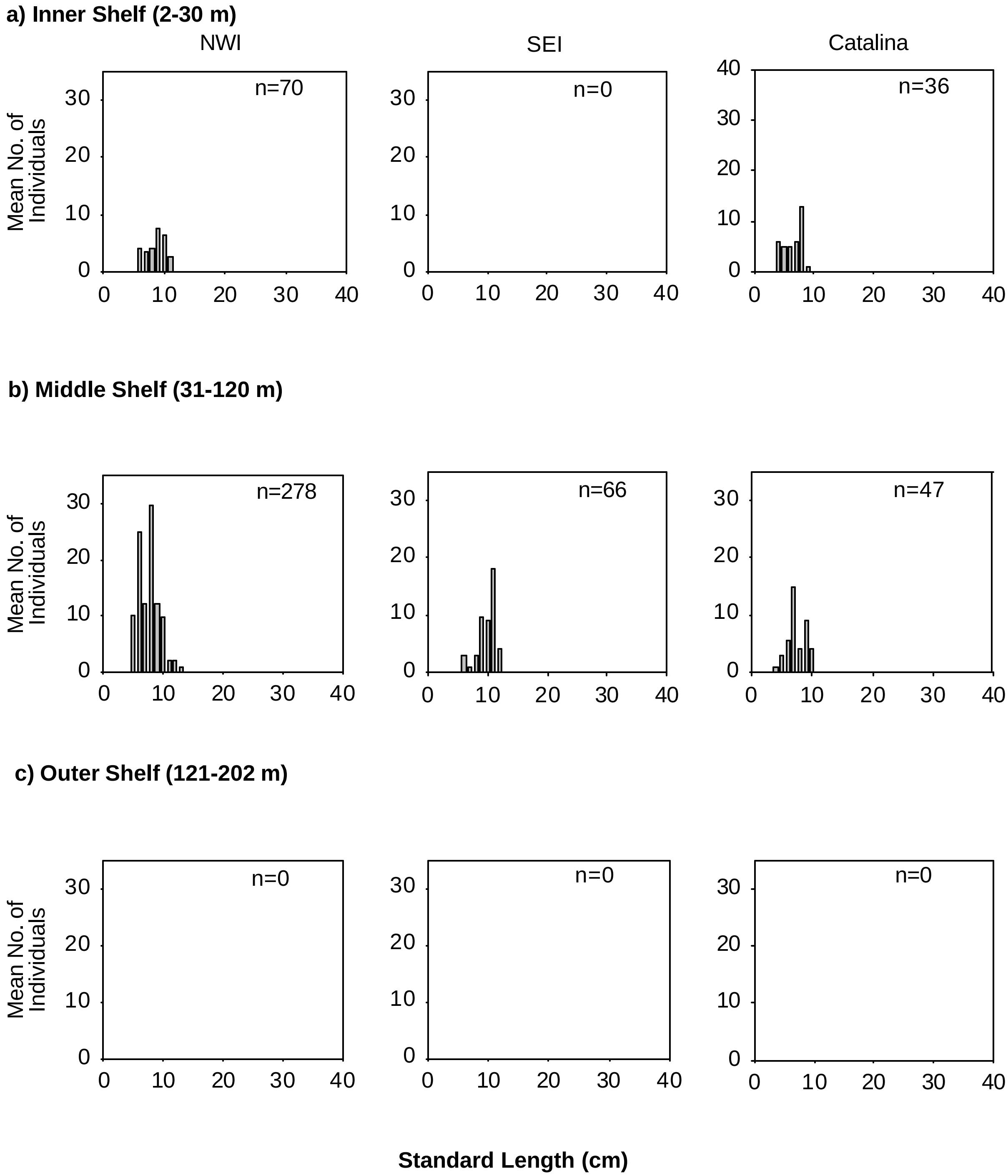
Appendix C40. Length-frequency distribution (mean number of fish per size class) of Dover sole (*Microstomus pacificus*) collected at southern California islands by depth and regional subpopulation, July-September 1998. n = Number of fish measured. NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; Catalina = Santa Catalina Island.



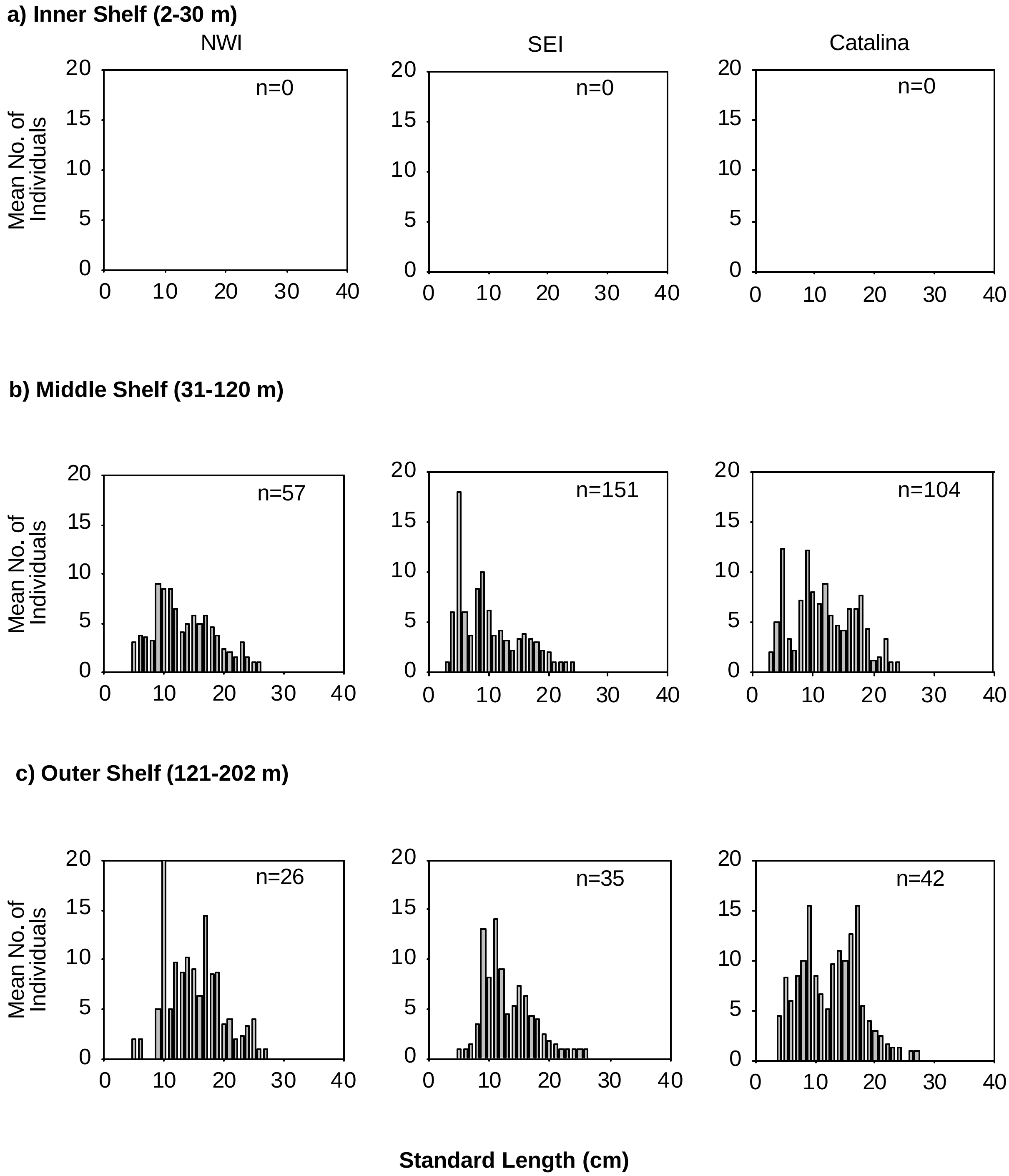
Appendix C41. Length-frequency distribution (mean number of fish per size class) of yellowchin sculpin (*Icelinus quadriseriatus*) collected at southern California islands by depth and regional subpopulation, July-September 1998. n = Number of fish measured. NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; Catalina = Santa Catalina Island.



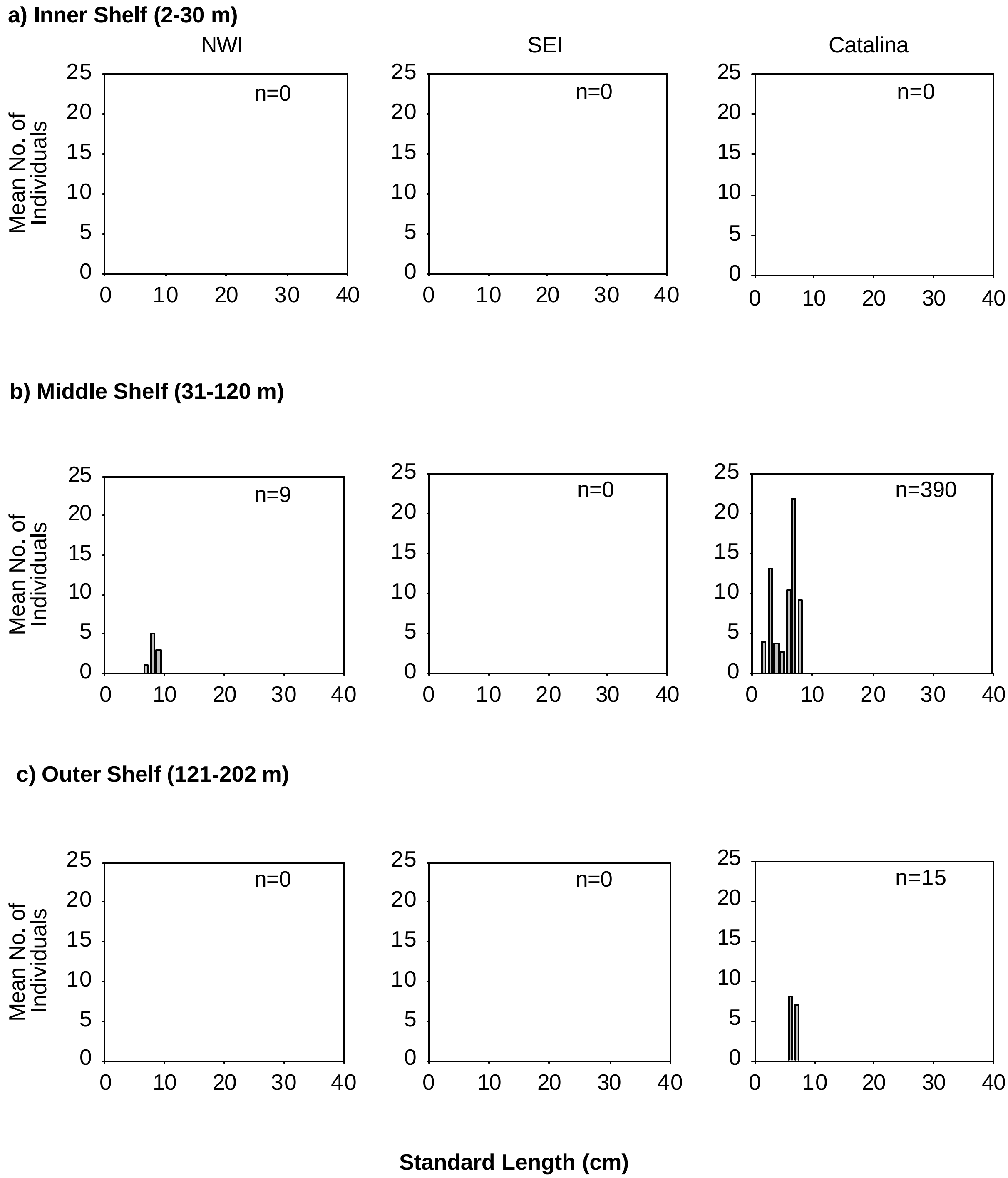
Appendix C42. Length-frequency distribution (mean number of fish per size class) of shortspine combfish (*Zaniolepis frenata*) collected at southern California islands by depth and regional subpopulation, July-September 1998. n = n = Number of fish measured. NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; Catalina = Santa Catalina Island.



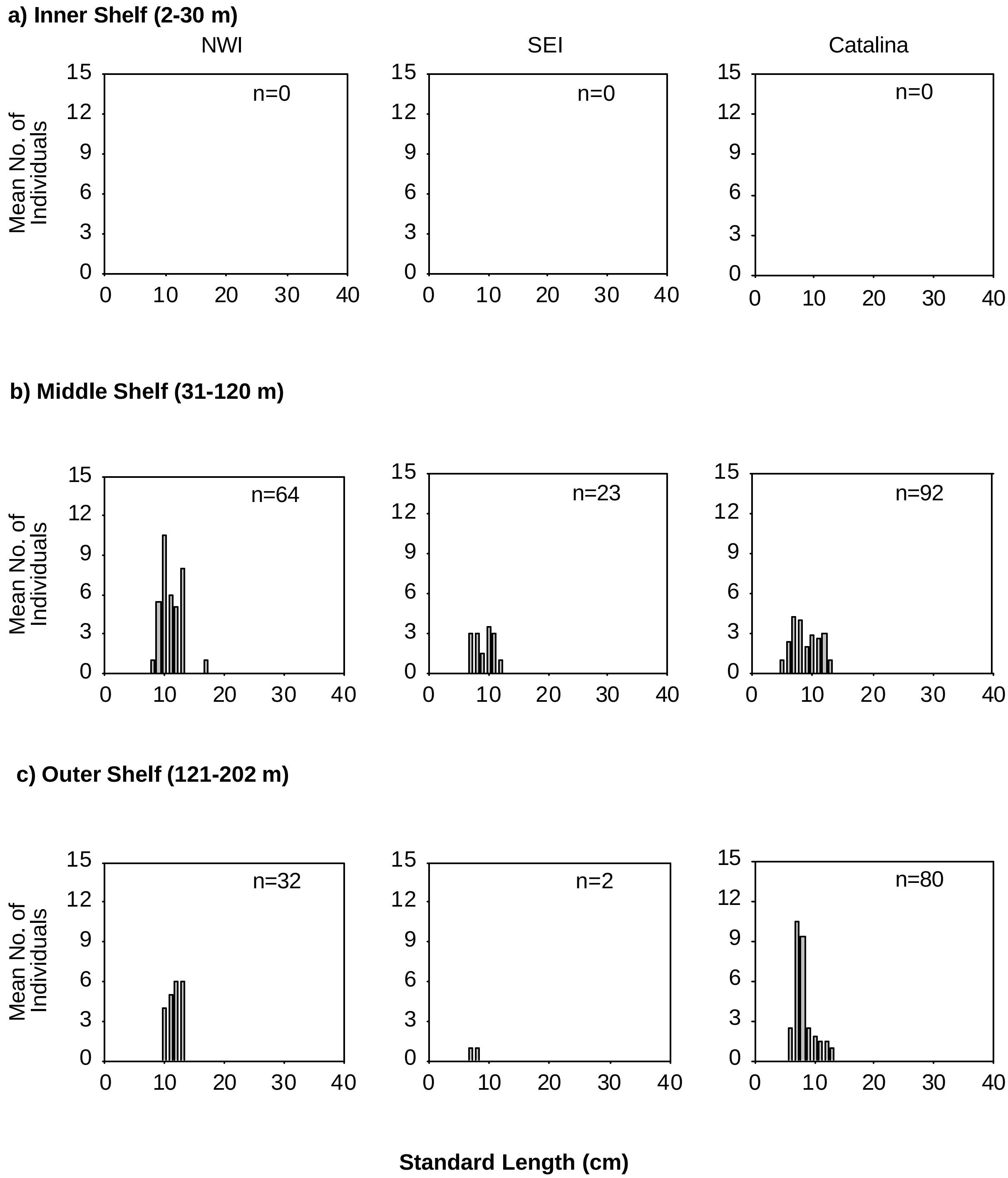
Appendix C43. Length-frequency distribution (mean number of fish per size class) of speckled sanddab (*Citharichthys stigmaeus*) collected at southern California islands by depth and regional subpopulation, July-September 1998. n = n = Number of fish measured. NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; Catalina = Santa Catalina Island.



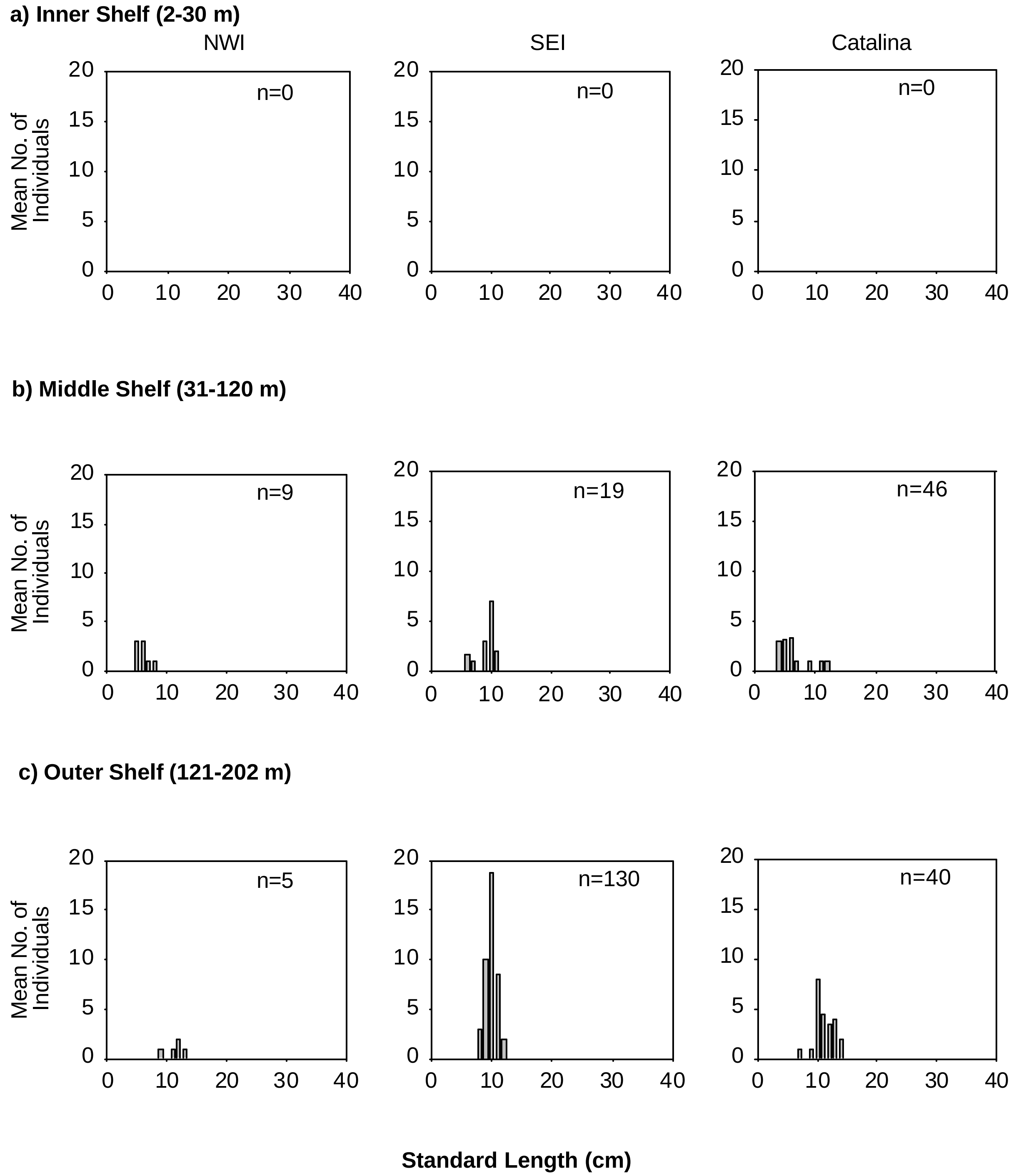
Appendix C44. Length-frequency distribution (mean number of fish per size class) of plainfin midshipman (*Porichthys notatus*) collected at southern California islands by depth and regional subpopulation, July-September 1998. n = Number of fish measured. NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; Catalina = Santa Catalina Island.



Appendix C45. Length-frequency distribution (mean number of fish per size class) of bay goby (*Lepidogobius lepidus*) collected at southern California islands by depth and regional subpopulation, July-September 1998. n = Number of fish measured. NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; Catalina = Santa Catalina Island.



Appendix C46. Length-frequency distribution (mean number of fish per size class) of spotfin sculpin (*Icelinus tenuis*) collected at southern California islands by depth and regional sub-population, July-September 1998. n = Number of fish measured. NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; Catalina = Santa Catalina Island.

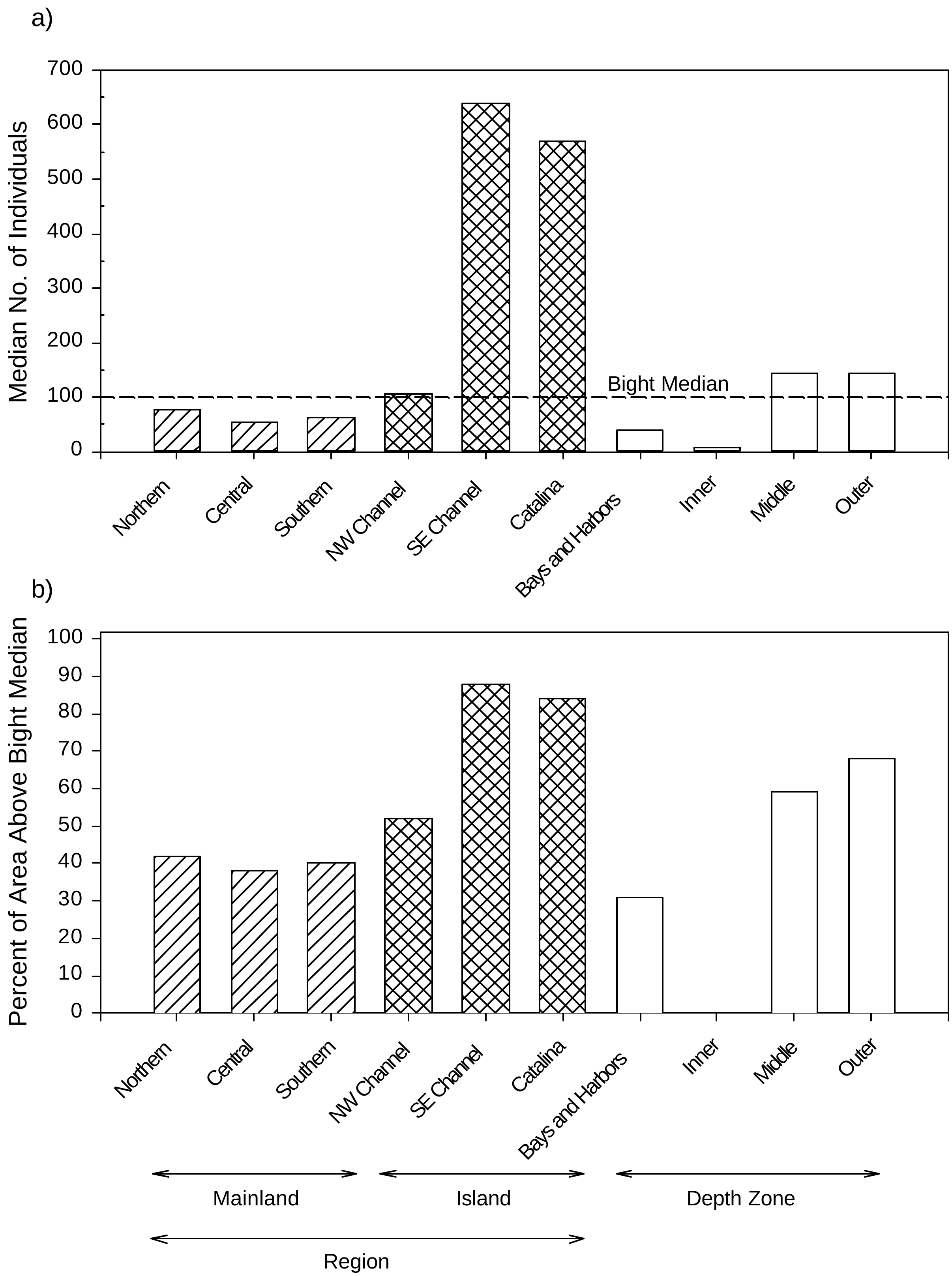


Appendix C47. Length-frequency distribution (mean number of fish per size class) of stripetail rockfish (*Sebastes saxicola*) collected at southern California islands by depth and regional sub-population, July-September 1998. n = Number of fish measured. NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; Catalina = Santa Catalina Island.

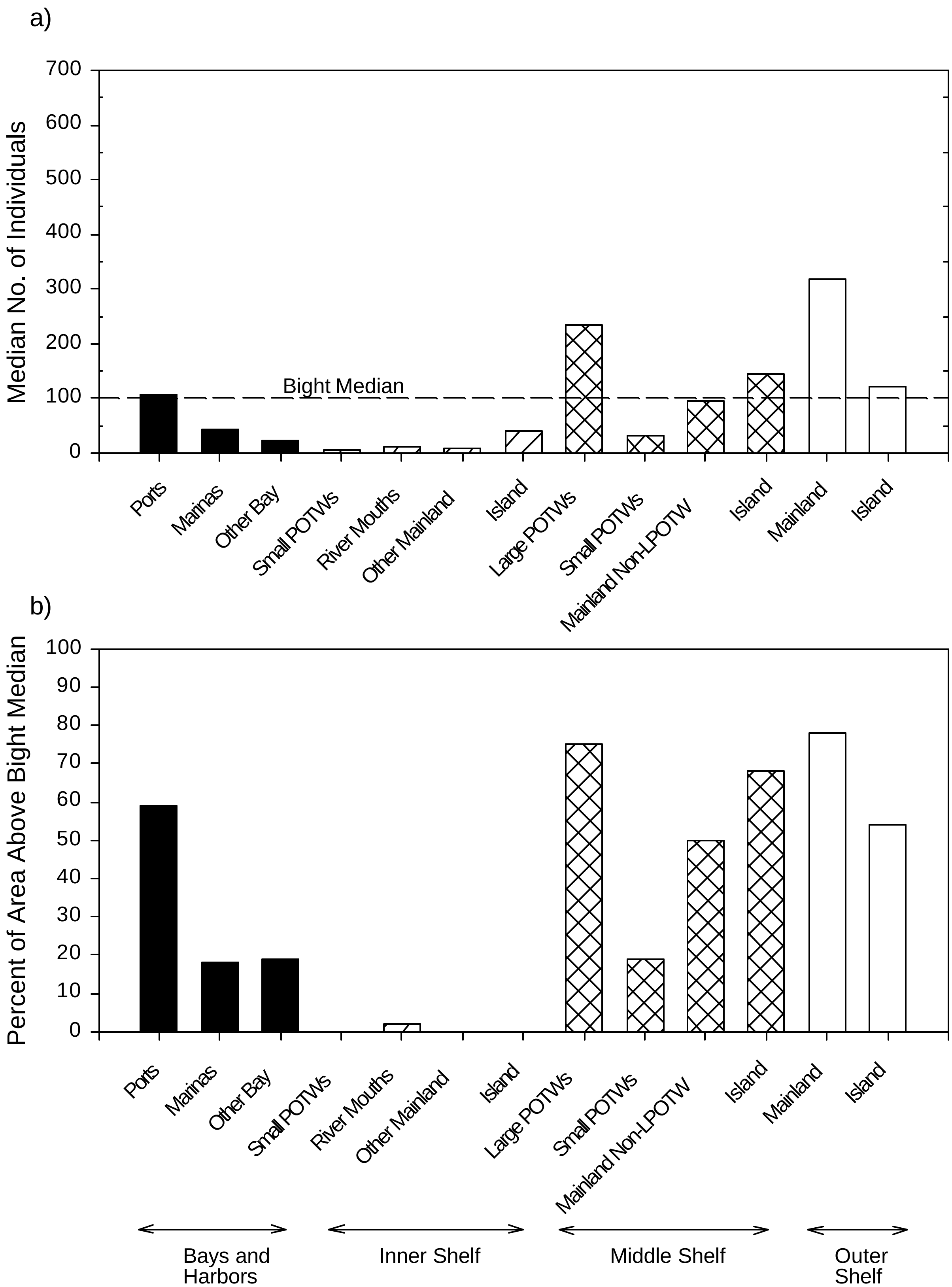
APPENDIX D

APPENDIX D. INVERTEBRATE POPULATION ATTRIBUTES

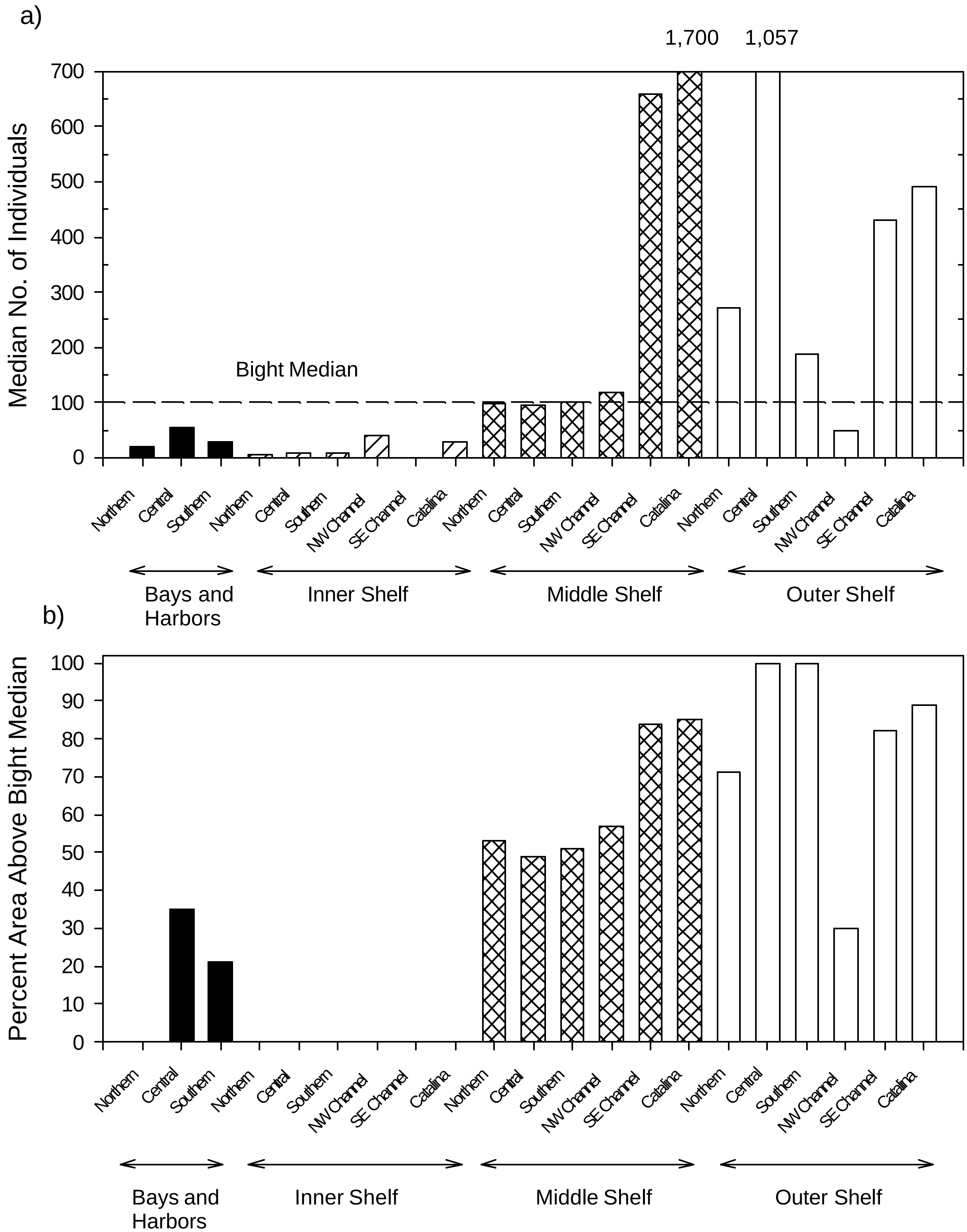
NUMBER **PAGE**



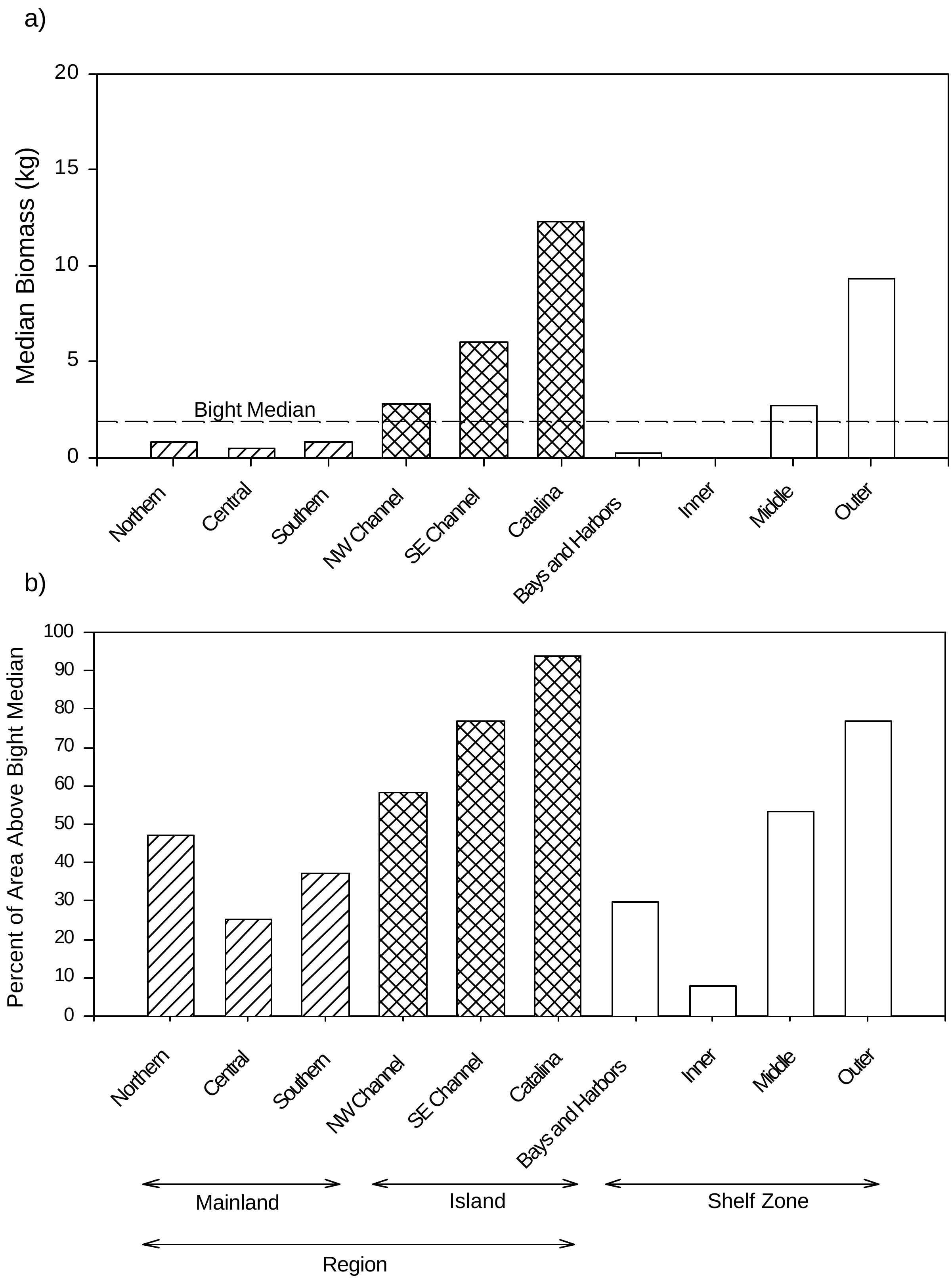
Appendix D1. Megabenthic invertebrate abundance per haul by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



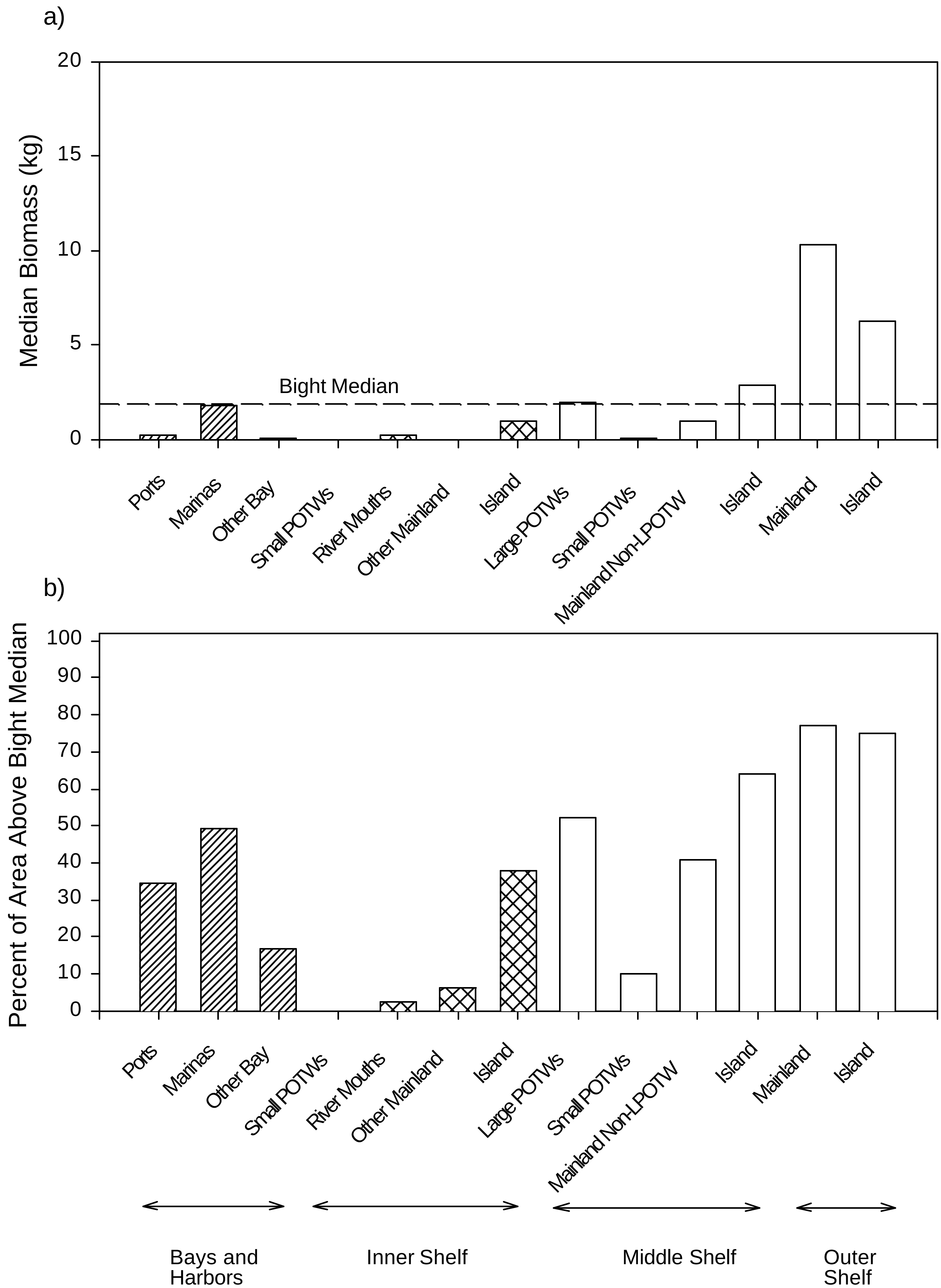
Appendix D2. Megabenthic invertebrate abundance per haul by shelf zone subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent area above Bight median.



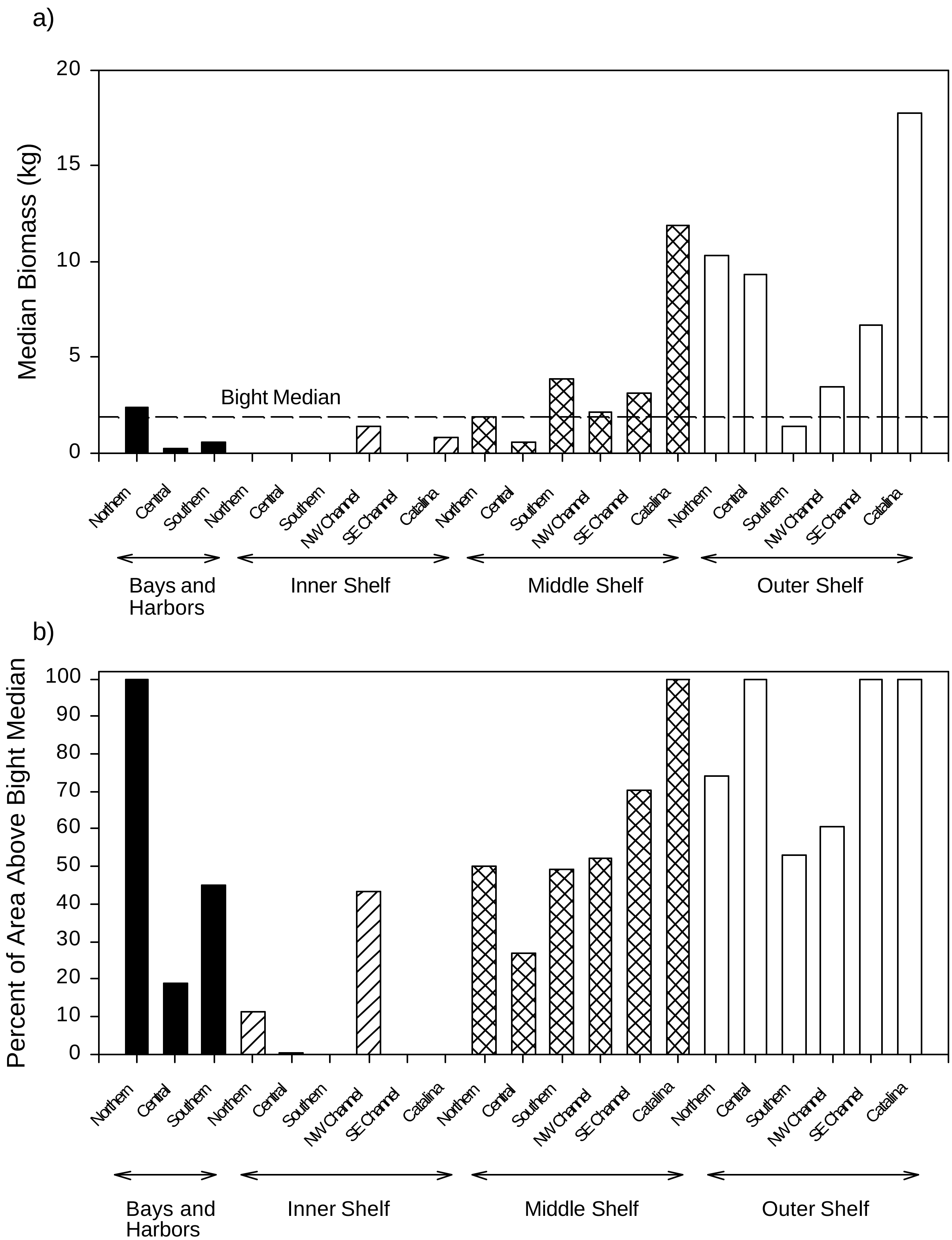
Appendix D3. Megabenthic invertebrate abundance per haul by region within shelf zone subpopulations on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



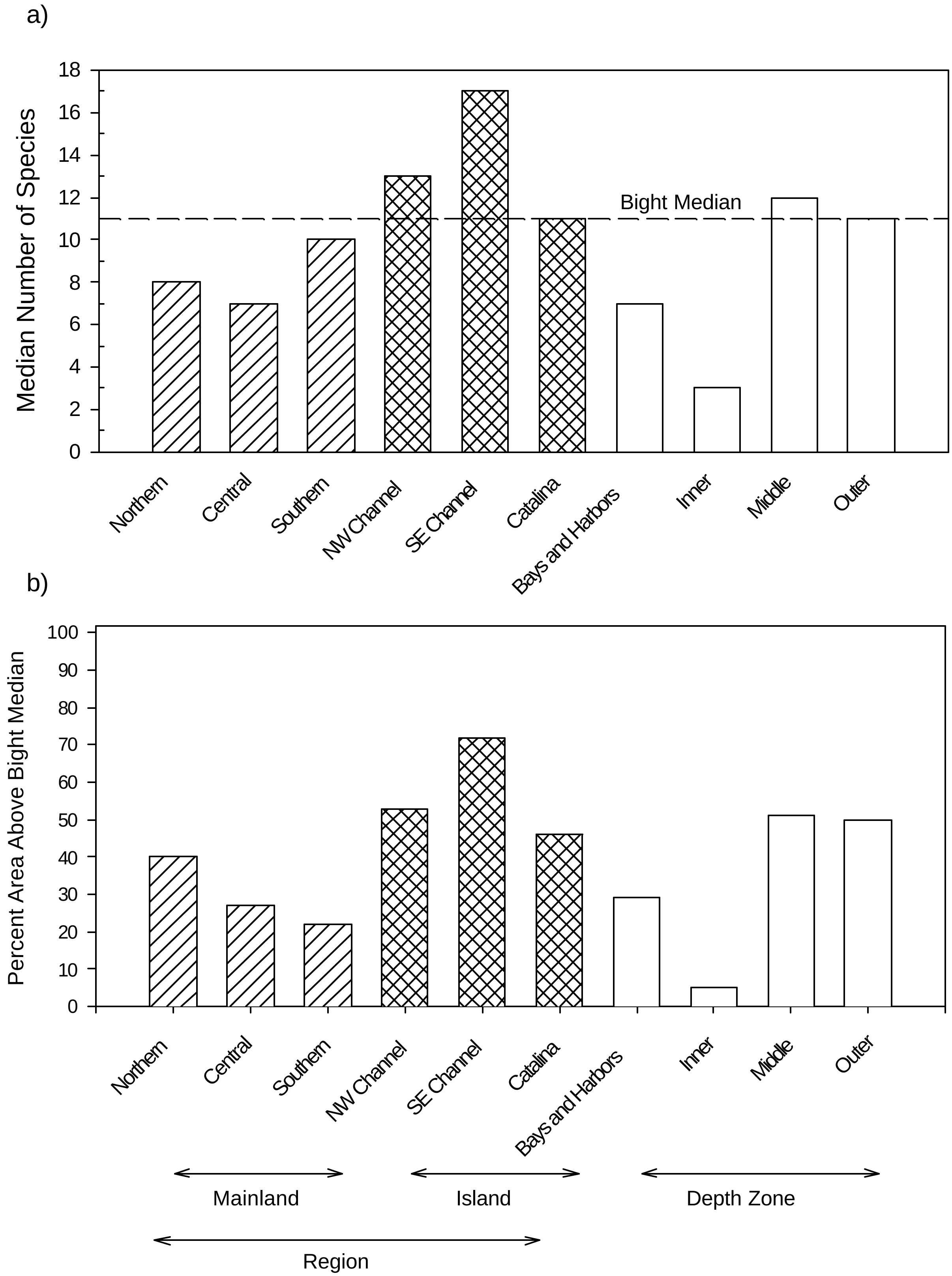
Appendix D4. Megabenthic invertebrate biomass per haul by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



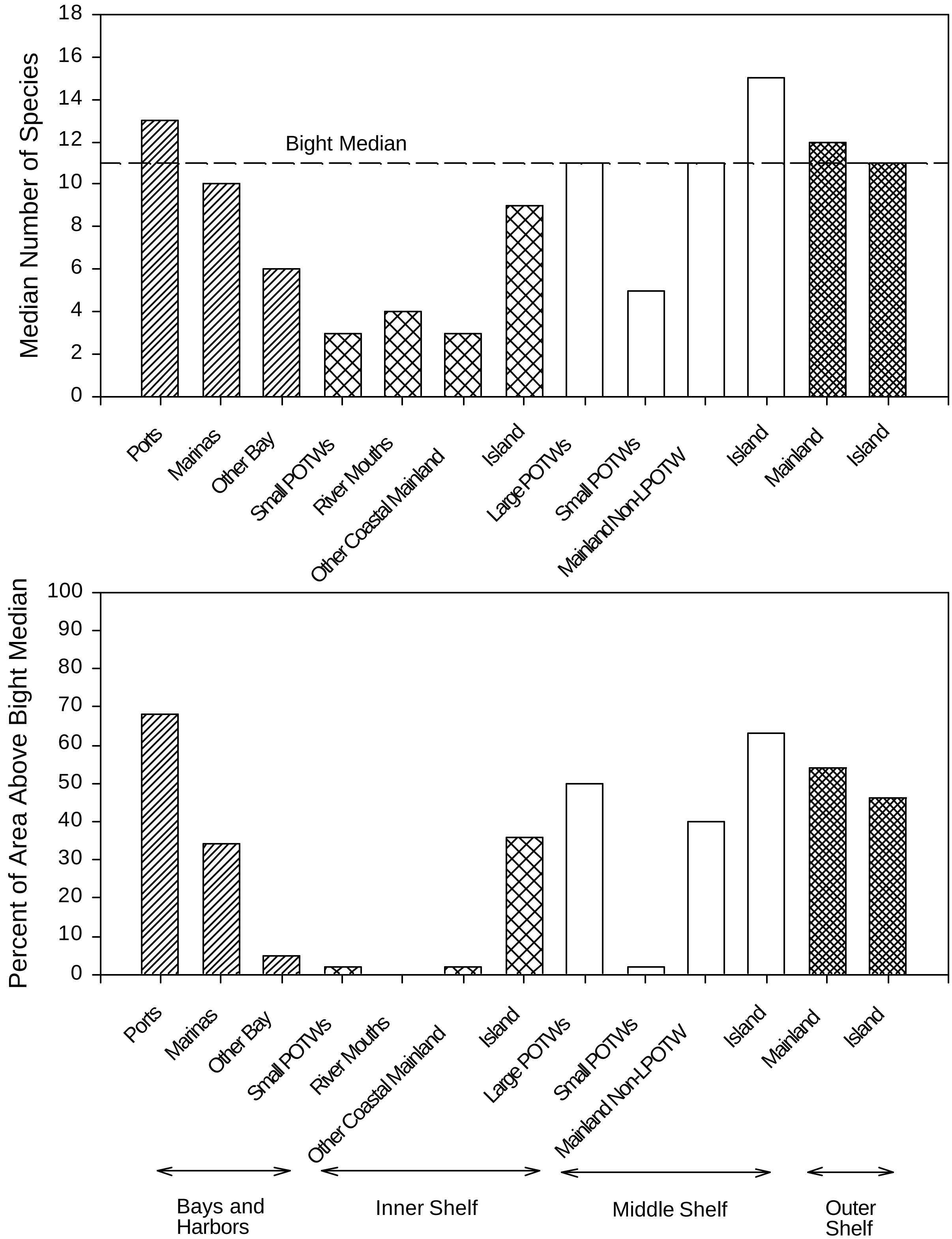
Appendix D5. Megabenthic invertebrate biomass per haul by shelf zone subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



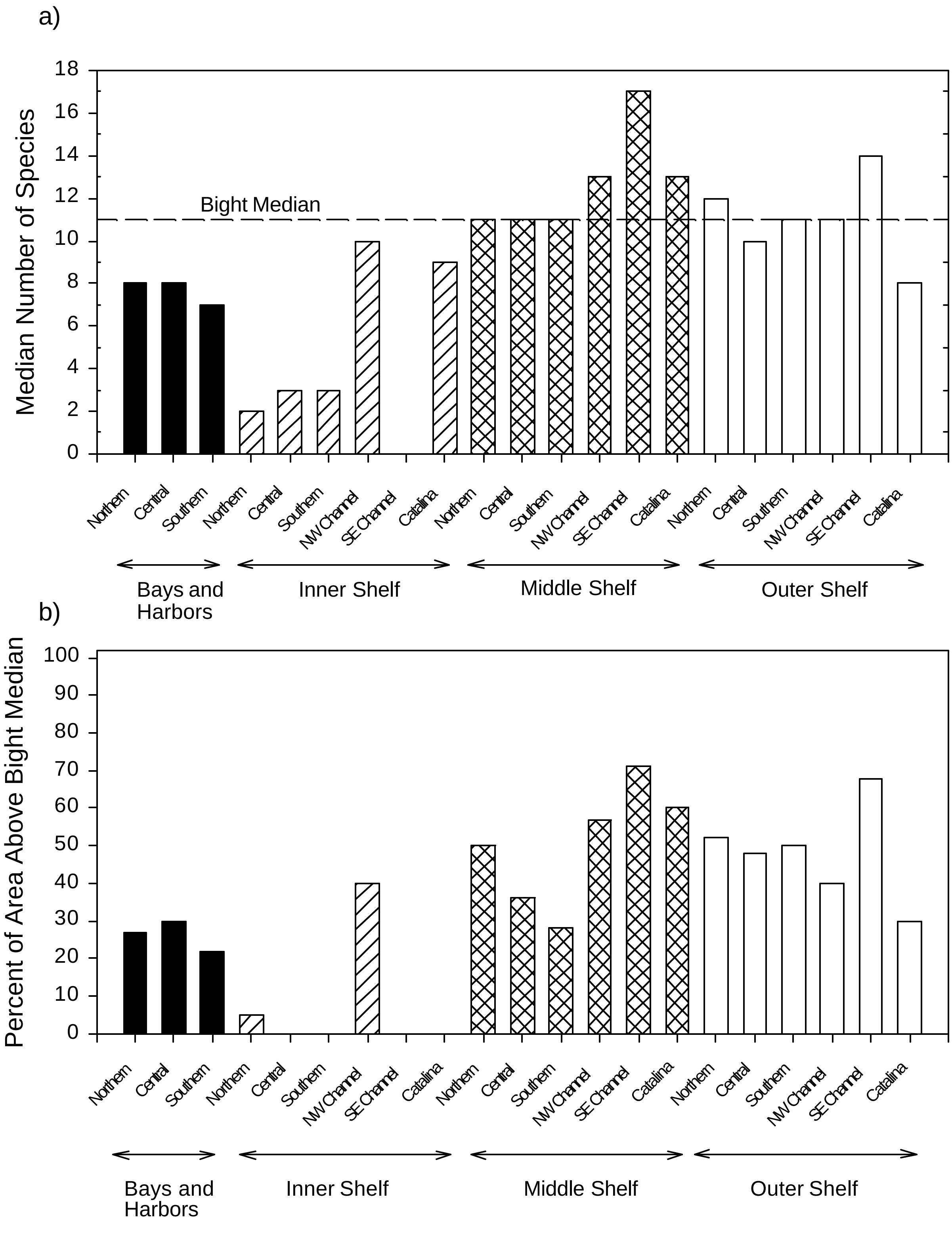
Appendix D6. Megabenthic invertebrate biomass per haul by region within shelf zone sub-populations on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



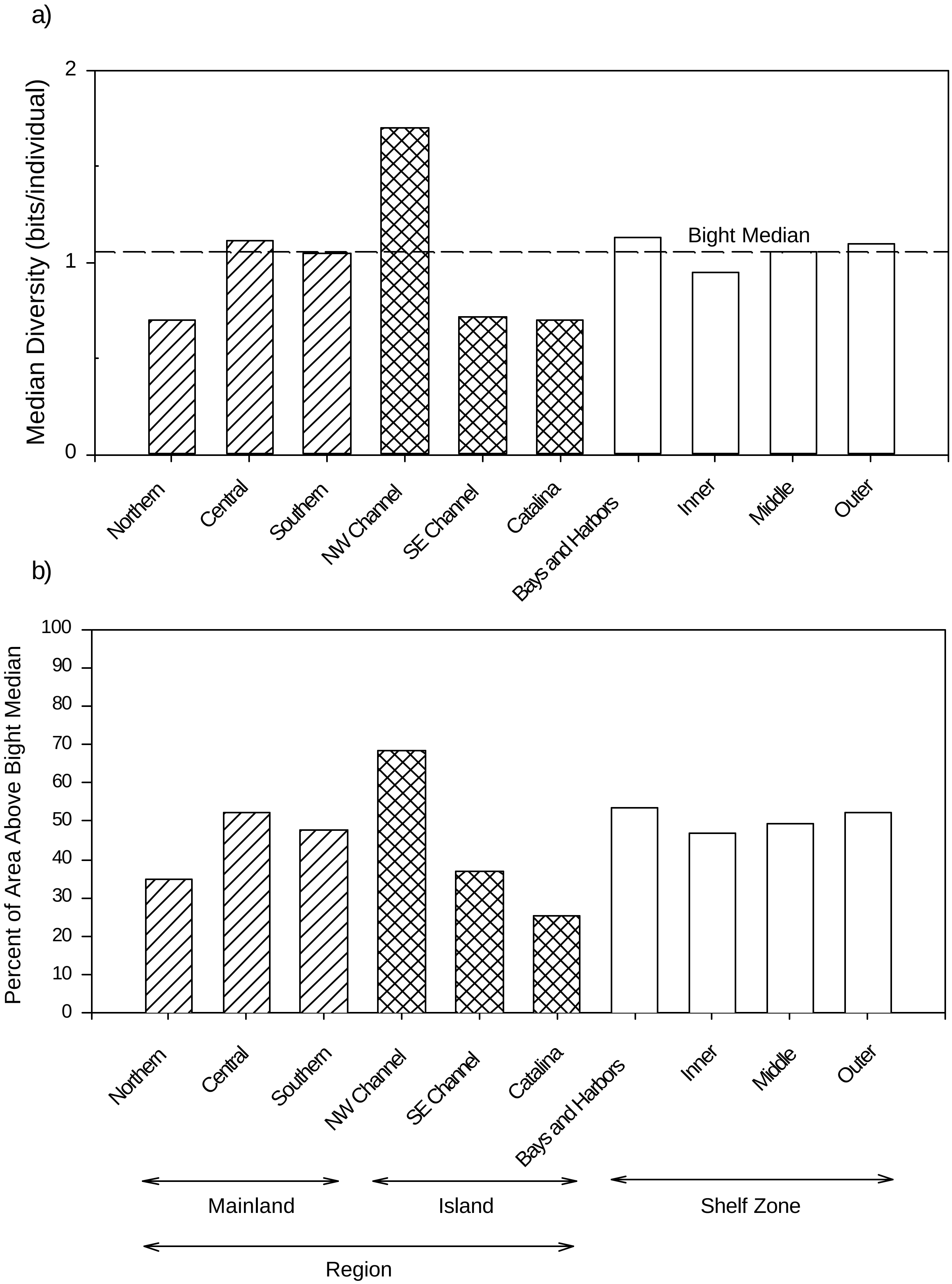
Appendix D7. Number of megabenthic invertebrate species per haul by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



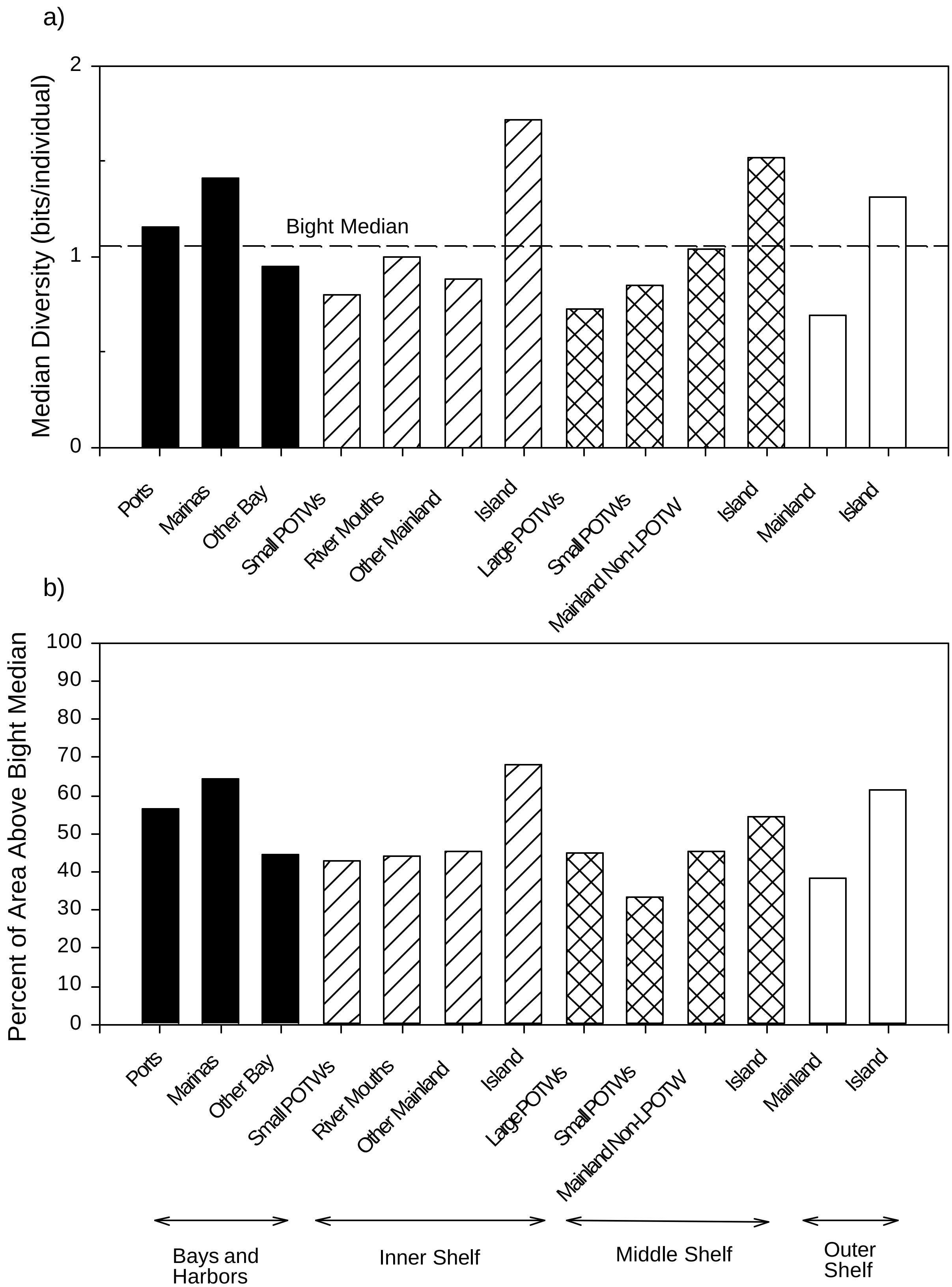
Appendix D8. Number of megabenthic invertebrate species per haul by shelf zone subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



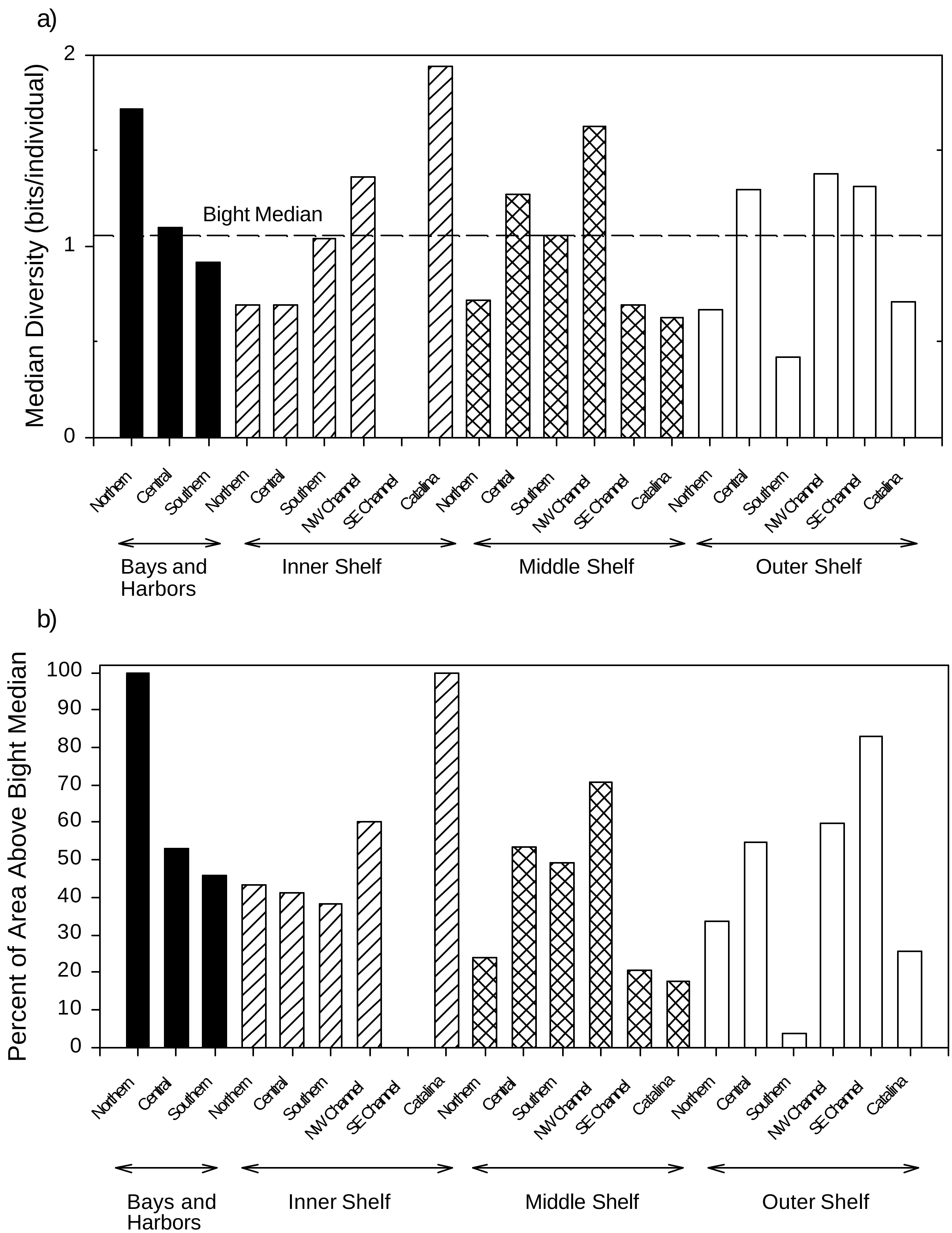
Appendix D9. Number of megabenthic invertebrate species per haul by region within shelf zone subpopulations on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



Appendix D10. Megabenthic invertebrate diversity (Shannon-Wiener) per haul by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



Appendix D11. Megabenthic invertebrate diversity (Shannon-Wiener) per haul by shelf zone sub-population on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.



Appendix D12. Megabenthic invertebrate diversity (Shannon-Wiener) per haul by region within shelf zone subpopulations on the southern California shelf at depths of 2-202 m, July-September 1998: a) median and b) percent of area above Bight median.

Appendix D13. Taxonomic list of megabenthic invertebrate species collected on the southern California shelf at depths of 2-202 m, July-September 1998.

Taxon/Species	Author	Common Name
PORIFERA		
Porifera sp SD 1		"sponge"
Porifera sp SD 2		"sponge"
Porifera sp SD 3		"sponge"
Porifera sp SD 4		"sponge"
Porifera sp SD 5		"sponge"
Porifera sp SD 6		"sponge"
Porifera sp SD 7		"sponge"
Porifera sp SD 8		"sponge"
Porifera sp SD 10		"sponge"
Porifera sp SD 14		"sponge"
CALCEREA		
--SCYCETTIDA		
Amphoriscidae		
Leucilla nuttingi	(Urban 1902)	urn sponge
HEXACTINELLIDA		
--LYSSACINOSA		
Rossellidae		
Rhabdocalyptus dawsoni	(Lambe 1892)	"glass sponge"
Staurocalyptus solidus	Schulze 1899	"glass sponge"
--HEXACTINOSA		
Aphrocallistidae		
Aphrocallistes vastus	Schulze 1887	cloud sponge
DEMOSPONGIAE		
--CHORISTIDA		
Pachastrellidae		
Poecillastra tenuilaminaris	(Sollas 1886)	plate sponge
Sphincturella sp A	Greem & Bakus 1994	"sponge"
--HADROMERIDA		
Suberitidae		
Suberites suberea	(Johnson 1842)	hermitcrab sponge
Tethyidae		
Tethya aurantium	(Pallas 1766)	orange puffball sponge
--POECILOSCLERIDA		
Plocamiidae		
Plocamia karykina	deLaubenfels 1927	"sponge"
CNIDARIA		
HYDROZOA		
--THECATAE		
Aglaopheniidae		
Aglaophenia struthionides	(Murray 1860)	ostrichplume hydroid
Plumulariidae		
Plumularia sp		"seabristle"

Appendix D13 (continued)

Taxon/Species	Author	Common Name
--SIPHONOPHORA		
Rhodaliidae		
Dromalia alexandri	Bigelow 1911	sea dandelion
ANTHOZOA		
--ALCYONACEA		
Alcyonacea (=Alcyonaria)		
sp SD 1		"gorgonian"
Gorgoniidae		
Adelogorgia phyllosclera	Bayer 1958	orange gorgonian
Eugorgia rubens	Verrill 1868	purple gorgonian
Heterogorgia tortuosa	Verrill 1868	"gorgonian"
Lophogorgia chilensis	(Verrill 1868)	pink sea whip
Muriceidae		
Muricea californica	Aurivillius 1931	golden gorgonian
Thesea sp A	Ljubenkov 1986 §	"sea twig"
Thesea sp B	Ljubenkov 1986 §	yellow sea twig
Primnoidae		
Parastenella doederleini	(Wright & Studer 1889)	"gorgonian"
--PENNATULACEA		
Stachyptilidae		
Stachyptilum superbum	Studer 1894	"sea pen"
Virgulariidae		
Acanthoptilum sp		trailtip sea pen, unid.
Stylatula elongata	(Gabb 1862)	slender sea pen
Virgularia agassizi	Studer 1894	"sea pen"
Virgularia californica	Pfeffer 1886	California sea pen
Pennatulidae		
Ptilosarcus gurneyi	(Gray 1860)	fleshy sea pen
--SCLERACTINIA		
Caryophylliidae		
Caryophyllia alaskensis	Vaughn 1941	"cup coral"
Coenocyathus bowersi	Vaughn 1906	colonial cup coral
Paracyathus stearnsii	Verrill 1869	brown cup coral
--ACTINIARIA		
Actiniaria sp SD 1		"anemone"
Actiniidae		
Epiactis prolifera	Verrill 1869	brooding anemone
Metridiidae		
Metridium farcimen (=*senile* Cmplx)	(Brandt 1835)	gigantic anemone
MOLLUSCA		
POLYPLACOPHORA		
Polyplacophora		"chiton"

Appendix D13 (continued)

Taxon/Species	Author	Common Name
GASTROPODA		
--PATELLOGASTROPODA		
Addisoniidae		
Addisonia brophyi	McLean 1985	eggcase limpet
--VETIGASTROPODA		
Fissurellidae		
Fissurella volcano	Reeve 1849	volcano keyhole limpet
Puncturella galeata	(Gould 1846)	helmet puncturella
Calliostomatidae		
Calliostoma gloriosum	Dall 1871	glorious topsnail
Calliostoma turbinum	Dall 1896	spindle topsnail
Trochidae		
Cidarina cidaris	(Carpenter 1864)	spiny margarite
--NEOTAENIOGLOSSA		
Calyptraeidae		
Crepidula onyx	G. B. Sowerby I 1824	onyx slippersnail
Crepidula perforans	(Valenciennes 1846)	white slippersnail
Crepipatella dorsata	(Broderip 1834)	Pacific half-slippersnail
Crucibulum spinosum	(G. B. Sowerby I 1824)	spiny cup-and-saucer
Ovulidae		
Neosimnia aequalis	(G. B. Sowerby I 1832)	Vidler spindlesnail
Neosimnia barbarensis	(Dall 1892)	seapen spindlesnail
Neosimnia loebbeckeana	(Weinkauff 1881)	Loebbeck spindlesnail
Triviidae		
Erato vitellina	Hinds 1844	appleseed erato
Naticidae		
Calinaticina oldroydii	(Dall 1897)	delicate moonsnail
Euspira (=*Polinices*) *draconis*	(Dall 1903)	Drake moonsnail
Euspira (=*Polinices*) *lewisii*	(Gould 1847)	Lewis moonsnail
Neverita reclusiana	(Deshayes 1839)	southern moonsnail
Bursidae		
Crossata californica	(Hinds 1843)	California frogsnail
--NEOGASTROPODA		
Muricidae		
Austrotrophon catalinensis	I. Oldroyd 1927	Catalina forreria
Boreotrophon sp		"trophon"
Ocinebrina sp		"rocksnail"
Pteropurpura festiva	(Hinds 1844)	festive murex
Pteropurpura vokesae	Emerson 1964	wrinkle-wing murex
Scabrotrophon grovesi	McLean 1996	"trophon"
Buccinidae		
Kelletia kelletii (=*kelletti*)	(Forbes 1850)	Kellet whelk
Neptunea tabulata	(Baird 1863)	tabled whelk

Appendix D13 (continued)

Taxon/Species	Author	Common Name
Nassariidae		
Nassarius fossatus	(Gould 1850)	channeled nassa
Nassarius insculptus	(Carpenter 1864)	smooth western nassa
Nassarius perpinguis	(Hinds 1844)	fat western nassa
Nassarius tiarula (=*tegula*)	(Kiener 1841)	western mud nassa
Fasciolariidae		
Fusinus barbarensis	(Trask 1855)	Santa Barbara spindle
Mitridae		
Mitra idae	Melvill 1893	half-pitted miter
Cancellariidae		
Cancellaria cooperii		
(=*cooperi*)	Gabb 1865	Cooper nutmeg
Cancellaria crawfordiana	Dall 1891	Crawford nutmeg
Conidae		
Conus californicus	Hinds 1844	California cone
Terebridae		
Terebra pedroana	Dall 1908	San Pedro auger
Turridae		
Antiplanes catalinae		
(=*perversus*)	(Raymond 1904)	Catalina turrid
Crassispira semiinflata	(Grant & Gale 1931)	California drillia
Megasurcula carpenteriana	(Gabb 1865)	tower snail
--ANASPIDEA		
Aplysiidae		
Aplysia californica	J. G. Cooper 1863	purple sea hare
Aplysia vaccaria	Winkler 1955	black sea hare
--CEPHALASPIDEA		
Bullidae		
Bulla gouldiana	Pilsbry 1895	California bubble
Haminoeidae		
Haminoea (=*Haminaea*)		
vesicula	(Gould 1855)	blister glassy-bubble
Aglajidae		
Navanax inermis	(J. G. Cooper 1863)	California aglaja
Philinidae		
Philine alba	Mattox 1958	white paperbubble
Philine auriformis	Suter 1909	New Zealand paperbubble
--NOTASPIDEA		
Pleurobranchaeidae		
Berthella californica	(Dall 1900)	California sidegill slug
Pleurobranchaea californica	MacFarland 1966	California sea slug
--NUDIBRANCHIA		
Archidorididae		
Archidoris montereyensis	(J. G. Cooper 1863)	Monterey sea-lemon

Appendix D13 (continued)

Taxon/Species	Author	Common Name
Discodorididae		
Diaulula sandiegensis	(J. G. Cooper 1863)	ringed doris
Platydorididae		
Platydoris macfarlandi	Hanna 1951	California flat doris
Onchidorididae		
Acanthodoris brunnea	MacFarland 1905	brown spiny doris
Acanthodoris hudsoni	MacFarland 1905	Hudson spiny doris
Acanthodoris rhodoceras	Cockerell in Cockerell & Elliot 1905	black-tipped spiny doris
Polyceratidae		
Triopha maculata	MacFarland 1905	maculated triopha
Dendrodorididae		
Doriopsilla albopunctata	(J. G. Cooper 1863)	salted yellow doris
Tritoniidae		
Tochuina tetraquetra	(Pallas 1788)	giant orange tochui
Tritonia diomedea	Bergh 1894	rosy tritonia
Dendronotidae		
Dendronotus iris	J. G. Cooper 1863	giant frond-aeolis
Arminidae		
Armina californica	(J. G. Cooper 1863)	California armina
Dironidae		
Dirona sp		"dirona"
Flabellinidae		
Flabellina iodinea	J. G. Cooper 1863	Spanish shawl
Flabellina pricei	(MacFarland 1966)	smooth-tooth aeolis
BIVALVIA		
Mytilidae		
Amygdalum politum	(Verrill & Smith in Verrill 1880)	pallid papermussel
Musculista senhousia	(Benson in Cantor 1842)	mat mussel
Mytilus galloprovincialis	Lamarck 1819	Mediterranean mussel
Limidae		
Limaria hemphilli	(Hertlein & Strong 1946)	Hemphill fileclam
--OSTREOIDA		
Ostreidae		
Ostrea sp		"oyster"
Pectinidae		
Argopecten ventricosus	(G. B. Sowerby II 1842)	Pacific calico scallop
Chlamys hastata	(G. B. Sowerby II 1842)	spiny scallop
Crassadoma gigantea	(J. E. Gray 1825)	giant rock scallop
Euvola diegensis	(Dall 1898)	San Diego scallop
Pectinidae (continued)		
Leptopecten latiauratus	(Conrad 1837)	kelp scallop

Appendix D13 (continued)

Taxon/Species	Author	Common Name
--VENEROIDA		
Chamidae		
Chama arcana	Bernard 1976	secret jewelbox
CEPHALOPODA		
--SEPIOLIDA		
Sepiolidae		
Rossia pacifica	Berry 1911	eastern Pacific bobtail
--TEUTHIDA		
Loliginidae		
Loligo opalescens	Berry 1911	California market squid
--OCTOPODA		
Octopodidae		
Octopus bimaculoides	Pickford & McConnaughey 1949	California two-spot octopus
Octopus californicus	(Berry 1911)	orange bigeye octopus
Octopus rubescens	Berry 1953	red octopus
Octopus veligero	Berry 1953	brownspot octopus
ANNELIDA		
POLYCHAETA		
--SPIONIDA		
Chaetopteridae		
Chaetopterus variopedatus Cmplx		parchment tube worm
--PHYLLODOCIDA		
Aphroditidae		
Aphrodita armifera	Moore 1910	copperwire sea mouse
Aphrodita negligens	Moore 1905	shaggy sea mouse
Aphrodita refulgida	Moore 1910	green sea mouse
--SABELLIDA		
Serpulidae		
Protula superba	Moore 1909	chalktube worm
ARTHROPODA		
PYCNOGONIDA		
--PEGMATA		
Phoxychillidiidae		
Anoplodactylus erectus	Cole 1904	"sea spider"
Anoplodactylus virdintestinalis	Cole 1904	"sea spider"
CIRRIPEDIA		
--THORACICA		
Scalpellidae		
Hamatoscalpellum californicum	(Pilsbry 1907)	California blade barnacle
Balanidae		
Balanus pacificus	Pilsbry 1916	Pacific acorn barnacle

Appendix D13 (continued)

Taxon/Species	Author	Common Name
MALACOSTRACA		
--STOMATOPODA		
Hemisquillidae		
Hemisquilla ensigera californiensis	Stephenson 1967	blueleg mantis shrimp
Squillidae		
Schmittius politus	(Bigelow 1891)	polished mantis shrimp
--ISOPODA		
Aegidae		
Rocinela angustata	Richardson 1904	"fish louse"
Corallanidae		
Excorallana truncata	(Richardson 1899)	cuttail sea louse
--DECAPODA		
Solenoceridae		
Solenocera mutator	Burkenroad 1938	blossom shrimp
Penaeidae		
Farfantepenaeus (=*Penaeus*) *californiensis*	(Holmes 1900)	yellowleg shrimp
Sicyoniidae		
Sicyonia ingentis	(Burkenroad 1938)	ridgeback rock shrimp
Sicyonia penicillata	Lockington 1879	peanut rock shrimp
Pandalidae		
Pandalus jordani	Rathbun 1902	ocean shrimp
Pandalus platyceros	Brandt 1851	spot shrimp
Pantomus affinis	Chace 1937	hinged shrimp
Plesionika trispinus	Squires & Barragán 1976	Colombian longbeak shrimp
Alpheidae		
Alpheus californiensis	Holmes 1900	mudflat snapping shrimp
Synalpheus lockingtoni	Coutiere 1909	littoral pistol shrimp
Hippolytidae		
Heptacarpus stimpsoni	Holthuis 1947	Stimpson coastal shrimp
Heptacarpus tenuissimus	Holmes 1900	slender coastal shrimp
Lysmata californica	(Stimpson 1866)	red rock shrimp
Spirontocaris holmesi	Holthuis 1947	slender blade shrimp
Spirontocaris sica	Rathbun 1902	offshore blade shrimp
Crangonidae		
Crangon alaskensis	Lockington 1877	Alaska bay shrimp
Crangon nigromaculata	Lockington 1877	blackspotted bay shrimp
Metacrangon spinosissima	(Rathbun 1902)	southern spinyhead
Neocrangon communis	(Rathbun 1899)	gray shrimp
Neocrangon resima	(Rathbun 1902)	flagnose bay shrimp
Neocrangon zacae	(Chace 1937)	moustache bay shrimp
Panuliridae		
Panulirus interruptus	Randall 1839	California spiny lobster

Appendix D13 (continued)

Taxon/Species	Author	Common Name
Callianassidae		
Neotrypaea californiensis	(Dana 1854)	bay ghost shrimp
Diogenidae		
Isocheles pilosus	(Holmes 1900)	moon snail hermit
Paguristes bakeri	Holmes 1900	digger hermit
Paguristes sp A		"left-handed hermit"
Paguristes turgidus	(Stimpson 1857)	slenderclaw hermit
Paguristes ulreyi	Schmitt 1921	furry hermit
Paguridae		
Enallopaguropsis guatemoci	(Glassell 1937)	"right-handed hermit"
Orthopagurus minimus	(Holmes 1900)	tubicolous hermit
Pagurus armatus	(Dana 1851)	armed hermit
Pagurus redondoensis	Wicksten 1982	bandclaw hermit
Pagurus spilocarpus	Haig 1977	spotwrist hermit
Parapagurodes makarovi	McLaughlin & Haig 1973	smoothpalm hermit
Phimochirus californiensis	(Benedict 1892)	porcelainclaw hermit
Lithodidae		
Lopholithodes foraminatus	(Stimpson 1859)	brown box crab
Paralithodes californiensis	(Benedict 1894)	California king crab
Paralithodes rathbuni	(Benedict 1894)	forknose king crab
Galatheidae		
Galathea californiensis	Benedict 1902	California squat lobster
Munida hispida	Benedict 1902	bristle squat lobster
Munida quadrispina	Benedict 1902	northern squat lobster
Pleuroncodes planipes	Stimpson 1860	pelagic red crab
Dromiidae		
Cryptodromiopsis larraburei	(Rathbun 1910)	Pacific sponge crab
Calappidae		
Platymera gaudichaudii	H. Milne Edwards 1837	armed box crab
Leucosiidae		
Randallia ornata	(Randall 1839)	globose sand crab
Majidae		
Chorilia longipes	Dana 1851	longhorn decorator crab
Epialtoides hiltoni	(Rathbun 1923)	winged kelp crab
Erileptus spinosus	Rathbun 1893	shortneck pear crab
Loxorhynchus crispatus	Stimpson 1857	moss crab
Loxorhynchus grandis	Stimpson 1857	sheep crab
Podochela hemphillii	(Lockington 1877)	Hemphill neck crab
Podochela lobifrons	Rathbun 1893	thinbeak neck crab
Pugettia dalli	Rathbun 1893	spined kelp crab
Pugettia producta	(Randall 1839)	northern kelp crab
Pugettia richii	Dana 1851	cryptic kelp crab

Appendix D13 (continued)

Taxon/Species	Author	Common Name
Majidae (continued)		
Pyromaia tuberculata	(Lockington 1877)	tuberculate pear crab
Scyra acutifrons	Dana 1851	sharpnose crab
Stenorhynchus debilis	(Smith 1871)	Pacific arrow crab
Parthenopidae		
Heterocrypta occidentalis	(Dana 1854)	sandflat elbow crab
Cancridae		
Cancer anthonyi	Rathbun 1879	yellow rock crab
Cancer branneri	Rathbun 1926	furrowed rock crab
Cancer gracilis	Dana 1852	graceful rock crab
Cancer jordani	Rathbun 1900	hairy rock crab
Cancer productus	Randall 1839	red rock crab
Portunidae		
Portunus xantusii	(Stimpson 1860)	Xantus swimming crab
Xanthidae		
Lophopanopeus bellus	(Stimpson 1860)	blackclaw crestleg crab
Lophopanopeus frontalis	(Rathbun 1893)	molarless crestleg crab
Paraxanthias taylori	(Stimpson 1861)	lumpy rubble crab
Pilumnus spinohirsutus	(Lockington 1876)	retiring hairy crab
Pinnotheridae		
Opisthopus transversus	Rathbun 1893	mottled pea crab
ECHINODERMATA		
CRINOIDEA		
--COMATULIDA		
Antedonidae		
Florometra serratissima	(A. H. Clark 1907)	feather star
ASTEROIDEA		
--PAXILLOSIDA		
Luidiidae		
Luidia armata	Ludwig 1905	mosaic sand star
Luidia asthenosoma	Fisher 1906	fringed sand star
Luidia foliolata	Grube 1866	gray sand star
Astropectinidae		
Astropecten armatus	Gray 1840	spiny sand star
Astropecten ornatissimus	Fisher 1906	orange sand star
Astropecten verrilli	de Loriol 1899	California sand star
--VALVATIDA		
Goniasteridae		
Ceramaster sp		"cookie star"
Hippasteria spinosa	Verrill 1909	spiny red star
Mediaster aequalis	Stimpson 1857	red sea star
Asterinidae		
Asterina miniata	(Brandt 1835)	bat star

Appendix D13 (continued)

Taxon/Species	Author	Common Name
--SPINULOSIDA		
Poraniidae		
Poraniopsis inflata	(Fisher 1906)	spiny sea star
Echinasteridae		
Henricia leviuscula	(Stimpson 1857)	blood star
--FORCIPULATIDA		
Asteriidae		
Leptasterias hexactis	(Stimpson 1853)	six-arm sea star
Pisaster brevispinus	(Stimpson 1857)	shortspined sea star
Pisaster giganteus capitatus	(Stimpson 1862)	giant spined star
Pisaster ochraceus	(Brandt 1835)	ochre star
Pycnopodia helianthoides	(Brandt 1835)	sunflower star
Rathbunaster californicus	Fisher 1906	California sun star
Sclerasterias heteropaes	Fisher 1924	banded sea star
Stylasterias forreri	(de Loriol 1887)	fish-eating star
OPHIUROIDEA		
Ophiuroidea		
--PHRYNOPHIURIDA		
Gorgonocephalidae		
Gorgonocephalus eucnemis	(J. Müller & Troschel 1842)	basket star
--OPHIURIDA		
Ophiacanthidae		
Ophiacantha phragma	Ziesenhenne 1940	fragile spinyarm brittlestar
Ophiactidae		
Ophiopholis bakeri	McClendon 1909	roughspine brittlestar
Amphiuridae		
Amphichondrius granulatus	(Lütken & Mortensen 1899)	roughdisk brittlestar
Amphiodia digitata	Nielsen 1932	"brittlestar"
Amphiodia psara	H. L. Clark 1935	"brittlestar"
Amphiodia urtica	(Lyman 1860)	red brittlestar
Amphioplus sp		
Amphiura arcystata	H. L. Clark 1911	"brittlestar"
Ophiotricidae		
Ophiothrix spiculata	Le Conte 1851	Pacific spiny brittlestar
Ophiocomidae		
Ophiopteris papillosa	(Lyman 1875)	flatspine brittlestar
Ophionereidae		
Ophionereis eurybrachiplax	H. L. Clark 1911	"brittlestar"
Ophiuridae		
Ophiura luetkenii	(Lyman 1860)	brokenspine brittlestar
ECHINOIDEA		
--TEMNOPLEUROIDA		
Toxopneustidae		
Lytechinus pictus	(Verrill 1867)	white sea urchin

Appendix D13 (continued)

Taxon/Species	Author	Common Name
--ECHINOIDA		
Strongylocentrotidae		
Allocentrotus fragilis	(Jackson 1912)	fragile sea urchin
Strongylocentrotidae (continued)		
Strongylocentrotus franciscanus	(A. Agassiz 1863)	red sea urchin
Strongylocentrotidae (continued)		
Strongylocentrotus purpuratus	(Stimpson 1857)	Pacific purple urchin
--CLYPEASTEROIDA		
Dendrasteridae		
Dendraster excentricus	(Eschscholtz 1831)	Pacific sand dollar
Dendraster terminalis	(Grant & Hertlein 1938)	offshore sand dollar
--SPATANGOIDA		
Schizasteridae		
Brisaster latifrons	(A. Agassiz 1898)	northern heart urchin
Brissidae		
Brissopsis pacifica	(A. Agassiz 1898)	Pacific heart urchin
Spatangidae		
Spatangus californicus	H. L. Clark 1917	California heart urchin
Loveniidae		
Lovenia cordiformis	A. Agassiz 1872	sea porcupine
HOLOTHUROIDEA		
--DENDROCHIROTIDA		
Psolidae		
Psolus squamatus	(Koren 1844)	scaly sea cucumber
Phyllophoridae		
Pentamera pseudocalcigera	Deichmann 1938	globose hooked cucumber
Pentamera pseudopopulifera	Deichmann 1938	southern hooked cucumber
Cucumariidae		
Cucumaria sp		"nestling sea cucumber"
--ASPIDOCHIROTIDA		
Stichopodidae		
Parastichopus californicus	(Stimpson 1857)	California sea cucumber
Paristichopus parvimensis	(H. L. Clark 1913)	warty sea cucumber
Parastichopus sp A	SCAMIT 1998 §	"sea cucumber"
BRACHIOPODA		
ARTICULATA		
--TEREBRATULIDA		
Cancellothyrididae		
Terebratulina crossei	Davidson 1882	white lamp shell
Laqueidae		
Laqueus californianus	Koch 1847	California lamp shell

Appendix D13 (continued)

Taxon/Species	Author	Common Name
Dallinidae		
Terebratalia occidentalis	(Dall 1871)	ribbed lamp shell
Terebratalia transversa	(G. B. Sowerby II 1846)	red lamp shell
ECTOPROCTA		
GYMNOLAEMATA		
--CTENOOSTOMATA		
Vesiculariidae		
Zoobotryon verticillatum (=*pellucida*)	(delle Chiaje 1828)	spaghetti moss-animal
--CHEILOSTOMATA		
Thalamoporellidae		
Thalamoporella californica	Levinsen 1909	chambered bryozoan
CHORDATA		
ASCIDIACEA		
--APLOUSOBRANCHIATA		
Polyclinidae		
Aplydium sp		"colonial tunicate"
--PHLEBOBRANCHIATA		
Cionidae		
Ciona intestinalis	(Linnaeus 1767)	yellow-green sea squirt
Ascidiidae		
Ascidiidae sp SD 1		"tunicate"
Ascidia zara	Oka 1935	"tunicate"
--STOLIDOBRANCHIATA		
Styelidae		
Styela montereyensis	(Dall 1872)	longstalk sea squirt
Styela plicata	(Lesueur 1823)	cobblestone sea squirt
Pyuridae		
Microcosmus (=*Microcosmos*) *squamiger*	Hartmeyer & Michaelsen 1926	scaly tunicate
Molgulidae		
Molgula verrucifera	Ritter & Forsyth 1917	warty tunicate

Taxonomic arrangement and scientific names from (SCAMIT 2001). Common names from Turgeon *et al.* (1988), Williams *et al*. (1989), and Cairns *et al*. (1991) if possible. Otherwise, names are from miscellaneous sources.

(...=.....) means 'current valid name (= database name)'

Appendix D14. Percent of area of megabenthic invertebrate species by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	Percent of Area										
	Region										
	Mainland			Island			Shelf Zone				
Species*	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Lytechinus pictus	33	46	56	75	90	65	-	14	79	21	56
Astropecten verrilli	63	69	56	32	65	50	-	47	67	27	55
Sicyonia ingentis	64	50	67	26	61	65	8	0	65	63	52
Luidia foliolata	38	34	8	68	67	31	-	0	55	48	43
Philine auriformis	28	28	41	36	45	54	28	18	45	13	34
Pleurobranchaea californica	34	14	10	57	50	23	-	3	43	33	33
Hamatoscalpellum californicum	24	30	18	52	43	-	-	3	45	20	33
Parastichopus californicus	43	26	41	10	41	62	7	-	41	34	32
Thesea sp B	20	44	40	26	37	12	-	-	43	19	30
Acanthoptilum sp	23	6	36	36	63	46	1	-	37	34	29
Mediaster aequalis	2	5	7	67	70	27	-	-	33	37	27
Ophiura luetkenii	31	24	1	26	48	19	-	-	35	21	25
Octopus rubescens	20	12	24	32	37	31	-	7	30	22	24
Ophiothrix spiculata	29	13	16	22	48	23	4	8	32	10	24
Allocentrotus fragilis	11	6	2	25	46	31	-	-	9	64	16
Luidia asthenosoma	9	11	1	31	34	-	-	-	23	7	16
Luidia armata	16	33	10	10	-	4		6	22	4	16
Loligo opalescens	11	14	34	-	17	23	3	0	17	13	13
Paguristes turgidus	-	14	1	20	33	4	-	-	12	22	11
Megasurcula carpenteriana	6	2	18	21	-	4	-	-	14	4	10
Stylatula elongata	19	14	5	-	2	15	-	10	11	5	10
Metridium senile Cmplx	6	1	4	26	11	-	-	-	10	20	10
Ptilosarcus gurneyi	2	-	-	26	20	15	-	-	12	12	9
Crangon nigromaculata	16	11	20	-	-	-	38	37	3	-	9
Pyromaia tuberculata	10	22	9	-	-	-	59	28	4	-	9
Aglaophenia sp	-	2		23	26	-	-	6	11	5	9
Platymera gaudichaudii	-	3	7	21	17	8	-	-	14	1	9
Ophiopholis bakeri	-	-	1	15	43	15	-	-	6	28	8
Fusinus barbarensis	12	5	-	15	-	4	-	-	9	14	8
Neocrangon zacae	10	3	1	15	5	12	-	-	4	30	8
Asterina miniata	-	3	0	22	17	-	3	5	11	-	8
Brisaster latifrons	11	4	-	15	2	-	-	-	4	31	8
Tritonia diomedea	5	1	-	10	34	8	-	-	11	4	8
Podochela lobifrons	4	5	1	10	26	12	-	-	12	2	8
Neosimnia barbarensis	1	0	7	-	65	-	-	0	10	9	8
Rossia pacifica	7	8	23	-	2	4	-	-	9	10	7
Philine alba	4	-	-	21	9	-	-	-	11	-	7
Gorgonocephalus eucnemis	2	-	-	15	20	8	-	-	3	26	6
Spatangus californicus	12	1	8	-	7	19	-	-	4	20	6
Virgularia californica	-	1	-	10	34	-	-	-	10	-	6
Heterogorgia tortuosa	1	16	15	-	-	-	-	-	9	2	6
Calliostoma turbinum	9	-	1	10	9	-	-	6	7	2	6
Pycnopodia helianthoides	-	-	-	21	5	-	-	-	9	1	6
Kelletia kelletii	0	5	14	10	-	-	-	9	6	2	6
Hemisquilla ensigera	6	1	9	10	-	-	-	3	8	-	6
Astropecten armatus	2	17	4	-	-	8	26	26	0	-	5
Cancer productus	-	-	-	21	-	-	-	-	8	-	5

Appendix D14 (continued)

	Percent of Area										
	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Erileptus spinosus	-	-	-	21	-	-	-	-	8	-	5
Poecillastra tenuilaminaris	-	-	-	20	-	4	-	-	4	14	5
Eugorgia rubens	-	5	-	5	28	4	-	-	5	12	5
Armina californica	-	1	-	11	17	8	2	2	7	-	5
Pleuroncodes planipes	1	-	10	5	16	12	-	-	3	17	5
Paguristes bakeri	1	5	24	-	-	-	-	-	7	2	5
Penaeus californiensis	-	14	13	-	-	-	44	16	2	-	5
Octopus californicus	1	3	7	5	11	8	-	-	3	16	5
Henricia leviuscula	-	-	-	10	17	8	-	-	7	2	4
Dendronotus sp	12	5	-	-	-	-	-	3	5	4	4
Astropecten ornatissimus	5	-	1	-	11	50	-	-	1	20	4
Aphrodita sp	4	0	1	10	2	8	-	-	7	1	4
Suberites suberea	-	5	-	5	20	-	-	-	3	13	4
Dendronotus iris	2	0	-	10	9	-	4	3	5	-	4
Loxorhynchus grandis	8	3	8	-	-	-	3	12	2	2	4
Ophionereis eurybrachiplax	-	-	-	15	-	-	-	-	4	7	4
Schmittius politus	7	6	1	-	-	4	3	-	6	-	4
Pandalus platyceros	3	3	1	5	9	-	-	3	2	13	4
Flabellina iodinea	13	0	-	-	-	-	-	3	5	-	4
Anthozoa	-	-	-	10	9	4	-	-	5	1	4
Neocrangon resima	8	4	1	-	-	4	-	-	0	19	3
Paracyathus stearnsii	-	-	0	10	9	-	-	-	4	5	3
Euvola diegensis	-	-	-	10	9	-	-	-	5	-	3
Ophiacantha sp	-	-	0	10	2	19	-	-	1	16	3
Strongylocentrotus purpuratus	2	0	-	11	-	-	3	4	4	-	3
Doridoidea	-	-	-	5	20	-	-	-	2	12	3
Paralithodes californiensis	-	0	-	10	2	8	-	-	0	17	3
Sclerasterias heteropaes	-	-	-	-	28	8	-	-	5	1	3
Amphichondrius granulatus	-	0	1	10	2	-	-	-	5	-	3
Loxorhynchus crispatus	0	0	1	11	-	-	-	2	0	14	3
Pantomus affinis	4	6	3	-	-	8	-	-	-	17	3
Tochuina tetraquetra	-	-	2	10	-	-	-	-	4	2	3
Podochela hemphillii	7	1	1	2	-	4	1	6	2	2	3
Pisaster brevispinus	2	10	0	-	-	-	4	9	2	-	3
Pugettia dalli	-	-	-	11	-	-	-	1	4	-	3
Pugettia richii	-	-	-	11	-	-	-	1	4	-	3
Tethya aurantium	-	-	-	10	-	4	-	-	4	-	3
Heterocrypta occidentalis	6	4	1	-	-	4	2	12	1	-	3
Pagurus spilocarpus	-	7	8	-	-	-	6	0	4	-	3
Coenocyathus bowersi	-	-	0	10	-	-	-	-	4	-	3
Acanthodoris hudsoni	-	-	-	10	-	-	-	-	4	-	3
Addisonia brophyi	-	-	-	10	-	-	-	-	4	-	3
Amphioplus sp	-	-	-	10	-	-	-	-	4	-	3
Hippolytidae	-	-	-	10	-	-	-	-	4	-	3
Hydrozoa	-	-	-	10	-	-	-	-	4	-	3
Orthopagurus minimus	-	-	-	10	-	-	-	-	4	-	3
Paralithodes rathbuni	-	-	-	10	-	-	-	-	-	14	2
Randallia ornata	-	7	5	-	-	4	3	6	2	-	2
Paguristes sp	9	-	-	-	-	-	-	-	3	2	2

Appendix D14 (continued)

	Percent of Area										
	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Metacrangon spinosissima	7	1	0	-	-	-	-	-	2	8	2
Crossata californica	-	0	17	-	-	-	-	0	4	-	2
Solenocera mutator	-	8	1	-	-	8	-	-	2	4	2
Virgularia agassizi	4	0	7	-	-		-	-	3	-	2
Portunus xantusii	2	3	1	2	-	4	4	11	-	-	2
Ophiopteris papillosa	-	-	-	2	17	-	-	2	3	-	2
Lopholithodes foraminatus	1	-	-	5	5	-	-	-	-	12	2
Stylasterias forreri	1	-	-	5	5	-	-	-	0	10	2
Cancellaria crawfordiana	2	-	1	5	-	-	-	-	0	11	2
Conus californicus	6	0	-	-	-	4	4	3	2	-	2
Muricea californica	-	5	4	-	-	-	-	3	2	-	2
Ophiacantha phragma	6	-	-	-	-	-	-	-	2	4	2
Polyplacophora	2	-	-	-	11	-	-	3	0	5	2
Pisaster ochraceus	6	0	-	-	-	-	-	3	2	-	2
Brissopsis pacifica	4	1	-	-	2	-	-	-	-	9	2
Plumularia sp	-	7	-	-	-	-	-	3	2	-	2
Antiplanes perversus	1	-	-	5	-	-	-	-	-	9	2
Acanthodoris brunnea	5	1	-	-	-	-	-	-	2	2	1
Laqueus californianus	1	-	-	-	-	31	-	-	1	4	1
Aplysia californica	2	0	3	2	-	-	4	5	0	2	1
Staurocalyptus solidus	-	-	-	5	-	4	-	-	-	8	1
Mitra idae	5	-	0	-	-	-	-	0	2	2	1
Ophiuroidea	5	-	-	-	-	-	-	-	2	2	1
Spirontocaris holmesi	2	3	0	-	-	-	-	-	-	8	1
Virgularia sp	4	1	-	-	-	-	-	-	2	-	1
Luidia sp	4	0	-	-	-	4	-	-	2	-	1
Aphrocallistes vastus	-	-	-	5	-	-	-	-	-	7	1
Caryophyllia alaskensis	-	-	-	5	-	-	-	-	-	7	1
Ceramaster sp	-	-	-	5	-	-	-	-	-	7	1
Chorilia longipes	-	-	-	5	-	-	-	-	-	7	1
Poraniopsis inflata	-	-	-	5	-	-	-	-	-	7	1
Sphincterella sp A	-	-	-	5	-	-	-	-	-	7	1
Navanax inermis	0	2	0	-	-	19	24	1	1	-	1
Rathbunaster californicus	1	-	-	-	9	-	-	-	1	2	1
Holothuroidea	1	-	-	-	9	-	-	-	1	2	1
Cancer sp	-	-	8	-	-	-	2	6	0	-	1
Parastichopus parvimensis	-	0	3	1	-	15	2	2	1	2	1
Protula superba	-	0	1	-	9	4	-	-	2	-	1
Isocheles pilosus	-	5	-	-	-	-	-	6	-	-	1
Neocrangon sp	4	-	1	-	-	-	-	-	2	-	1
Pteropurpura vokesae	-	5	0	-	-	-	1	-	2	-	1
Paguristes ulreyi	-	5	0	-	-	-	-	0	2	-	1
Acanthodoris rhodoceras	4	-	-	-	-	-	-	-	2	-	1
Anoplodactylus erectus	-	-	7	-	-	-	-	-	2	-	1
Chaetopterus variopedatus	4	-	-	-	-	-	-	-	2	-	1
Crassispira seminflata	-	-	7	-	-	-	-	-	2	-	1
Epiactis prolifera	-	-	7	-	-	-	-	-	2	-	1
Erato vitellina	4	-	-	-	-	-	-	-	2	-	1
Majidae	-	-	7	-	-	-	-	-	2	-	1

Appendix D14 (continued)

	Percent of Area										
	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Porifera sp SD 3	-	-	7	-	-	-	-	-	2	-	1
Rocinela angustata	-	5	-	-	-	-	-	-	2	-	1
Aphrodita negligens	-	5	-	-	-	-	-	-	2	-	1
Fissurella volcano	4	-	-	-	-	-	-	-	2	-	1
Leptasterias hexactis	-	-	-	-	9	4	-	-	2	-	1
Ciona sp	0	0	0	-	9	-	7	-	1	-	1
Panulirus interruptus	-	0	4	1	-	-	3	4	-	-	1
Chlamys hastata	-	-	-	-	9	-	-	-	1	-	1
Florometra serratissima	-	-	-	-	9	-	-	-	1	-	1
Terebratalia transversa	-	-	-	-	9	-	-	-	1	-	1
Pugettia producta	0	0	5	-	-	-	7	3	-	-	1
Hippasteria spinosa	1	-	-	-	-	12	-	-	-	4	1
Nassarius perpinguis	2	1	0	-	-	-	6	3	-	-	1
Pteropurpura festiva	-	0	4	-	-	-	5	3	0	-	1
Lophogorgia chilensis	-	0	-	1	-	12	-	1	1	-	1
Galathea californiensis	1	-	3	-	-	-	-	-	-	4	1
Pandalus jordani	1	1	-	-	-	-	-	-	-	4	1
Thalamoporella californica	2	0	-	-	-	-	4	3	-	-	1
Cancer anthonyi	0	2	0	-	-	-	1	1	0	2	1
Polinices draconis	2	-	1	-	-	-	-	3	0	-	1
Cancer gracilis	0	0	4	-	-	-	-	3	-	-	1
Ascidiidae sp SD 1	0	-	4	-	-	-	1	3	-	-	1
Dendraster excentricus	2	-	0	-	-	-	-	3	-	-	1
Dendraster terminalis	-	2	0	-	-	-	-	3	-	-	1
Amphiodia psara	-	2	-	-	-	-	-	3	-	-	1
Boreotrophon sp	2	-	-	-	-	-	-	3	-	-	1
Flabellina pricei	-	2	-	-	-	-	-	3	-	-	1
Lysmata californica	2	-	-	-	-	-	-	3	-	-	1
Crangon alaskensis	-	1	3	-	-	-	3	-	1	-	1
Styela sp	0	2	0	-	-	-	20	-	0	-	1
Cryptodromiopsis larraburei	-	-	2	-	-	4	-	-	0	2	0
Calinaticina oldroydii	1	1	-	-	-	-	3	-	0	2	0
Stenorhynchus debilis	-	-	-	-	-	12	-	-	1	-	0
Terebratalia occidentalis	-	-	-	-	-	12	-	-	1	-	0
Strongylocentrotus	-	0	0	2	-	-	-	2	-	-	0
Musculista senhousia	-	1	2	-	-	-	23	-	-	-	0
Lovenia cordiformis	-	-	0	1	-	4	-	2	0	-	0
Amphiura arcystata	-	0	-	-	-	8	-	1	0	-	0
Argopecten ventricosus	-	1	2	-	-	-	20	-	-	-	0
Leucilla nuttingi	-	1	0	-	-	4	1	-	0	-	0
Ciona intestinalis	0	1	0	-	-	-	18	-	-	-	0
Aphrodita refulgida	1	-	-	-	-	-	-	-	-	2	0
Dromalia alexandri	-	1	-	-	-	-	-	-	-	2	0
Hyperiidae	1	-	-	-	-	-	-	-	-	2	0
Neocrangon communis	1	-	-	-	-	-	-	-	-	2	0
Octopus veligero	-	1	-	-	-	-	-	-	-	2	0
Pentamera pseudocalcigera	1	-	-	-	-	-	-	-	-	2	0
Pentamera sp	1	-	-	-	-	-	-	-	-	2	0
Plesionika trispinus	-	1	-	-	-	-	-	-	-	2	0

Appendix D14 (continued)

	Percent of Area										
	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Psolidae	1	-	-	-	-	-	-	-	-	2	0
Psolus sp	1	-	-	-	-	-	-	-	-	2	0
Puncturella galeata	1	-	-	-	-	-	-	-	-	2	0
Spirontocaris sica	-	1	-	-	-	-	-	-	-	2	0
Adelogorgia phyllosclera	-	-	0	-	-	8	-	-	0	-	0
Pentamera pseudopopulifera	-	-	0	-	-	8	-	-	0	-	0
Mytilus galloprovincialis	0	1	-	-	-	-	16	-	-	-	0
Cidarina cidaris	-	-	-	-	-	8	-	-	-	2	0
Rhabdocalyptus dawsoni	-	-	-	-	-	8	-	-	0	1	0
Cancer branneri	-	-	0	-	2	-	2	-	0	-	0
Styela montereyensis	0	1	0	-	-	-	14	0	-	-	0
Microcosmus squamiger	0	0	1	-	-	-	14	-	-	-	0
Brachyura	-	-	0	1	-	-	-	1	0	-	0
Bulla gouldiana	-	0	1	-	-	-	11	-	-	-	0
Amphiodia digitata	-	0	-	-	-	4	4	-	0	-	0
Patellogastropoda	-	-	-	1	-	-	-	1	-	-	0
Neverita reclusiana	-	0	1	-	-	-	5	0	0	-	0
Amphiodia urtica	-	0	1	-	-	-	-	-	0	-	0
Excorallana truncata	-	1	-	-	-	-	-	-	0	-	0
Platydoris macfarlandi	-	-	1	-	-	-	-	-	0	-	0
Zoobotryon pellucida	0	1	-	-	-	-	9	-	-	-	0
Ostrea sp	-	0	1	-	-	-	8	-	-	-	0
Astropecten sp	-	-	-	-	-	4	-	-	-	1	0
Berthella californica	-	-	-	-	-	4	-	-	0	-	0
Cancellaria cooperi	-	-	-	-	-	4	-	-	0	-	0
Cucumaria sp	-	-	-	-	-	4	-	-	0	-	0
Enallopaguropsis guatemoci	-	-	-	-	-	4	-	-	0	-	0
Munida quadrispina	-	-	-	-	-	4	-	-	0	-	0
Nassarius insculptus	-	-	-	-	-	4	-	-	0	-	0
Neosimnia aequalis	-	-	-	-	-	4	-	-	0	-	0
Neptunea tabulata	-	-	-	-	-	4	-	-	-	1	0
Parastenella doederleini	-	-	-	-	-	4	-	-	-	1	0
Parastichopus sp A	-	-	-	-	-	4	-	-	-	1	0
Plocamia karykina	-	-	-	-	-	4	-	-	0	-	0
Psolus squamatus	-	-	-	-	-	4	-	-	0	-	0
Scabrotrophon grovesi	-	-	-	-	-	4	-	-	0	-	0
Stachyptilum superbum	-	-	-	-	-	4	-	-	-	1	0
Terebratulina crossei	-	-	-	-	-	4	-	-	-	1	0
Porifera sp SD 4	-	-	1	-	-	-	7	-	-	-	0
Diaulula sandiegensis	-	0	0	-	-	-	7	-	-	-	0
Aphrodita armifera	-	1	-	-	-	-	2	-	0	-	0
Styela plicata	-	0	1	-	-	-	6	-	-	-	0
Heptacarpus stimpsoni	-	1	-	-	-	-	5	0	-	-	0
Crepidula onyx	-	-	1	-	-	-	6	-	-	-	0
Muricea sp	-	0	-	-	-	-	-	-	0	-	0
Porifera sp SD 5	-	-	1	-	-	-	6	-	-	-	0
Octopus bimaculoides	-	0	-	-	-	-	5	-	-	-	0
Ocinebrina sp	-	0	-	-	-	-	2	0	0	-	0
Sicyonia penicillata	-	0	0	-	-	-	3	0	0	-	0

Appendix D14 (continued)

	Percent of Area										
	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Crucibulum spinosum	-	0	0	-	-	-	5	-	-	-	0
Nassarius tegula	-	0	0	-	-	-	5	-	-	-	0
Molgula verrucifera	0	0	-	-	-	-	5	-	-	-	0
Amygdalum politum	-	-	1	-	-	-	-	-	0	-	0
Austrotrophon catalinensis	-	0	-	-	-	-	-	-	0	-	0
Dirona sp	-	0	-	-	-	-	-	-	0	-	0
Neosimnia loebbeckeana	-	0	-	-	-	-	-	-	0	-	0
Paguristes sp A	-	0	-	-	-	-	-	-	0	-	0
Parapagurodes makarovi	-	-	1	-	-	-	-	-	0	-	0
Porifera sp SD 14	-	-	1	-	-	-	-	-	0	-	0
Scyra acutifrons	-	0	-	-	-	-	-	-	0	-	0
Thesea sp A	-	0	-	-	-	-	-	-	0	-	0
Virgularia cf.agassizi	-	0	-	-	-	-	-	-	0	-	0
Virgulariidae	-		1	-	-	-	-	-	0	-	0
Chama arcana	0	0	-	-	-	-	4	-	-	-	0
Pilumnus spinohirsutus	-	0	-	-	-	-	2	0	-	-	0
Synalpheus lockingtoni	-	0	0	-	-	-	2	0	-	-	0
Opisthopus transversus	-	0	-	-	-	-	2	0	-	-	0
Ascidia zara	-	0	-	-	-	-	3	-	-	-	0
Haminaea vesicula	-	0	0	-	-	-	3	-	-	-	0
Alpheus californiensis	-	0	-	-	-	-	3	-	-	-	0
Aplidium sp	-	-	0	-	-	-	3	-	-	-	0
Nassarius fossatus	-	0	-	-	-	-	3	-	-	-	0
Polinices lewisii	-	0	-	-	-	-	3	-	-	-	0
Triopha maculata	-	0	-	-	-	-	3	-	-	-	0
Balanus pacificus	0	-	0	-	-	-	1	-	0	-	0
Paraxanthias taylori	-	0	0	-	-	-	1	-	-	0	0
Phimochirus californiensis	0	-	0	-	-	-	-	0	-	-	0
Lophopanopeus bellus	-	0	0	-	-	-	2	-	-	-	0
Limaria hemphilli	-	-	0	-	-	-	1	-	-	0	0
Cancer jordani	0	-	0	-	-	-	-	0	0	-	0
Lophopanopeus frontalis	-	-	0	-	-	-	2	-	-	-	0
Porifera sp SD 2	-	-	0	-	-	-	2	-	-	-	0
Neotrypaea californiensis	-	0	-	-	-	-	2	-	-	-	0
Cirripedia	-	0	-	-	-	-	2	-	-	-	0
Crepipatella dorsata	-	0	-	-	-	-	2	-	-	-	0
Gorgonacea	-	0	-	-	-	-	2	-	-	-	0
Molgula sp	-	0	-	-	-	-	2	-	-	-	0
Aplysia vaccaria	-	0	-	-	-	-	-	0	-	-	0
Calliostoma gloriosum	0	-	-	-	-	-	-	-	-	-	0
Cephalopoda	-	-	0	-	-	-	-	-	-	0	0
Hemisquilla sp	-	-	0	-	-	-	-	-	-	0	0
Pagurus sp	0	-	-	-	-	-	-	0	-	-	0
Archidoris montereyensis	0	-	-	-	-	-	1	-	-	-	0
Crassadoma gigantea	0	-	-	-	-	-	1	-	-	-	0
Crepidula perforans	0	-	-	-	-	-	1	-	-	-	0
Porifera sp SD 6	-	-	0	-	-	-	1	-	-	-	0
Porifera sp SD 7	-	-	0	-	-	-	1	-	-	-	0
Anoplodactylus virdintestinalis	-	-	0	-	-	-	1	-	-	-	0

Appendix D14 (continued)

	Percent of Area										
	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Molgulidae	-	0	-	-	-	-	1	-	-	-	0
Pisaster giganteus capitatus	-	0	-	-	-	-	1	-	-	-	0
Muricea californica	-	0	-	-	-	-	1	-	-	-	0
Aglaophenia struthionides	-	0	-	-	-	-	-	0	-	-	0
Lophopanopeus sp	-	-	0	-	-	-	-	0	-	-	0
Pagurus redondoensis	-	0	-	-	-	-	-	0	-	-	0
Terebra pedroana	-	-	0	-	-	-	-	0	-	-	0
Actiniaria sp SD 1	-	-	0	-	-	-	1	-	-	-	0
Doriopsilla albopunctata	-	-	0	-	-	-	1	-	-	-	0
Epialtoides hiltoni	-	-	0	-	-	-	1	-	-	-	0
Leptopecten latiauratus	-	-	0	-	-	-	1	-	-	-	0
Loxorhynchus sp	-	-	0	-	-	-	1	-	-	-	0
Nassarius sp	-	-	0	-	-	-	1	-	-	-	0
Porifera sp SD 1	-	-	0	-	-	-	1	-	-	-	0
Porifera sp SD 10	-	-	0	-	-	-	1	-	-	-	0
Porifera sp SD 8	-	-	0	-	-	-	1	-	-	-	0
Alcyonaria sp SD 1	-	-	0	-	-	-	-	-	0	-	0
Heptacarpus tenuissimus	-	-	0	-	-	-	-	-	0	-	0
Munida hispida	-	-	0	-	-	-	-	-	0	-	0
Pagurus armatus	-	-	0	-	-	-	-	-	0	-	0
Pisaster sp	-	-	0	-	-	-	-	-	0	-	0

*See Glossary G4 for common names of invertebrate species.

N = Northern; C = Central; Southern; NWI = Northwest Channel Islands; SEI = Southeast Channel Islan CAT = Santa Catalina Island; B&H = Bays and Harbors; IS = Inner Shelf; MS = Middle Shelf; OS = Ou Shelf; SCB = Southern California Bight

sp = species

"0" = present in less than 0.5% of area

Appendix D15. Abundance (number of individuals) of megabenthic invertebrate species by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	Region										
	Mainland			Island			Shelf Zone				
Species*	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Lytechinus pictus	1,324	11,578	14,614	1,387	14,331	27,523	-	16	69,770	971	70,757
Sicyonia ingentis	13,008	3,862	1,162	413	1,069	1,707	10	1	8,906	12,304	21,221
Laqueus californianus	1	-	-	-	-	13,013	-	-	12,226	788	13,014
Allocentrotus fragilis	1,006	556	177	93	652	2,206	-	-	67	4,623	4,690
Astropecten verrilli	249	1,099	413	24	32	144	-	176	1,731	54	1,961
Pyromaia tuberculata	60	1,712	23	-	-	-	1,676	103	16	-	1,795
Philine auriformis	27	851	113	9	11	179	577	46	550	17	1,190
Ophiothrix spiculata	434	24	17	37	606	33	6	33	1,094	18	1,151
Pantomus affinis	8	1,047	52	-	-	4	-	-	-	1,111	1,111
Musculista senhousia	-	44	988	-	-	-	1,032	-	-	-	1,032
Parastichopus californicus	153	279	147	2	119	249	32	-	720	197	949
Crangon nigromaculata	103	766	74	-	-	-	730	207	6	-	943
Acanthoptilum sp	93	19	51	22	479	189	2	-	567	284	853
Astropecten ornatissimus	37	-	2	-	2	746	-	-	29	758	787
Hamatoscalpellum californicum	131	433	111	73	9	-	-	13	640	104	757
Bulla gouldiana	-	554	162	-	-	-	716	-	-	-	716
Neocrangon zacae	451	86	17	7	22	10	-	-	12	581	593
Microcosmus squamiger	2	122	378	-	-	-	502	-	-	-	502
Penaeus californiensis	-	401	57	-	-	-	318	139	1	-	458
Ophiopholis bakeri	-	-	3	380	7	9	-	-	10	389	399
Mytilus galloprovincialis	2	358	-	-	-	-	360	-	-	-	360
Ophiura luetkenii	67	15	5	26	234	9	-	-	201	155	356
Luidia foliolata	146	53	10	43	87	16	-	1	172	182	355
Spatangus californicus	247	1	6	-	21	25	-	-	30	270	300
Thesea sp B	40	206	36	5	6	4	-	-	266	31	297
Ciona intestinalis	4	252	2	-	-	-	258	-	-	-	258
Gorgonocephalus eucnemis	7	-	-	20	178	29	-	-	178	56	234
Molgula verrucifera	2	232	-	-	-	-	234	-	-	-	234
Brisaster latifrons	207	10	-	14	2	-	-	-	1	232	233
Heterogorgia tortuosa	1	205	6	-	-	-	-	-	211	1	212
Mediaster aequalis	2	3	2	76	65	38	-	-	111	75	186
Pleurobranchaea californica	88	14	7	32	34	9	-	6	123	55	184
Dendraster excentricus	4	-	167	-	-	-	-	171	-	-	171
Ostrea sp	-	8	158	-	-	-	166	-	-	-	166
Stylatula elongata	87	21	16	-	1	41	-	6	156	4	166
Solenocera mutator	-	65	93	-	-	2	-	-	7	153	160
Crepidula onyx	-	-	154	-	-	-	154	-	-	-	154
Crucibulum spinosum	-	28	124	-	-	-	152	-	-	-	152
Nassarius tegula	-	4	136	-	-	-	140	-	-	-	140
Luidia armata	40	78	12	1	-	1	-	2	126	4	132
Pleuroncodes planipes	1	-	7	1	57	41	-	-	10	97	107
Styela sp	2	86	12	-	-	-	98	-	2	-	100
Asterina miniata	-	5	2	87	5	-	4	57	38	-	99
Astropecten armatus	2	82	8	-	-	4	21	74	1	-	96

Appendix D15 (continued)

Species	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Neocrangon resima	76	15	1	-	-	1	-	-	1	92	93
Megasurcula carpenteriana	4	8	73	3	-	1	-	-	85	4	89
Paguristes turgidus	-	4	1	17	64	1	-	-	16	71	87
Octopus rubescens	34	7	14	5	7	16	-	11	53	19	83
Florometra serratissima	-	-	-	-	80	-	-	-	80	-	80
Loligo opalescens	11	20	35	-	2	9	6	4	52	15	77
Molgula sp	-	74	-	-	-	-	74	-	-	-	74
Metridium senile Cmplx	17	4	37	7	4	-	-	-	10	59	69
Navanax inermis	2	53	4	-	-	7	57	4	5	-	66
Haminaea vesicula	-	60	2	-	-	-	62	-	-	-	62
Philine alba	8	-	-	46	6	-	-	-	60	-	60
Cancer anthonyi	10	6	43	-	-	-	6	50	2	1	59
Luidia asthenosoma	4	10	2	8	34	-	-	-	54	4	58
Styela montereyensis	2	50	6	-	-	-	57	1	-	-	58
Chama arcana	20	34	-	-	-	-	54	-	-	-	54
Portunus xantusii	4	26	11	10	-	1	22	30	-	-	52
Neptunea tabulata	-	-	-	-	-	51	-	-	-	51	51
Spirontocaris holmesi	10	37	4	-	-	-	-	-	-	51	51
Argopecten ventricosus	-	14	28	-	-	-	42	-	-	-	42
Pandalus jordani	1	41	-	-	-	-	-	-	-	42	42
Pandalus platyceros	33	4	1	1	1	-	-	1	3	36	40
Styela plicata	-	2	38	-	-	-	40	-	-	-	40
Stylasterias forreri	1	-	-	12	27	-	-	-	2	38	40
Heterocrypta occidentalis	18	15	5	-	-	1	2	31	6	-	39
Ptilosarcus gurneyi	5	-	-	5	4	20	-	-	25	9	34
Rossia pacifica	7	10	15	-	1	1	-	-	23	11	34
Parastichopus parvimensis	-	2	3	1	-	27	2	5	25	1	33
Dromalia alexandri	-	31	-	-	-	-	-	-	-	31	31
Actiniaria sp SD 1	-	-	30	-	-	-	30	-	-	-	30
Lopholithodes foraminatus	1	-	-	1	28	-	-	-	-	30	30
Heptacarpus stimpsoni	-	29	-	-	-	-	27	2	-	-	29
Podochela hemphillii	4	10	3	11	-	1	4	14	10	1	29
Crangon alaskensis	-	15	11	-	-	-	14	-	12	-	26
Pugettia producta	7	4	14	-	-	-	12	13	-	-	25
Metacrangon spinosissima	19	3	2	-	-	-	-	-	1	23	24
Nassarius perpinguis	4	19	1	-	-	-	14	10	-	-	24
Panulirus interruptus	-	12	11	1	-	-	20	4	-	-	24
Paralithodes californiensis	-	17	-	4	1	2	-	-	17	7	24
Pteropurpura festiva	-	3	21	-	-	-	22	1	1	-	24
Fusinus barbarensis	18	1	-	3	-	1	-	-	9	14	23
Loxorhynchus grandis	9	8	6	-	-	-	2	13	7	1	23
Platymera gaudichaudii	-	10	3	4	2	4	-	-	21	2	23
Podochela lobifrons	2	3	4	2	8	4	-	-	20	3	23
Amphichondrius granulatus	-	1	7	8	6	-	-	-	22	-	22
Kelletia kelletii	1	2	16	3	-	-	-	4	17	1	22
Paracyathus stearnsii	-	-	1	18	3	-	-	-	19	3	22

Appendix D15 (continued)

	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Schmittius politus	5	10	4	-	-	1	1	-	19	-	20
Conus californicus	2	16	-	-	-	1	16	1	2	-	19
Dendraster terminalis	-	4	15	-	-	-	-	19	-	-	19
Molgulidae	-	18	-	-	-	-	18	-	-	-	18
Neosimnia barbarensis	1	3	1	-	13	-	-	2	11	5	18
Ocinebrina sp	-	18	-	-	-	-	16	1	1	-	18
Ophiacantha sp	-	-	1	9	1	7	-	-	4	14	18
Pagurus spilocarpus	-	15	3	-	-	-	6	2	10	-	18
Cancer sp	-	-	17	-	-	-	6	10	1	-	17
Brissopsis pacifica	12	2	-	-	2	-	-	-	-	16	16
Ciona sp	6	4	5	-	1	-	15	-	1	-	16
Paguristes bakeri	1	3	12	-	-	-	-	-	15	1	16
Flabellina iodinea	14	1	-	-	-	-	-	1	14	-	15
Hemisquilla ensigera californien	4	4	6	1	-	-	-	2	13	-	15
Pisaster brevispinus	2	10	3	-	-	-	4	5	6	-	15
Aplysia californica	5	4	3	2	-	-	6	5	2	1	14
Diaulula sandiegensis	-	8	6	-	-	-	14	-	-	-	14
Armina californica	-	5	-	2	4	2	2	2	9	-	13
Lovenia cordiformis	-	-	5	1	-	7	-	10	3	-	13
Loxorhynchus crispatus	3	2	3	5	-	-	-	6	5	2	13
Dendronotus iris	1	6	-	1	4	-	6	1	5	-	12
Luidia sp	2	9	-	-	-	1	-	-	12	-	12
Octopus californicus	3	2	1	2	2	2	-	-	2	10	12
Strongylocentrotus purpuratus	3	5	-	4	-	-	4	7	1	-	12
Pilumnus spinohirsutus	-	11	-	-	-	-	10	1	-	-	11
Porifera sp SD 4	-	-	11	-	-	-	11	-	-	-	11
Sclerasterias heteropaes	-	-	-	-	9	2	-	-	10	1	11
Strongylocentrotus franciscanus	-	1	1	9	-	-	-	11	-	-	11
Terebratalia occidentalis	-	-	-	-	-	11	-	-	11	-	11
Tritonia diomedea	2	1	-	1	5	2	-	-	9	2	11
Dendronotus sp	5	5	-	-	-	-	-	1	7	2	10
Lophopanopeus frontalis	-	-	10	-	-	-	10	-	-	-	10
Muricea cf.californica	-	7	3	-	-	-	-	8	2	-	10
Randallia ornata	-	4	5	-	-	1	1	4	5	-	10
Stenorhynchus debilis	-	-	-	-	-	10	-	-	10	-	10
Aglaophenia sp	-	1	-	5	3	-	-	4	4	1	9
Cancer gracilis	3	1	5	-	-	-	-	9	-	-	9
Erileptus spinosus	-	-	-	9	-	-	-	-	9	-	9
Eugorgia rubens	-	1	-	1	6	1	-	-	7	2	9
Henricia leviuscula	-	-	-	1	6	2	-	-	7	2	9
Neverita reclusiana	-	8	1	-	-	-	6	2	1	-	9
Ophiacantha phragma	9	-	-	-	-	-	-	-	1	8	9
Virgularia californica	-	4	-	1	4	-	-	-	9	-	9
Aphrodita sp	1	1	2	1	1	2	-	-	7	1	8
Calliostoma turbinum	5	-	1	1	1	-	-	3	4	1	8
Cancer branneri	6	-	1	-	1	-	7	-	1	-	8

Appendix D15 (continued)

Species	Region: Mainland N	C	S	Island NWI	SEI	CAT	Shelf Zone B&H	IS	MS	OS	SCB
Amphiodia urtica	-	5	2	-	-	-	-	-	7	-	7
Cidarina cidaris	-	-	-	-	-	7	-	-	-	7	7
Synalpheus lockingtoni	-	1	6	-	-	-	6	1	-	-	7
Terebratulina crossei	-	-	-	-	-	7	-	-	-	7	7
Cancer jordani	3	-	3	-	-	-	-	3	3	-	6
Leucilla nuttingi	-	3	2	-	-	1	2	-	4	-	6
Zoobotryon pellucida	1	5	-	-	-	-	6	-	-	-	6
Calinaticina oldroydii	1	4	-	-	-	-	2	-	2	1	5
Doridoidea	-	-	-	2	3	-	-	-	2	3	5
Galathea californiensis	3	-	2	-	-	-	-	-	-	5	5
Limaria hemphilli	-	-	5	-	-	-	4	-	-	1	5
Lophogorgia chilensis	-	1	-	1	-	3	-	1	4	-	5
Porifera sp SD 5	-	-	5	-	-	-	5	-	-	-	5
Virgularia sp	1	4	-	-	-	-	-	-	5	-	5
Amphiura arcystata	-	1	-	-	-	3	-	1	3	-	4
Ascidia zara	-	4	-	-	-	-	4	-	-	-	4
Balanus pacificus	2	-	2	-	-	-	2	-	2	-	4
Cancellaria crawfordiana	2	-	1	1	-	-	-	-	1	3	4
Crepipatella dorsata	-	4	-	-	-	-	4	-	-	-	4
Epiactis prolifera	-	-	4	-	-	-	-	-	4	-	4
Hippasteria spinosa	1	-	-	-	-	3	-	-	-	4	4
Isocheles pilosus	-	4	-	-	-	-	-	4	-	-	4
Lophopanopeus bellus	-	2	2	-	-	-	4	-	-	-	4
Ophiopteris papillosa	-	-	-	2	2	-	-	2	2	-	4
Opisthopus transversus	-	4	-	-	-	-	2	2	-	-	4
Phimochirus californiensis	3	-	1	-	-	-	-	4	-	-	4
Poecillastra tenuilaminaris	-	-	-	3	-	1	-	-	2	2	4
Polyplacophora	1	-	-	-	3	-	-	1	1	2	4
Protula superba	-	1	1	-	1	1	-	-	4	-	4
Pteropurpura vokesae	-	3	1	-	-	-	2	-	2	-	4
Pycnopodia helianthoides	-	-	-	2	2	-	-	-	3	1	4
Sicyonia penicillata	-	3	1	-	-	-	2	1	1	-	4
Staurocalyptus solidus	-	-	-	3	-	1	-	-	-	4	4
Thalamoporella californica	1	3	-	-	-	-	2	2	-	-	4
Adelogorgia phyllosclera	-	-	1	-	-	2	-	-	3	-	3
Anthozoa	-	-	-	1	1	1	-	-	2	1	3
Aphrodita armifera	-	3	-	-	-	-	2	-	1	-	3
Ascidiidae sp SD 1	2	-	1	-	-	-	2	1	-	-	3
Brachyura	-	-	1	2	-	-	-	2	1	-	3
Enallopaguropsis guatemoci	-	-	-	-	-	3	-	-	3	-	3
Mitra idae	2	-	1	-	-	-	-	1	1	1	3
Muricea sp	-	3	-	-	-	-	-	-	3	-	3
Ophionereis eurybrachiplax	-	-	-	3	-	-	-	-	1	2	3
Paguristes sp	3	-	-	-	-	-	-	-	2	1	3
Parastichopus sp A	-	-	-	-	-	3	-	-	-	3	3
Paraxanthias taylori	-	2	1	-	-	-	2	-	-	1	3

Appendix D15 (continued)

Species	Region: Mainland N	C	S	Island NWI	SEI	CAT	Shelf Zone B&H	IS	MS	OS	SCB
Rathbunaster californicus	1	-	-	-	2	-	-	-	2	1	3
Virgularia agassizi	1	1	1	-	-	-	-	-	3	-	3
Acanthodoris hudsoni	-	-	-	2	-	-	-	-	2	-	2
Anoplodactylus virdintestinalis	-	-	2	-	-	-	2	-	-	-	2
Antiplanes perversus	1	-	-	1	-	-	-	-	-	2	2
Aplidium sp	-	-	2	-	-	-	2	-	-	-	2
Aplysia vaccaria	-	2	-	-	-	-	-	2	-	-	2
Archidoris montereyensis	2	-	-	-	-	-	2	-	-	-	2
Cancer productus	-	-	-	2	-	-	-	-	2	-	2
Caryophyllia alaskensis	-	-	-	2	-	-	-	-	-	2	2
Coenocyathus bowersi	-	-	1	1	-	-	-	-	2	-	2
Crassadoma gigantea	2	-	-	-	-	-	2	-	-	-	2
Crepidula perforans	2	-	-	-	-	-	2	-	-	-	2
Cryptodromiopsis larraburei	-	-	1	-	-	1	-	-	1	1	2
Cucumaria sp	-	-	-	-	-	2	-	-	2	-	2
Dirona sp	-	2	-	-	-	-	-	-	2	-	2
Doriopsilla albopunctata	-	-	2	-	-	-	2	-	-	-	2
Euvola diegensis	-	-	-	1	1	-	-	-	2	-	2
Excorallana truncata	-	2	-	-	-	-	-	-	2	-	2
Nassarius fossatus	-	2	-	-	-	-	2	-	-	-	2
Nassarius sp	-	-	2	-	-	-	2	-	-	-	2
Neocrangon sp	1	-	1	-	-	-	-	-	2	-	2
Neosimnia aequalis	-	-	-	-	-	2	-	-	2	-	2
Neotrypaea californiensis	-	2	-	-	-	-	2	-	-	-	2
Ophiuroidea	2	-	-	-	-	-	-	-	1	1	2
Paguristes ulreyi	-	1	1	-	-	-	-	1	1	-	2
Paralithodes rathbuni	-	-	-	2	-	-	-	-	-	2	2
Pisaster giganteus capitatus	-	2	-	-	-	-	2	-	-	-	2
Plumularia sp	-	2	-	-	-	-	-	1	1	-	2
Polinices draconis	1	-	1	-	-	-	-	1	1	-	2
Polinices lewisii	-	2	-	-	-	-	2	-	-	-	2
Porifera Sp SD 1	-	-	2	-	-	-	2	-	-	-	2
Porifera Sp SD 2	-	-	2	-	-	-	2	-	-	-	2
Porifera Sp SD 8	-	-	2	-	-	-	2	-	-	-	2
Psolidae	2	-	-	-	-	-	-	-	-	2	2
Rhabdocalyptus dawsoni	-	-	-	-	-	2	-	-	1	1	2
Terebratalia transversa	-	-	-	-	2	-	-	-	2	-	2
Tethya aurantium	-	-	-	1	-	1	-	-	2	-	2
Tochuina tetraquetra	-	-	1	1	-	-	-	-	1	1	2
Triopha maculata	-	2	-	-	-	-	2	-	-	-	2
Virgularia cf.agassizi	-	2	-	-	-	-	-	-	2	-	2
Acanthodoris rhodoceras	1	-	-	-	-	-	-	-	1	-	1
Addisonia brophyi	-	-	-	1	-	-	-	-	1	-	1
Aglaophenia struthionides	-	1	-	-	-	-	-	1	-	-	1
Alcyonaria sp SD 1	-	-	1	-	-	-	-	-	1	-	1
Alpheus californiensis	-	1	-	-	-	-	1	-	-	-	1

Appendix D15 (continued)

	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Aphrodita refulgida	1	-	-	-	-	-	-	-	-	1	1
Astropecten sp	-	-	-	-	-	1	-	-	-	1	1
Austrotrophon catalinensis	-	1	-	-	-	-	-	-	1	-	1
Berthella californica	-	-	-	-	-	1	-	-	1	-	1
Boreotrophon sp	1	-	-	-	-	-	-	1	-	-	1
Calliostoma gloriosum	1	-	-	-	-	-	-	1	-	-	1
Cancellaria cooperi	-	-	-	-	-	1	-	-	1	-	1
Cephalopoda	-	-	1	-	-	-	-	-	-	1	1
Erato vitellina	1	-	-	-	-	-	-	-	1	-	1
Fissurella volcano	1	-	-	-	-	-	-	-	1	-	1
Flabellina pricei	-	1	-	-	-	-	-	1	-	-	1
Gorgonacea	-	1	-	-	-	-	1	-	-	-	1
Hemisquilla sp	-	-	1	-	-	-	-	-	-	1	1
Heptacarpus tenuissimus	-	-	1	-	-	-	-	-	1	-	1
Hippolytidae	-	-	-	1	-	-	-	-	1	-	1
Hydrozoa	-	-	-	1	-	-	-	-	1	-	1
Hyperiidae	1	-	-	-	-	-	-	-	-	1	1
Lysmata californica	1	-	-	-	-	-	-	1	-	-	1
Majidae	-	-	1	-	-	-	-	-	1	-	1
Munida hispida	-	-	1	-	-	-	-	-	1	-	1
Munida quadrispina	-	-	-	-	-	1	-	-	1	-	1
Nassarius insculptus	-	-	-	-	-	1	-	-	1	-	1
Neocrangon communis	1	-	-	-	-	-	-	-	-	1	1
Neosimnia loebbeckeana	-	1	-	-	-	-	-	-	1	-	1
Octopus veligero	-	1	-	-	-	-	-	-	-	1	1
Orthopagurus minimus	-	-	-	1	-	-	-	-	1	-	1
Paguristes sp A	-	1	-	-	-	-	-	-	1	-	1
Pagurus armatus	-	-	1	-	-	-	-	-	1	-	1
Pagurus redondoensis	-	1	-	-	-	-	-	1	-	-	1
Pagurus sp	1	-	-	-	-	-	-	1	-	-	1
Parapagurodes makarovi	-	-	1	-	-	-	-	-	1	-	1
Parastenella doederleini	-	-	-	-	-	1	-	-	-	1	1
Patellogastropoda	-	-	-	1	-	-	-	1	-	-	1
Pentamera pseudocalcigera	1	-	-	-	-	-	-	-	-	1	1
Pentamera sp	1	-	-	-	-	-	-	-	-	1	1
Pisaster sp	-	-	1	-	-	-	-	-	1	-	1
Plocamia karykina	-	-	-	-	-	1	-	-	1	-	1
Poraniopsis inflata	-	-	-	1	-	-	-	-	-	1	1
Porifera SP SD 10	-	-	1	-	-	-	1	-	-	-	1
Porifera SP SD 14	-	-	1	-	-	-	-	-	1	-	1
Porifera SP SD 3	-	-	1	-	-	-	-	-	1	-	1
Porifera SP SD 6	-	-	1	-	-	-	1	-	-	-	1
Porifera SP SD 7	-	-	1	-	-	-	1	-	-	-	1
Psolus sp	1	-	-	-	-	-	-	-	-	1	1
Psolus squamatus	-	-	-	-	-	1	-	-	1	-	1
Puncturella galeata	1	-	-	-	-	-	-	-	-	1	1

Appendix D15 (continued)

Species	Region						Shelf Zone				SCB
	Mainland			Island							
	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	
Sphincterella sp A	-	-	-	1	-	-	-	-	-	1	1
Spirontocaris sica	-	1	-	-	-	-	-	-	-	1	1
Stachyptilum superbum	-	-	-	-	-	1	-	-	-	1	1
Terebra pedroana	-	-	1	-	-	-	-	1	-	-	1
Thesea sp A	-	1	-	-	-	-	-	-	1	-	1
Virgulariidae	-	-	1	-	-	-	-	-	1	-	1
Total	18,518	26,110	20,182	3,018	18,387	46,484	8,004	1,406	99,008	24,281	132,699

*See Glossary G4 for common names of invertebrate species.

N = Northern; C = Central; Southern; NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; CAT = Santa Catalina Island; B&H = Bays and Harbors; IS = Inner Shelf; MS = Middle Shelf; OS = Outer Shelf; SCB = Southern California Bight

sp = species

Appendix D16. Biomass (kg) of megabenthic invertebrate species by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

	Region										
	Mainland			Island			Shelf Zone				
Species*	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Parastichopus californicus	50.0	76.3	57.0	1.2	27.3	188.2	3.2	-	196.2	200.6	400.0
Allocentrotus fragilis	51.7	26.0	12.1	7.7	52.5	101.1	-	-	4.5	246.6	251.1
Laqueus californianus	0.0	-	-	-	-	238.5	-	-	223.6	14.9	238.5
Sicyonia ingentis	107.7	35.9	8.9	2.8	18.8	9.6	0.0	0.0	63.9	119.9	183.8
Lytechinus pictus	5.9	32.6	35.0	4.1	25.9	63.9	-	0.0	165.1	2.4	167.4
Porifera sp SD 4	-	-	157.0	-	-	-	157.0	-	-	-	157.0
Gorgonocephalus eucnemis	2.1	-	-	4.4	50.8	5.2	-	-	50.8	11.7	62.4
Metridium senile Cmplx	10.4	4.0	17.7	8.4	1.6	-	-	-	9.2	32.9	42.1
Porifera sp SD 2	-	-	30.2	-	-	-	30.2	-	-	-	30.2
Porifera sp SD 10	-	-	28.0	-	-	-	28.0	-	-	-	28.0
Zoobotryon pellucida	5.0	16.5	-	-	-	-	21.5	-	-	-	21.5
Lopholithodes foraminatus	1.2	-	-	0.2	17.9	-	-	-	-	19.3	19.3
Loxorhynchus grandis	9.2	4.2	4.7	-	-	-	0.2	10.0	6.8	1.1	18.1
Luidia foliolata	13.2	2.3	0.0	0.8	1.1	0.7	-	0.0	3.0	15.1	18.1
Parastichopus parvimensis	-	0.2	0.2	0.2	-	17.0	0.2	1.0	16.2	0.2	17.6
Spatangus californicus	11.8	0.0	0.2	-	1.4	0.7	-	-	1.5	12.6	14.1
Porifera sp SD 6	-	-	14.0	-	-	-	14.0	-	-	-	14.0
Paguristes turgidus	-	0.0	0.0	1.8	10.0	0.0	-	-	0.8	11.0	11.8
Panulirus interruptus	-	5.7	5.6	0.5	-	-	9.8	2.0	-	-	11.8
Paralithodes californiensis	-	9.1	-	1.3	0.8	0.6	-	-	9.1	2.7	11.8
Penaeus californiensis	-	9.6	1.9	-	-	-	7.6	3.9	0.0	-	11.5
Stylasterias forreri	0.4	-	-	4.1	5.0	-	-	-	0.0	9.5	9.5
Pisaster brevispinus	0.4	6.3	1.5	-	-	-	1.3	2.7	4.2	-	8.2
Asterina miniata	-	0.4	0.4	6.8	0.1	-	0.6	4.3	2.8	-	7.7
Mytilus galloprovincialis	0.0	6.9	-	-	-	-	6.9	-	-	-	6.9
Porifera sp SD 5	-	-	6.4	-	-	-	6.4	-	-	-	6.4
Muricea cf.californica	-	4.6	1.2	-	-	-	-	4.2	1.6	-	5.8
Microcosmus squamiger	0.0	0.4	5.2	-	-	-	5.6	-	-	-	5.6
Astropecten ornatissimus	0.2	-	0.0	-	0.0	4.7	-	-	0.1	4.8	4.9
Pleurobranchaea californica	2.0	0.0	0.2	1.5	1.1	0.0	-	0.1	0.7	3.9	4.7
Staurocalyptus solidus	-	-	-	4.7	-	0.0	-	-	-	4.7	4.7
Ciona intestinalis	0.0	4.5	0.0	-	-	-	4.5	-	-	-	4.5
Astropecten verrilli	0.5	3.6	0.4	0.0	0.0	0.0	-	0.3	4.0	0.1	4.5
Aplysia californica	2.7	0.0	0.4	0.8	-	-	2.6	1.2	0.0	0.2	4.0
Loxorhynchus crispatus	0.2	0.1	3.0	0.2	-	-	-	0.2	3.1	0.2	3.5
Poecillastra tenuilaminaris	-	-	-	3.0	-	0.0	-	-	0.2	2.8	3.0
Aphrocallistes vastus	-	-	-	2.9	-	-	-	-	-	2.9	2.9
Rathbunaster californicus	1.2	-	-	-	1.7	-	-	-	1.7	1.2	2.9
Pycnopodia helianthoides	-	-	-	0.3	2.4	-	-	-	1.4	1.3	2.7
Bulla gouldiana	-	1.0	1.4	-	-	-	2.4	-	-	-	2.4
Kelletia kelletii	0.2	0.2	1.8	0.2	-	-	-	0.4	1.8	0.2	2.4
Parastichopus sp A	-	-	-	-	-	2.4	-	-	-	2.4	2.4
Brisaster latifrons	2.2	0.0	-	0.1	0.0	-	-	-	0.0	2.3	2.3
Octopus californicus	0.1	0.5	0.7	0.6	0.1	0.2	-	-	0.7	1.5	2.2
Platymera gaudichaudii	-	0.7	0.0	0.9	0.3	0.3	-	-	2.1	0.1	2.2

Appendix D16 (continued)

Species	Region						Shelf Zone				
	Mainland			Island							
	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Strongylocentrotus franciscanus	-	0.4	0.5	1.3	-	-	-	2.2	-	-	2.2
Chama arcana	1.5	0.5	-	-	-	-	2.0	-	-	-	2.0
Pyromaia tuberculata	0.0	1.9	0.0	-	-	-	1.9	0.0	0.0	-	1.9
Mediaster aequalis	0.0	0.0	0.0	0.5	1.0	0.2	-	-	0.9	0.8	1.7
Cancer anthonyi	0.0	1.5	0.1	-	-	-	0.0	0.1	1.0	0.5	1.6
Dromalia alexandri	-	1.5	-	-	-	-	-	-	-	1.5	1.5
Ophiothrix spiculata	0.5	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.5	0.0	1.5
Portunus xantusii	0.1	0.5	0.0	0.8	-	0.0	0.5	0.9	-	-	1.5
Luidia armata	0.3	1.1	0.0	0.0	-	0.0	-	0.0	1.3	0.0	1.3
Ptilosarcus gurneyi	0.7	-	-	0.3	0.1	0.3	-	-	0.4	1.0	1.3
Aplysia vaccaria	-	1.2	-	-	-	-	-	1.2	-	-	1.2
Octopus rubescens	0.2	0.2	0.2	0.0	0.0	0.6	-	0.1	1.0	0.1	1.2
Porifera sp SD 7	-	-	1.2	-	-	-	1.2	-	-	-	1.2
Calinaticina oldroydii	0.4	0.8	-	-	-	-	0.0	-	0.8	0.4	1.2
Cancer productus	-	-	-	1.1	-	-	-	-	1.1	-	1.1
Dendraster excentricus	0.0	-	1.1	-	-	-	-	1.1	-	-	1.1
Suberites suberea	-	0.0	-	1.1	0.0	-	-	-	0.0	1.1	1.1
Paguristes bakeri	0.0	0.0	1.0	-	-	-	-	-	1.0	0.0	1.0
Porifera sp SD 14	-	-	1.0	-	-	-	-	-	1.0	-	1.0
Octopus bimaculoides	-	0.8	-	-	-	-	0.8	-	-	-	0.8
Philine alba	0.0	-	-	0.8	0.0	-	-	-	0.8	-	0.8
Amphiodia digitata	-	0.0	-	-	-	0.7	0.0	-	0.7	-	0.7
Pandalus platyceros	0.7	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.7	0.7
Acanthoptilum sp	0.1	0.0	0.0	0.0	0.3	0.2	0.0	-	0.5	0.1	0.6
Pleuroncodes planipes	0.0	-	0.0	0.0	0.3	0.3	-	-	0.0	0.6	0.6
Solenocera mutator	-	0.3	0.3	-	-	0.0	-	-	0.0	0.6	0.6
Crassadoma gigantea	0.5	-	-	-	-	-	0.5	-	-	-	0.5
Crossata californica	-	0.0	0.5	-	-	-	-	0.0	0.5	-	0.5
Megasurcula carpenteriana	0.0	0.0	0.5	0.0	-	0.0	-	-	0.5	0.0	0.5
Styela sp	0.0	0.5	0.0	-	-	-	0.5	-	0.0	-	0.5
Coenocyathus bowersi	-	-	0.0	0.4	-	-	-	-	0.4	-	0.4
Molgula verrucifera	0.0	0.4	-	-	-	-	0.4	-	-	-	0.4
Paralithodes rathbuni	-	-	-	0.3	-	-	-	-	-	0.3	0.3
Astropecten armatus	0.0	0.3	0.0	-	-	0.0	0.1	0.2	0.0	-	0.3
Hemisquilla ensigera californiensis	0.1	0.0	0.2	0.0	-	-	-	0.1	0.2	-	0.3
Pantomus affinis	0.0	0.3	0.0	-	-	0.0	-	-	-	0.3	0.3
Florometra serratissima	-	-	-	-	0.3	-	-	-	0.3	-	0.3
Sphincterella sp A	-	-	-	0.3	-	-	-	-	-	0.3	0.3
Styela montereyensis	0.0	0.3	0.0	-	-	-	0.3	0.0	-	-	0.3
Pisaster ochraceus	0.2	0.1	-	-	-	-	-	0.3	0.0	-	0.3
Brissopsis pacifica	0.3	0.0	-	-	0.0	-	-	-	-	0.3	0.3
Hippasteria spinosa	0.3	-	-	-	-	0.0	-	-	-	0.3	0.3
Aphrodita sp	0.0	0.0	0.0	0.0	0.2	0.0	-	-	0.2	0.0	0.2
Diaulula sandiegensis	-	0.0	0.2	-	-	-	0.2	-	-	-	0.2
Lophogorgia chilensis	-	0.1	-	0.0	-	0.1	-	0.0	0.2	-	0.2
Musculista senhousia	-	0.0	0.2	-	-	-	0.2	-	-	-	0.2
Navanax inermis	0.0	0.2	0.0	-	-	0.0	0.2	0.0	0.0	-	0.2

Appendix D16 (continued)

Species	Region: Mainland N	C	S	Island NWI	SEI	CAT	Shelf Zone B&H	IS	MS	OS	SCB
Ostrea sp	-	0.0	0.2	-	-	-	0.2	-	-	-	0.2
Pteropurpura festiva	-	0.0	0.2	-	-	-	0.2	0.0	0.0	-	0.2
Stylatula elongata	0.2	0.0	0.0	-	0.0	0.0	-	0.0	0.2	0.0	0.2
Tritonia diomedea	0.2	0.0	-	0.0	0.0	0.0	-	-	0.2	0.0	0.2
Neocrangon zacae	0.2	0.0	0.0	0.0	0.0	0.0	-	-	0.0	0.2	0.2
Pandalus jordani	0.0	0.2	-	-	-	-	-	-	-	0.2	0.2
Aphrodita refulgida	0.1	-	-	-	-	-	-	-	-	0.1	0.1
Dendraster terminalis	-	0.0	0.1	-	-	-	-	0.1	-	-	0.1
Muricea sp	-	0.1	-	-	-	-	-	-	0.1	-	0.1
Pagurus spilocarpus	-	0.1	0.0	-	-	-	0.0	0.0	0.1	-	0.1
Strongylocentrotus purpuratus	0.0	0.1	-	0.0	-	-	0.0	0.1	0.0	-	0.1
Luidia asthenosoma	0.0	0.0	0.0	0.0	0.0	-	-	-	0.0	0.0	0.0
Sclerasterias heteropaes	-	-	-	-	0.0	0.0	-	-	0.0	0.0	0.0
Acanthodoris brunnea	0.0	0.0	-	-	-	-	-	-	0.0	0.0	0.0
Acanthodoris hudsoni	-	-	-	0.0	-	-	-	-	0.0	-	0.0
Acanthodoris rhodoceras	0.0	-	-	-	-	-	-	-	0.0	-	0.0
Actiniaria sp SD 1	-	-	0.0	-	-	-	0.0	-	-	-	0.0
Addisonia brophyi	-	-	-	0.0	-	-	-	-	0.0	-	0.0
Adelogorgia phyllosclera	-	-	0.0	-	-	0.0	-	-	0.0	-	0.0
Aglaophenia sp	-	0.0	-	0.0	0.0	-	-	0.0	0.0	0.0	0.0
Aglaophenia struthionides	-	0.0	-	-	-	-	-	0.0	-	-	0.0
Alcyonaria sp SD 1	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Alpheus californiensis	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Amphichondrius granulatus	-	0.0	0.0	0.0	0.0	-	-	-	0.0	-	0.0
Amphiodia psara	-	0.0	-	-	-	-	-	0.0	-	-	0.0
Amphiodia urtica	-	0.0	0.0	-	-	-	-	-	0.0	-	0.0
Amphioplus sp	-	-	-	0.0	-	-	-	-	0.0	-	0.0
Amphiura arcystata	-	0.0	-	-	-	0.0	-	0.0	0.0	-	0.0
Amygdalum politum	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Anoplodactylus erectus	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Anoplodactylus virdintestinalis	-	-	0.0	-	-	-	0.0	-	-	-	0.0
Anthozoa	-	-	-	0.0	0.0	0.0	-	-	0.0	0.0	0.0
Antiplanes perversus	0.0	-	-	0.0	-	-	-	-	-	0.0	0.0
Aphrodita armifera	-	0.0	-	-	-	-	0.0	-	0.0	-	0.0
Aphrodita negligens	-	0.0	-	-	-	-	-	-	0.0	-	0.0
Aplidium sp	-	-	0.0	-	-	-	0.0	-	-	-	0.0
Archidoris montereyensis	0.0	-	-	-	-	-	0.0	-	-	-	0.0
Argopecten ventricosus	-	0.0	0.0	-	-	-	0.0	-	-	-	0.0
Armina californica	-	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0
Ascidia zara	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Ascidiidae sp SD 1	0.0	-	0.0	-	-	-	0.0	0.0	-	-	0.0
Astropecten sp	-	-	-	-	-	0.0	-	-	-	0.0	0.0
Austrotrophon catalinensis	-	0.0	-	-	-	-	-	-	0.0	-	0.0
Balanus pacificus	0.0	-	0.0	-	-	-	0.0	-	0.0	-	0.0
Berthella californica	-	-	-	-	-	0.0	-	-	0.0	-	0.0
Boreotrophon sp	0.0	-	-	-	-	-	-	0.0	-	-	0.0
Brachyura	-	-	0.0	0.0	-	-	-	0.0	0.0	-	0.0

Appendix D16 (continued)

Species	Region: Mainland N	C	S	Island NWI	SEI	CAT	Shelf Zone B&H	IS	MS	OS	SCB
Calliostoma gloriosum	0.0	-	-	-	-	-	-	0.0	-	-	0.0
Calliostoma turbinum	0.0	-	0.0	0.0	0.0	-	-	0.0	0.0	0.0	0.0
Cancellaria cooperi	-	-	-	-	-	0.0	-	-	0.0	-	0.0
Cancellaria crawfordiana	0.0	-	0.0	0.0	-	-	-	-	0.0	0.0	0.0
Cancer branneri	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	0.0
Cancer gracilis	0.0	0.0	0.0	-	-	-	-	0.0	-	-	0.0
Cancer jordani	0.0	-	0.0	-	-	-	-	0.0	0.0	-	0.0
Cancer sp	-	-	0.0	-	-	-	0.0	0.0	0.0	-	0.0
Caryophyllia alaskensis	-	-	-	0.0	-	-	-	-	-	0.0	0.0
Cephalopoda	-	-	0.0	-	-	-	-	-	-	0.0	0.0
Ceramaster sp	-	-	-	0.0	-	-	-	-	-	0.0	0.0
Chaetopterus variopedatus Cmplx	0.0	-	-	-	-	-	-	-	0.0	-	0.0
Chlamys hastata	-	-	-	-	0.0	-	-	-	0.0	-	0.0
Chorilia longipes	-	-	-	0.0	-	-	-	-	-	0.0	0.0
Cidarina cidaris	-	-	-	-	-	0.0	-	-	-	0.0	0.0
Ciona sp	0.0	0.0	0.0	-	0.0	-	0.0	-	0.0	-	0.0
Cirripedia	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Conus californicus	0.0	0.0	-	-	-	0.0	0.0	0.0	0.0	-	0.0
Crangon alaskensis	-	0.0	0.0	-	-	-	0.0	-	0.0	-	0.0
Crangon nigromaculata	0.0	0.0	0.0	-	-	-	0.0	0.0	0.0	-	0.0
Crassispira semiinflata	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Crepidula onyx	-	-	0.0	-	-	-	0.0	-	-	-	0.0
Crepidula perforans	0.0	-	-	-	-	-	0.0	-	-	-	0.0
Crepipatella dorsata	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Crucibulum spinosum	-	0.0	0.0	-	-	-	0.0	-	-	-	0.0
Cryptodromiopsis larraburei	-	-	0.0	-	-	0.0	-	-	0.0	0.0	0.0
Cucumaria sp	-	-	-	-	-	0.0	-	-	0.0	-	0.0
Dendronotus iris	0.0	0.0	-	0.0	0.0	-	0.0	0.0	0.0	-	0.0
Dendronotus sp	0.0	0.0	-	-	-	-	-	0.0	0.0	0.0	0.0
Dirona sp	-	0.0	-	-	-	-	-	-	0.0	-	0.0
Doridoidea	-	-	-	0.0	0.0	-	-	-	0.0	0.0	0.0
Doriopsilla albopunctata	-	-	0.0	-	-	-	0.0	-	-	-	0.0
Enallopaguropsis guatemoci	-	-	-	-	-	0.0	-	-	0.0	-	0.0
Epiactis prolifera	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Epialtoides hiltoni	-	-	0.0	-	-	-	0.0	-	-	-	0.0
Erato vitellina	0.0	-	-	-	-	-	-	-	0.0	-	0.0
Erileptus spinosus	-	-	-	0.0	-	-	-	-	0.0	-	0.0
Eugorgia rubens	-	0.0	-	0.0	0.0	0.0	-	-	0.0	0.0	0.0
Euvola diegensis	-	-	-	0.0	0.0	-	-	-	0.0	-	0.0
Excorallana truncata	-	0.0	-	-	-	-	-	-	0.0	-	0.0
Fissurella volcano	0.0	-	-	-	-	-	-	-	0.0	-	0.0
Flabellina iodinea	0.0	0.0	-	-	-	-	-	0.0	0.0	-	0.0
Flabellina pricei	-	0.0	-	-	-	-	-	0.0	-	-	0.0
Fusinus barbarensis	0.0	0.0	-	0.0	-	0.0	-	-	0.0	0.0	0.0
Galathea californiensis	0.0	-	0.0	-	-	-	-	-	-	0.0	0.0
Gorgonacea	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Hamatoscalpellum californicum	0.0	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0	0.0

Appendix D16 (continued)

Species	Region: Mainland N	C	S	Island NWI	SEI	CAT	Shelf Zone B&H	IS	MS	OS	SCB
Haminaea vesicula	-	0.0	0.0	-	-	-	0.0	-	-	-	0.0
Hemisquilla sp	-	-	0.0	-	-	-	-	-	-	0.0	0.0
Henricia leviuscula	-	-	-	0.0	0.0	0.0	-	-	0.0	0.0	0.0
Heptacarpus stimpsoni	-	0.0	-	-	-	-	0.0	0.0	-	-	0.0
Heptacarpus tenuissimus	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Heterocrypta occidentalis	0.0	0.0	0.0	-	-	0.0	0.0	0.0	0.0	-	0.0
Heterogorgia tortuosa	0.0	0.0	0.0	-	-	-	-	-	0.0	0.0	0.0
Hippolytidae	-	-	-	0.0	-	-	-	-	0.0	-	0.0
Holothuroidea	0.0	-	-	-	0.0	-	-	-	0.0	0.0	0.0
Hydrozoa	-	-	-	0.0	-	-	-	-	0.0	-	0.0
Hyperiidae	0.0	-	-	-	-	-	-	-	-	0.0	0.0
Isocheles pilosus	-	0.0	-	-	-	-	-	0.0	-	-	0.0
Leptasterias hexactis	-	-	-	-	0.0	0.0	-	-	0.0	-	0.0
Leptopecten latiauratus	-	-	0.0	-	-	-	0.0	-	-	-	0.0
Leucilla nuttingi	-	0.0	0.0	-	-	0.0	0.0	-	0.0	-	0.0
Limaria hemphilli	-	-	0.0	-	-	-	0.0	-	-	0.0	0.0
Loligo opalescens	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lophopanopeus bellus	-	0.0	0.0	-	-	-	0.0	-	-	-	0.0
Lophopanopeus frontalis	-	-	0.0	-	-	-	0.0	-	-	-	0.0
Lophopanopeus sp	-	-	0.0	-	-	-	-	0.0	-	-	0.0
Lovenia cordiformis	-	-	0.0	0.0	-	0.0	-	0.0	0.0	-	0.0
Loxorhynchus sp	-	-	0.0	-	-	-	0.0	-	-	-	0.0
Luidia sp	0.0	0.0	-	-	-	0.0	-	-	0.0	-	0.0
Lysmata californica	0.0	-	-	-	-	-	-	0.0	-	-	0.0
Majidae	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Metacrangon spinosissima	0.0	0.0	0.0	-	-	-	-	-	0.0	0.0	0.0
Mitra idae	0.0	-	0.0	-	-	-	-	0.0	0.0	0.0	0.0
Molgula sp	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Molgulidae	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Munida hispida	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Munida quadrispina	-	-	-	-	-	0.0	-	-	0.0	-	0.0
Muricea californica	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Nassarius fossatus	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Nassarius insculptus	-	-	-	-	-	0.0	-	-	0.0	-	0.0
Nassarius perpinguis	0.0	0.0	0.0	-	-	-	0.0	0.0	-	-	0.0
Nassarius sp	-	-	0.0	-	-	-	0.0	-	-	-	0.0
Nassarius tegula	-	0.0	0.0	-	-	-	0.0	-	-	-	0.0
Neocrangon communis	0.0	-	-	-	-	-	-	-	-	0.0	0.0
Neocrangon resima	0.0	0.0	0.0	-	-	0.0	-	-	0.0	0.0	0.0
Neocrangon sp	0.0	-	0.0	-	-	-	-	-	0.0	-	0.0
Neosimnia aequalis	-	-	-	-	-	0.0	-	-	0.0	-	0.0
Neosimnia barbarensis	0.0	0.0	0.0	-	0.0	-	-	0.0	0.0	0.0	0.0
Neosimnia loebbeckeana	-	0.0	-	-	-	-	-	-	0.0	-	0.0
Neotrypaea californiensis	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Neptunea tabulata	-	-	-	-	-	0.0	-	-	-	0.0	0.0
Neverita reclusiana	-	0.0	0.0	-	-	-	0.0	0.0	0.0	-	0.0
Ocinebrina sp	-	0.0	-	-	-	-	0.0	0.0	0.0	-	0.0

Appendix D16 (continued)

	Region										
	Mainland			Island			Shelf Zone				
Species	N	C	S	NWI	SEI	CAT	B&H	IS	MS	OS	SCB
Octopus veligero	-	0.0	-	-	-	-	-	-	-	0.0	0.0
Ophiacantha phragma	0.0	-	-	-	-	-	-	-	0.0	0.0	0.0
Ophiacantha sp	-	-	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0
Ophionereis eurybrachiplax	-	-	-	0.0	-	-	-	-	0.0	0.0	0.0
Ophiopholis bakeri	-	-	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0
Ophiopteris papillosa	-	-	-	0.0	0.0	-	-	0.0	0.0	-	0.0
Ophiura luetkenii	0.0	0.0	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0
Ophiuroidea	0.0	-	-	-	-	-	-	-	0.0	0.0	0.0
Opisthopus transversus	-	0.0	-	-	-	-	0.0	0.0	-	-	0.0
Orthopagurus minimus	-	-	-	0.0	-	-	-	-	0.0	-	0.0
Paguristes sp	0.0	-	-	-	-	-	-	-	0.0	0.0	0.0
Paguristes sp A	-	0.0	-	-	-	-	-	-	0.0	-	0.0
Paguristes ulreyi	-	0.0	0.0	-	-	-	-	0.0	0.0	-	0.0
Pagurus armatus	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Pagurus redondoensis	-	0.0	-	-	-	-	-	0.0	-	-	0.0
Pagurus s p	0.0	-	-	-	-	-	-	0.0	-	-	0.0
Paracyathus stearnsii	-	-	0.0	0.0	0.0	-	-	-	0.0	0.0	0.0
Parapagurodes makarovi	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Parastenella doederleini	-	-	-	-	-	0.0	-	-	-	0.0	0.0
Paraxanthias taylori	-	0.0	0.0	-	-	-	0.0	-	-	0.0	0.0
Patellogastropoda	-	-	-	0.0	-	-	-	0.0	-	-	0.0
Pentamera pseudocalcigera	0.0	-	-	-	-	-	-	-	-	0.0	0.0
Pentamera pseudopopulifera	-	-	0.0	-	-	0.0	-	-	0.0	-	0.0
Pentamera sp	0.0	-	-	-	-	-	-	-	-	0.0	0.0
Philine auriformis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phimochirus californiensis	0.0	-	0.0	-	-	-	-	0.0	-	-	0.0
Pilumnus spinohirsutus	-	0.0	-	-	-	-	0.0	0.0	-	-	0.0
Pisaster giganteus capitatus	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Pisaster sp	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Platydoris macfarlandi	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Plesionika trispinus	-	0.0	-	-	-	-	-	-	-	0.0	0.0
Plocamia karykina	-	-	-	-	-	0.0	-	-	0.0	-	0.0
Plumularia sp	-	0.0	-	-	-	-	-	0.0	0.0	-	0.0
Podochela hemphillii	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0
Podochela lobifrons	0.0	0.0	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0
Polinices draconis	0.0	-	0.0	-	-	-	-	0.0	0.0	-	0.0
Polinices lewisii	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Polyplacophora	0.0	-	-	-	0.0	-	-	0.0	0.0	0.0	0.0
Poraniopsis inflata	-	-	-	0.0	-	-	-	-	-	0.0	0.0
Porifera sp SD 1	-	-	0.0	-	-	-	0.0	-	-	-	0.0
Porifera sp SD 3	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Porifera sp SD 8	-	-	0.0	-	-	-	0.0	-	-	-	0.0
Protula superba	-	0.0	0.0	-	0.0	0.0	-	-	0.0	-	0.0
Psolidae	0.0	-	-	-	-	-	-	-	-	0.0	0.0
Psolus sp	0.0	-	-	-	-	-	-	-	-	0.0	0.0
Psolus squamatus	-	-	-	-	-	0.0	-	-	0.0	-	0.0
Pteropurpura vokesae	-	0.0	0.0	-	-	-	0.0	-	0.0	-	0.0

Appendix D16 (continued)

Species	Region: Mainland N	C	S	Island NWI	SEI	CAT	Shelf Zone B&H	IS	MS	OS	SCB
Pugettia dalli	-	-	-	0.0	-	-	-	0.0	0.0	-	0.0
Pugettia producta	0.0	0.0	0.0	-	-	-	0.0	0.0	-	-	0.0
Pugettia richii	-	-	-	0.0	-	-	-	0.0	0.0	-	0.0
Puncturella galeata	0.0	-	-	-	-	-	-	-	-	0.0	0.0
Randallia ornata	-	0.0	0.0	-	-	0.0	0.0	0.0	0.0	-	0.0
Rocinela angustata	-	0.0	-	-	-	-	-	-	0.0	-	0.0
Rossia pacifica	0.0	0.0	0.0	-	0.0	0.0	-	-	0.0	0.0	0.0
Scabrotrophon grovesi	-	-	-	-	-	0.0	-	-	0.0	-	0.0
Schmittius politus	0.0	0.0	0.0	-	-	0.0	0.0	-	0.0	-	0.0
Scyra acutifrons	-	0.0	-	-	-	-	-	-	0.0	-	0.0
Sicyonia penicillata	-	0.0	0.0	-	-	-	0.0	0.0	0.0	-	0.0
Spirontocaris holmesi	0.0	0.0	0.0	-	-	-	-	-	-	0.0	0.0
Spirontocaris sica	-	0.0	-	-	-	-	-	-	-	0.0	0.0
Stachyptilum superbum	-	-	-	-	-	0.0	-	-	-	0.0	0.0
Stenorhynchus debilis	-	-	-	-	-	0.0	-	-	0.0	-	0.0
Styela plicata	-	0.0	0.0	-	-	-	0.0	-	-	-	0.0
Synalpheus lockingtoni	-	0.0	0.0	-	-	-	0.0	0.0	-	-	0.0
Terebra pedroana	-	-	0.0	-	-	-	-	0.0	-	-	0.0
Terebratalia occidentalis	-	-	-	-	-	0.0	-	-	0.0	-	0.0
Terebratalia transversa	-	-	-	-	0.0	-	-	-	0.0	-	0.0
Terebratulina crossei	-	-	-	-	-	0.0	-	-	-	0.0	0.0
Tethya aurantium	-	-	-	0.0	-	0.0	-	-	0.0	-	0.0
Thalamoporella californica	0.0	0.0	-	-	-	-	0.0	0.0	-	-	0.0
Thesea sp A	-	0.0	-	-	-	-	-	-	0.0	-	0.0
Thesea sp B	0.0	0.0	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0
Tochuina tetraquetra	-	-	0.0	0.0	-	-	-	-	0.0	0.0	0.0
Triopha maculata	-	0.0	-	-	-	-	0.0	-	-	-	0.0
Virgularia agassizi	0.0	0.0	0.0	-	-	-	-	-	0.0	-	0.0
Virgularia californica	-	0.0	-	0.0	0.0	-	-	-	0.0	-	0.0
Virgularia cf.agassizi	-	0.0	-	-	-	-	-	-	0.0	-	0.0
Virgularia sp	0.0	0.0	-	-	-	-	-	-	0.0	-	0.0
Virgulariidae	-	-	0.0	-	-	-	-	-	0.0	-	0.0
Rhabdocalyptus dawsoni	-	-	-	-	-	0.0	-	-	0.0	0.0	0.0

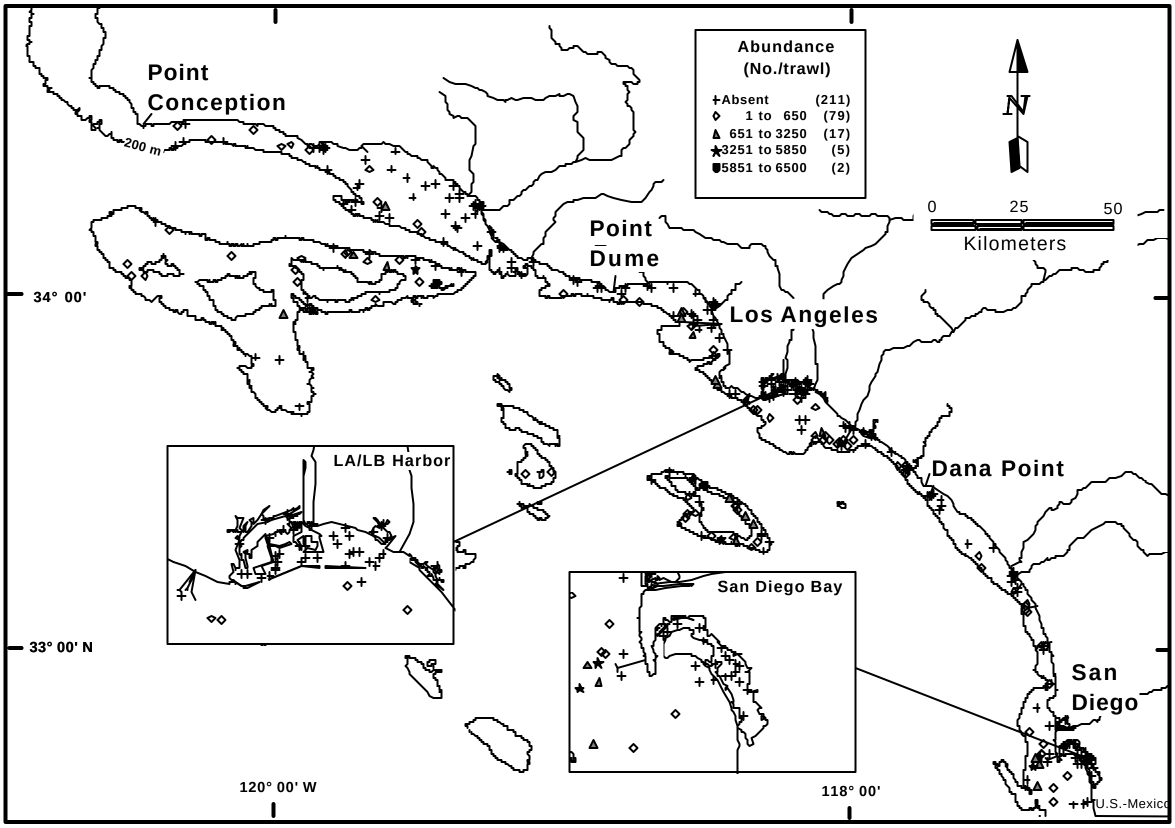
*See Glossary G4 for common names of invertebrate species.

N = Northern; C = Central; Southern; NWI = Northwest Channel Islands; SEI = Southeast Channel Islands; CAT = Santa Catalina Island; B&H = Bays and Harbors; IS = Inner Shelf; MS = Middle Shelf; OS = Outer Shelf; SCB = Southern California Bight

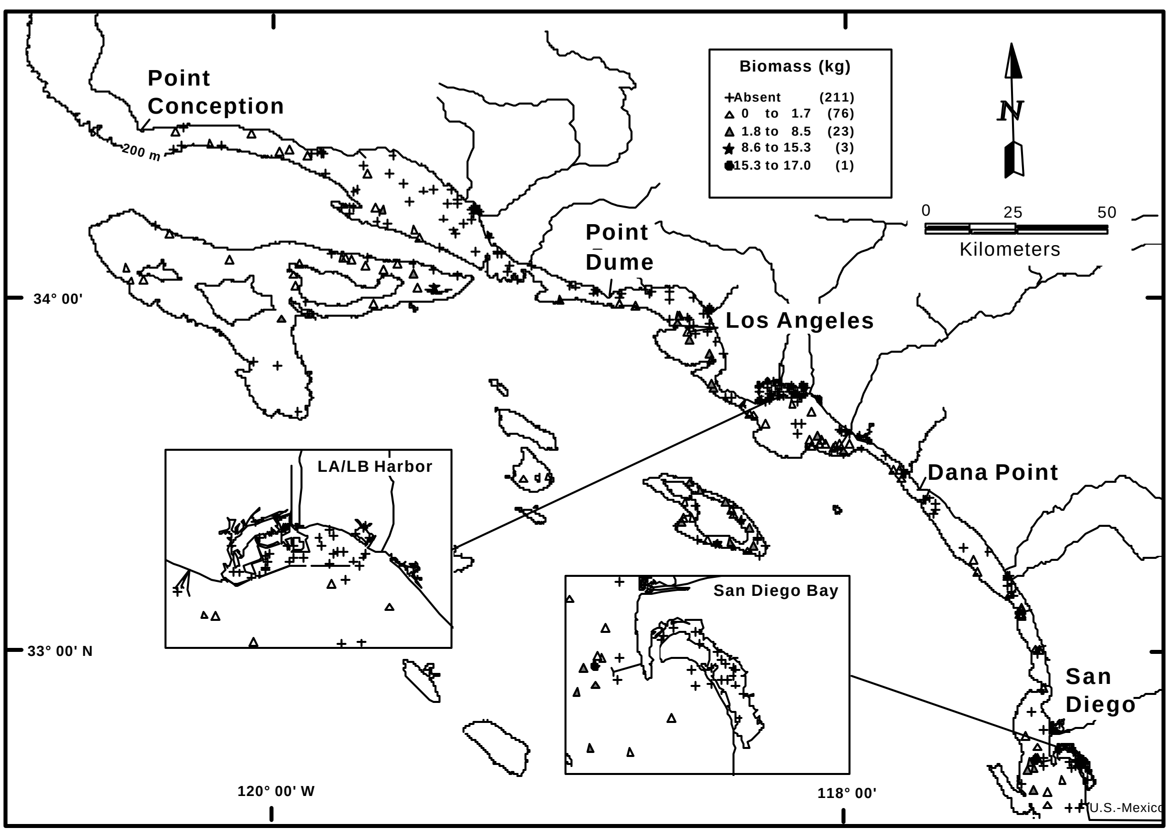
sp = species

"0.0" = less than 0.05 kg

a)

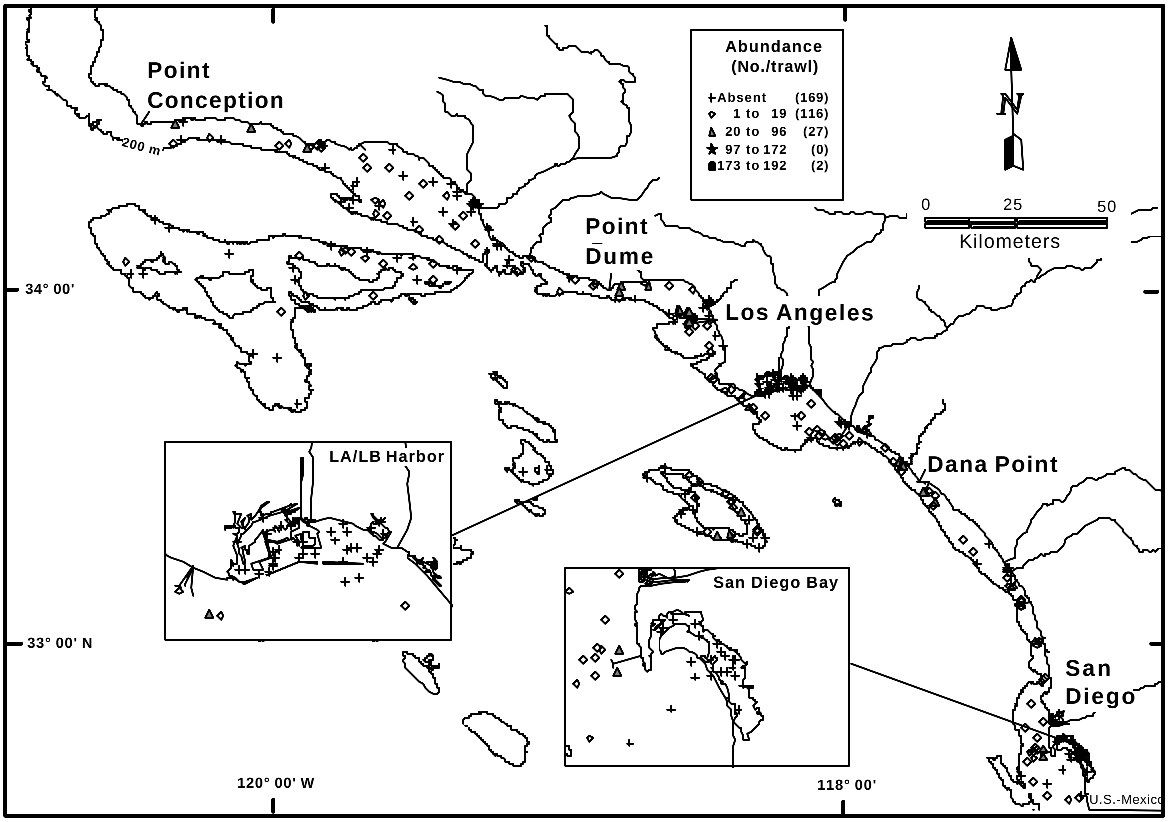


b)

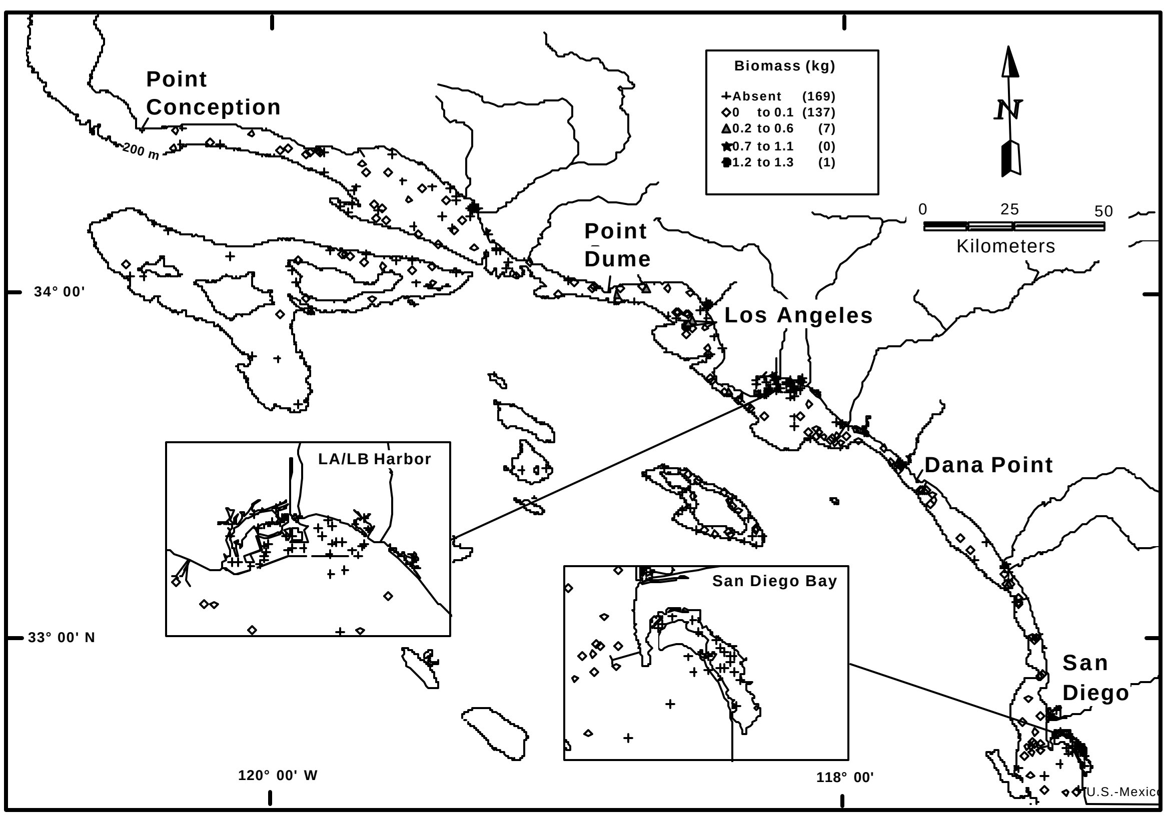


Appendix D17. Distribution of white sea urchin (*Lytechinus pictus*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

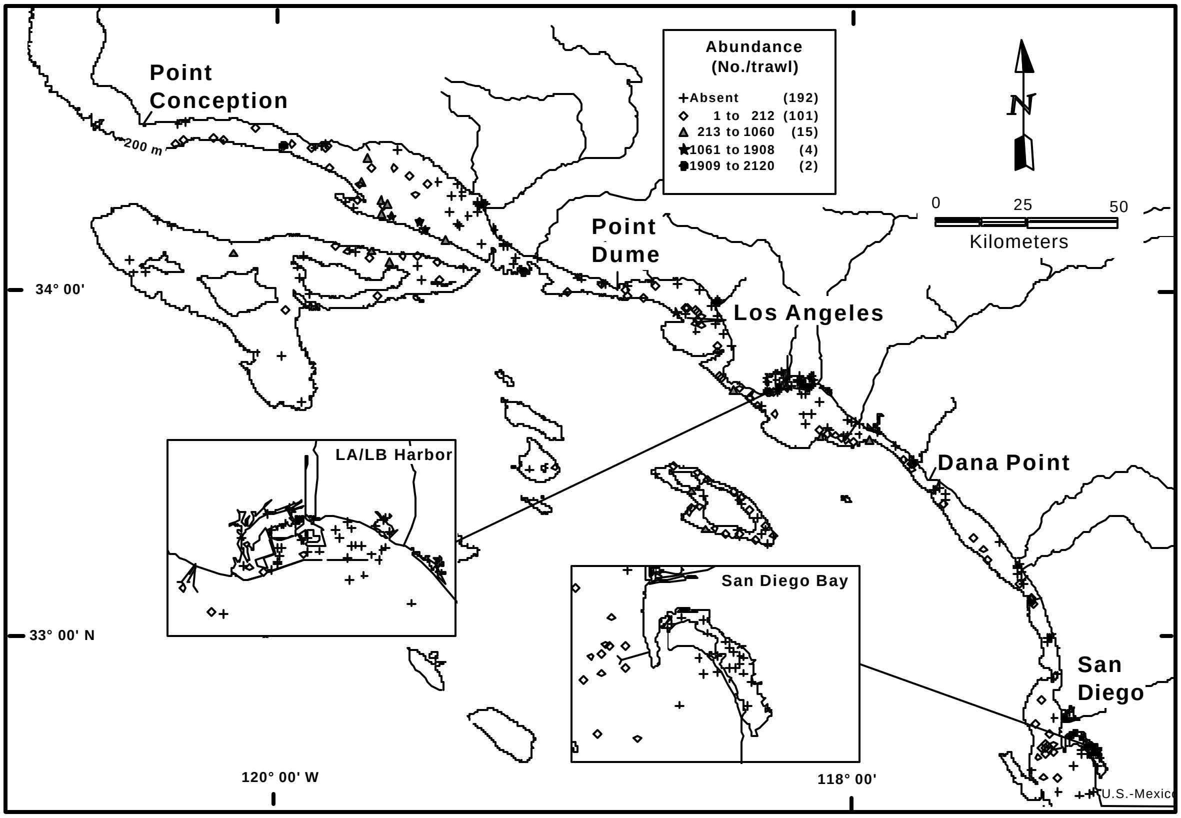


b)

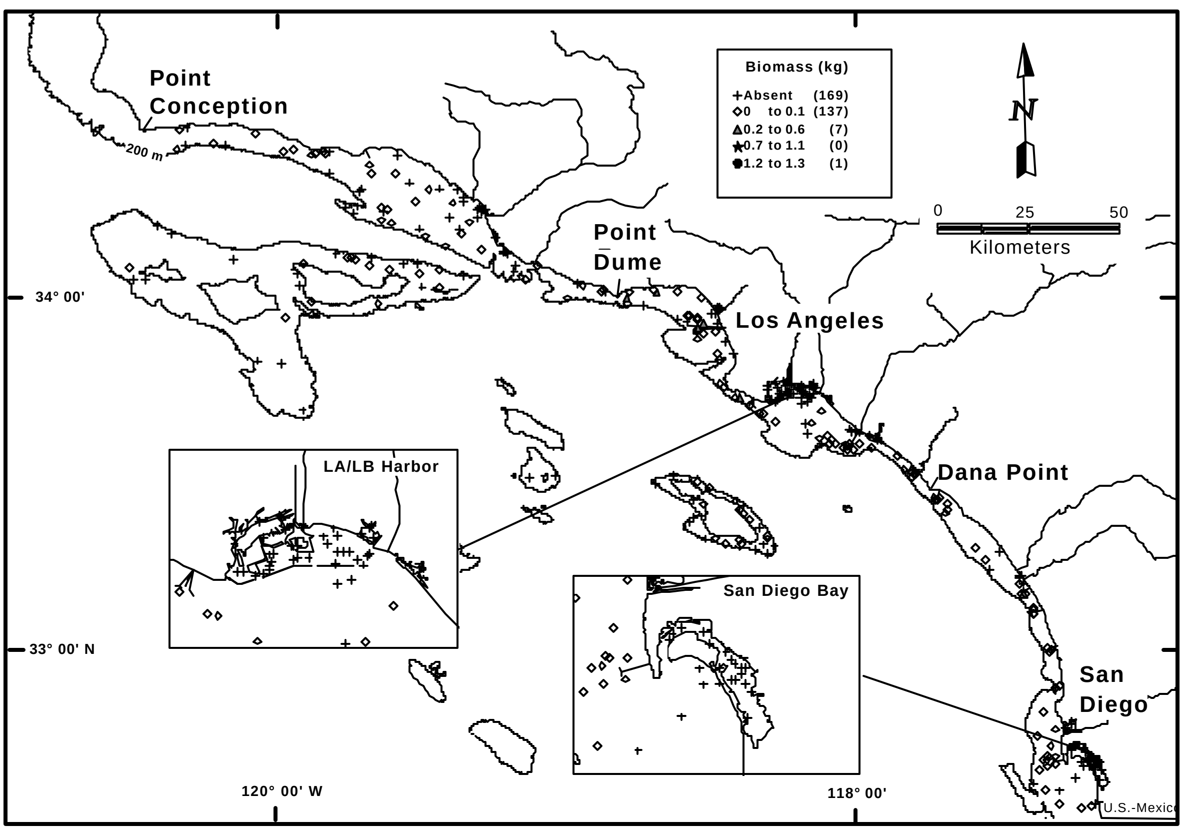


Appendix D18. Distribution of California sand star (*Astropecten verrilli*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

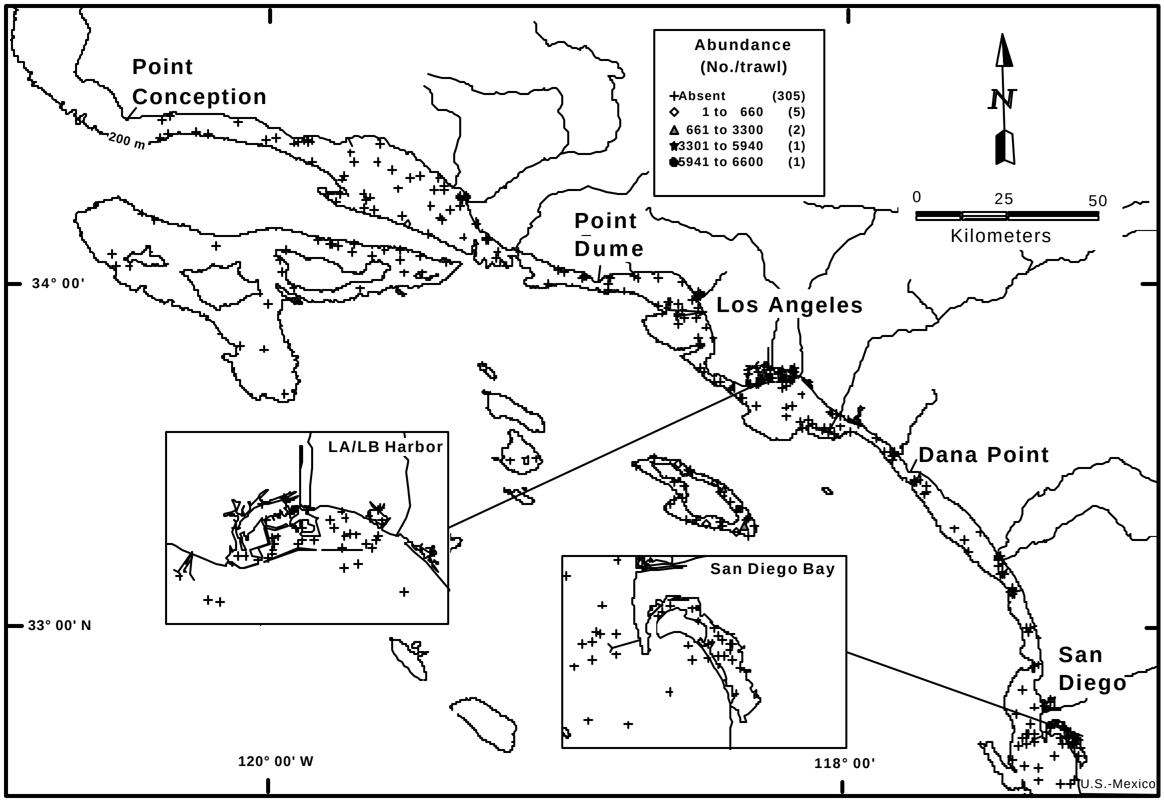


b)

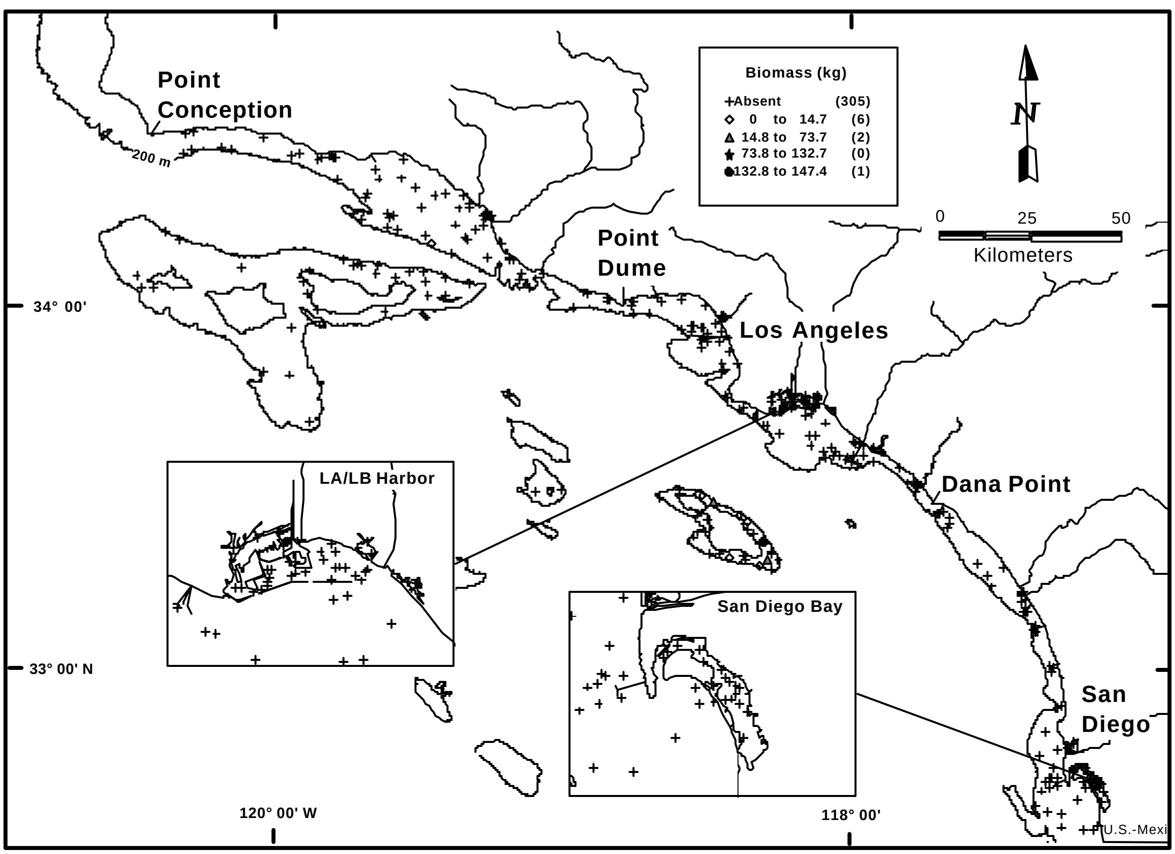


Appendix D19. Distribution of ridgeback rock shrimp (*Sicyonia ingentis*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

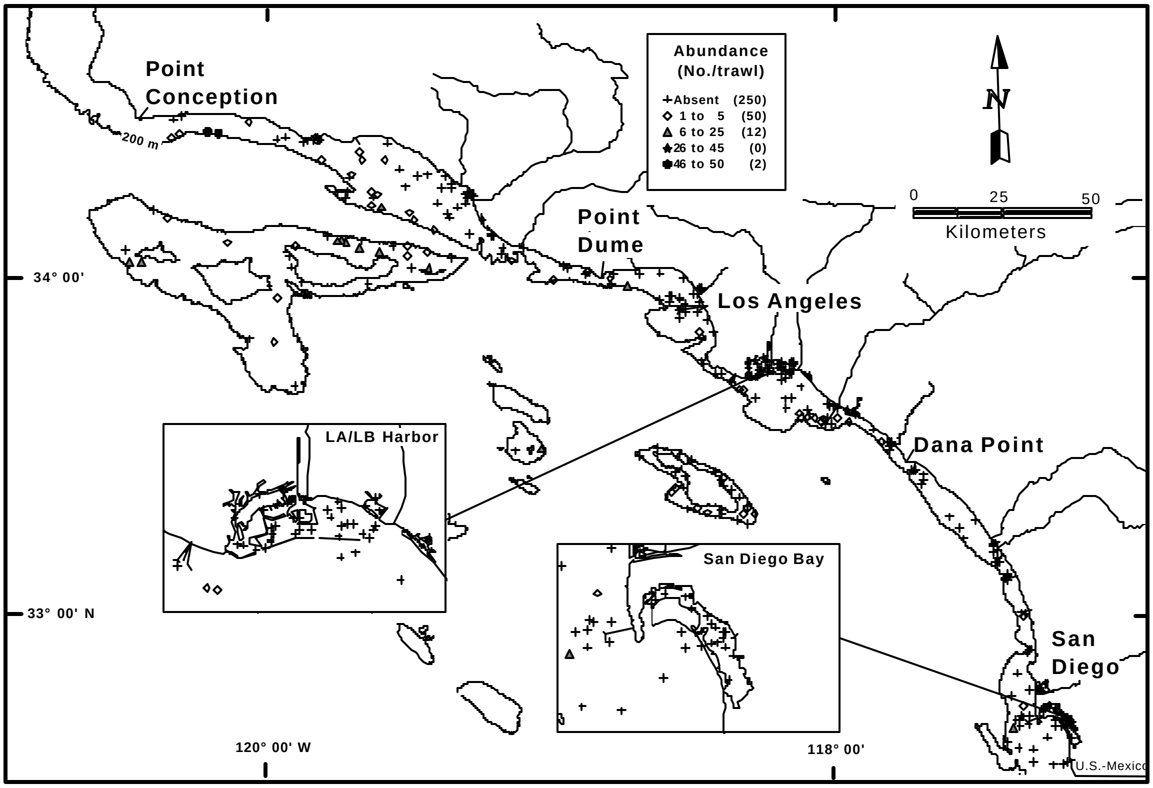


b)

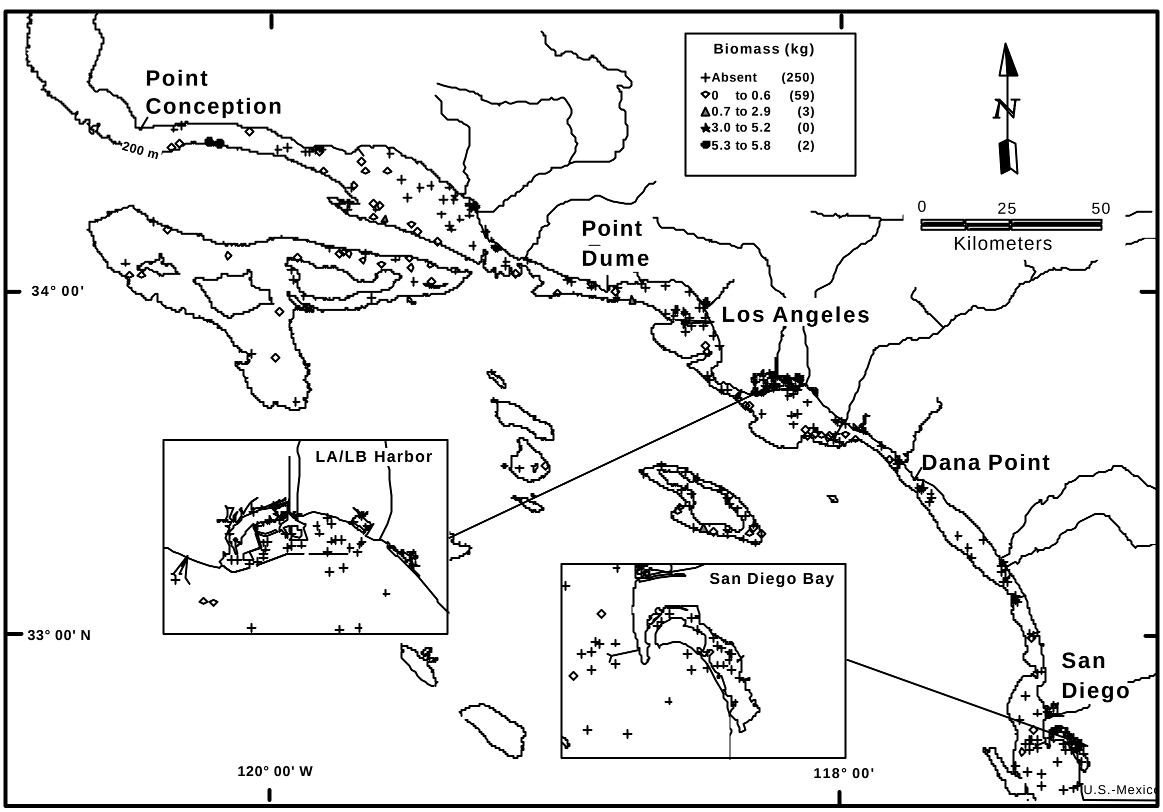


Appendix D20. Distribution of California lamp shell (*Laqueus californianus*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

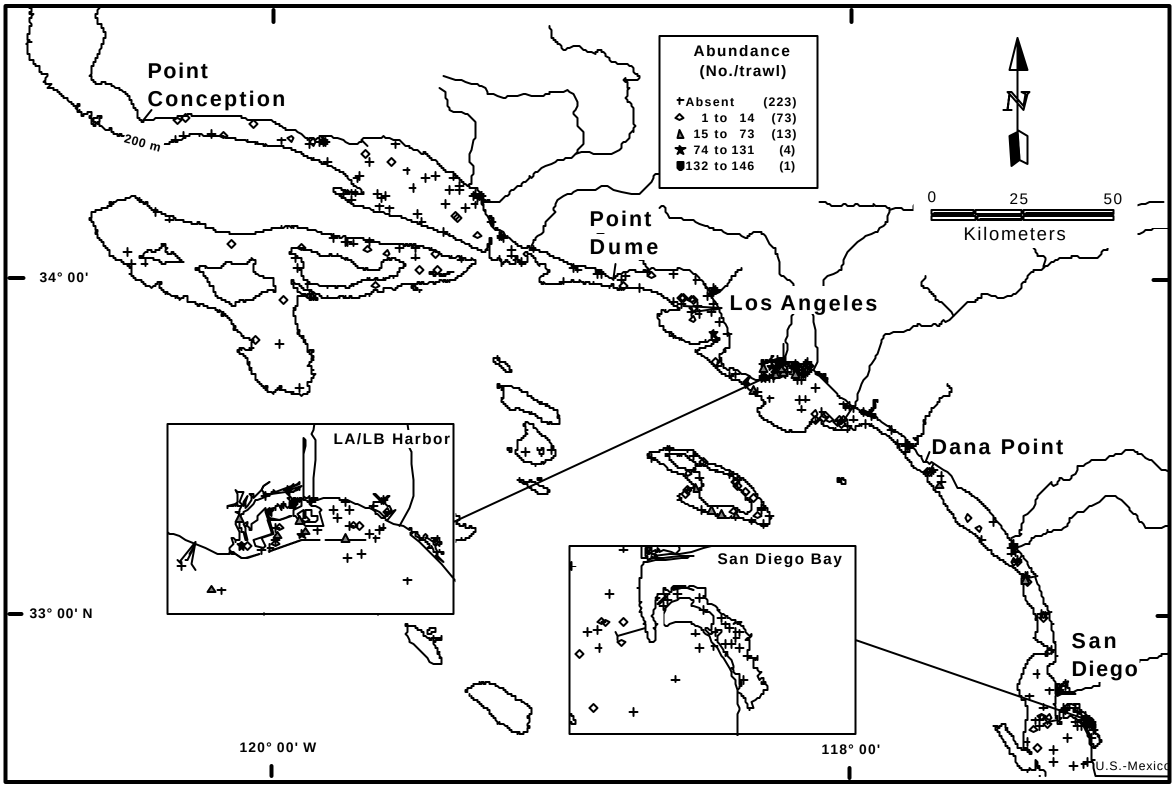


b)

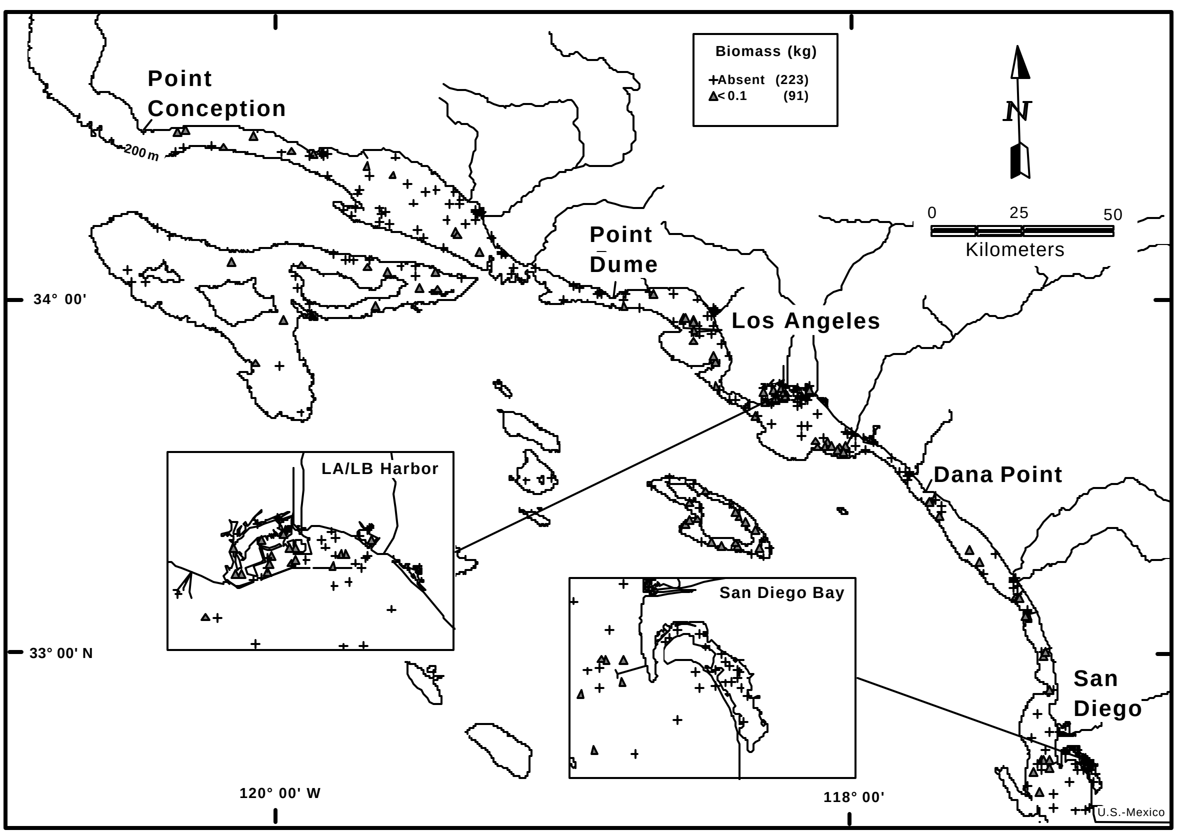


Appendix D21. Distribution of California sea cucumber (*Parastichopus californicus*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

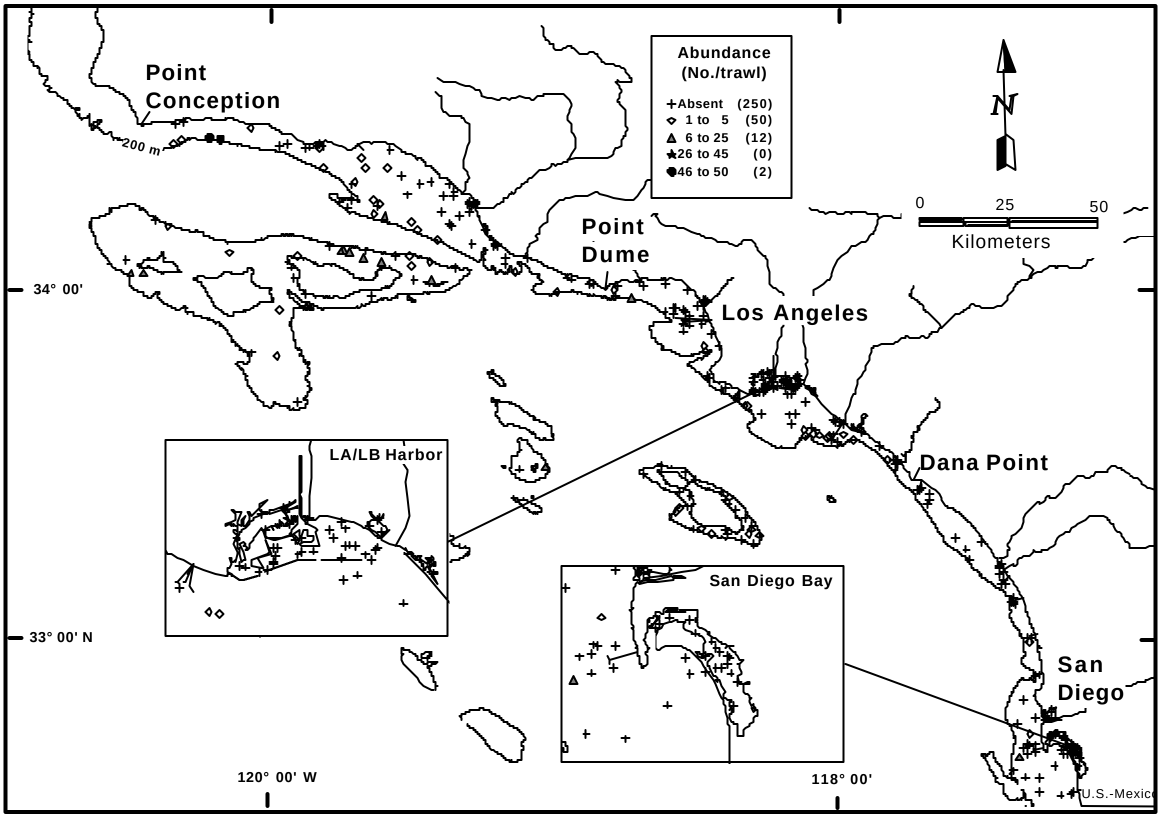


b)

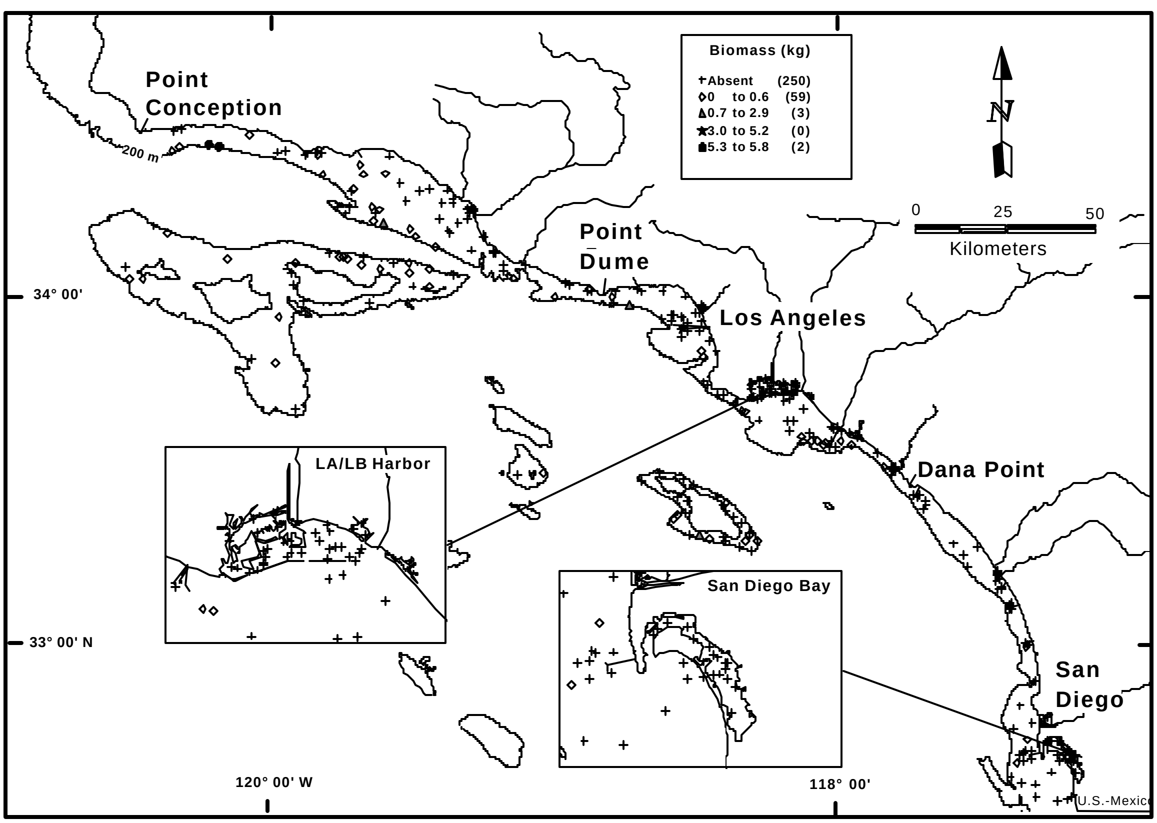


Appendix D22. Distribution of fragile sea urchin (*Allocentrotus fragilis*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

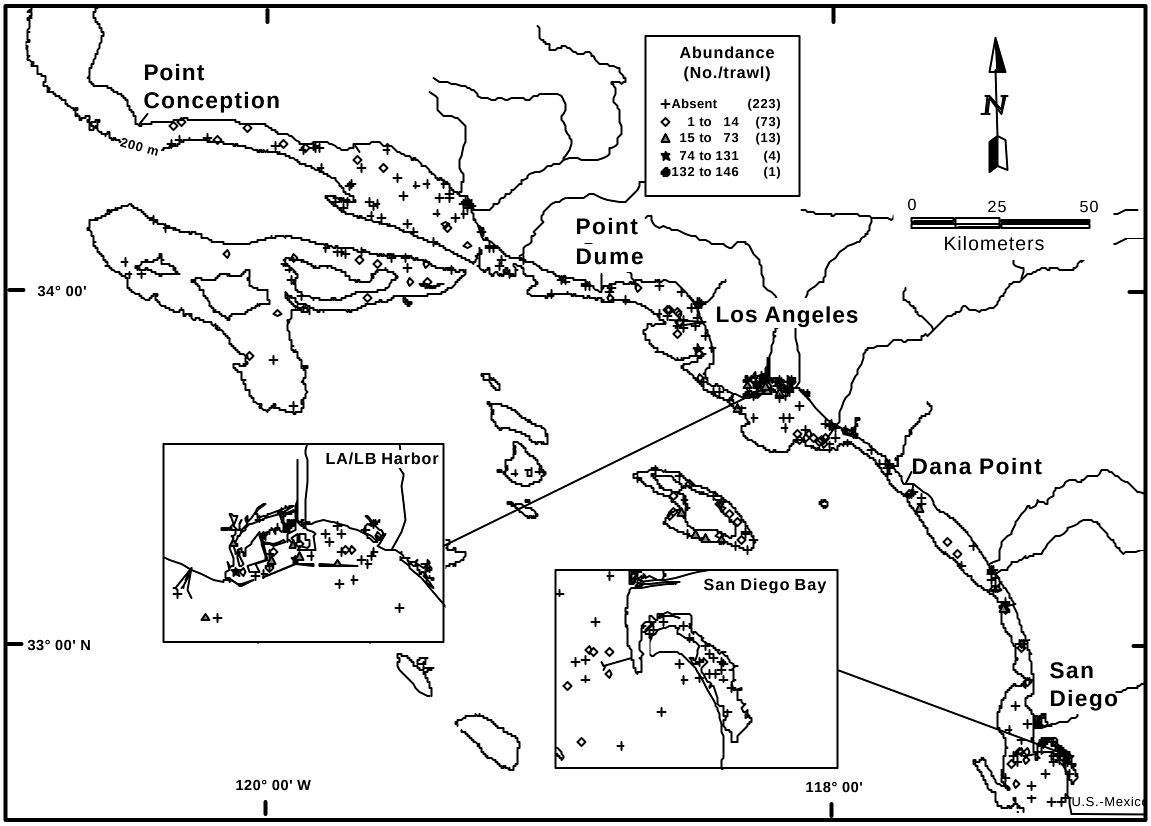


b)

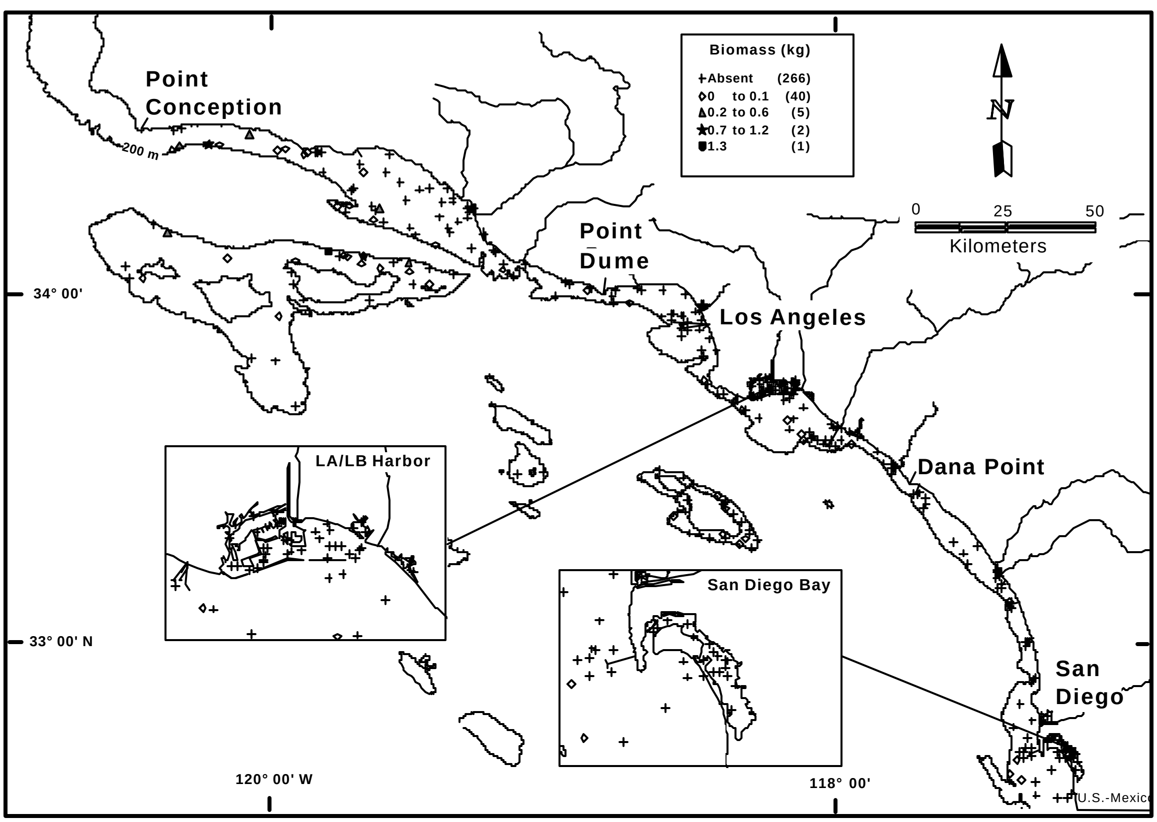


Appendix D23. Distribution of gray sand star (*Luidia foliolata*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

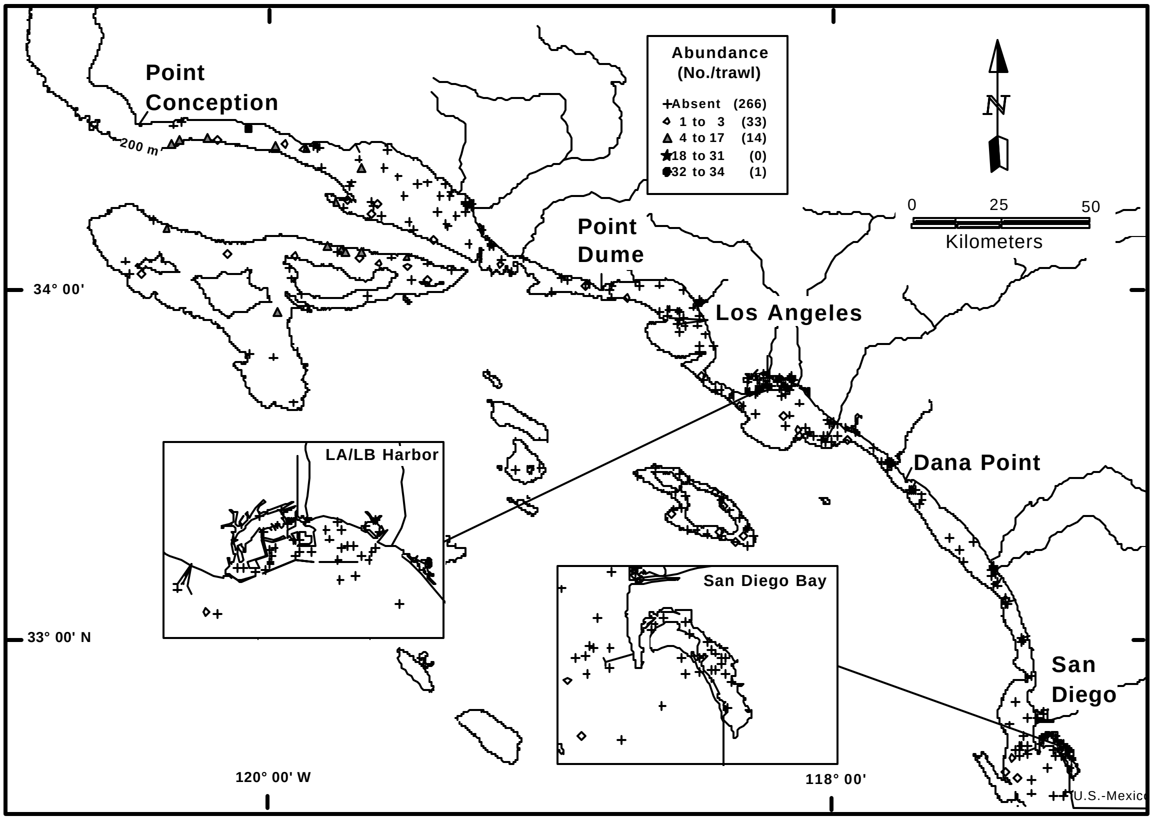


b)

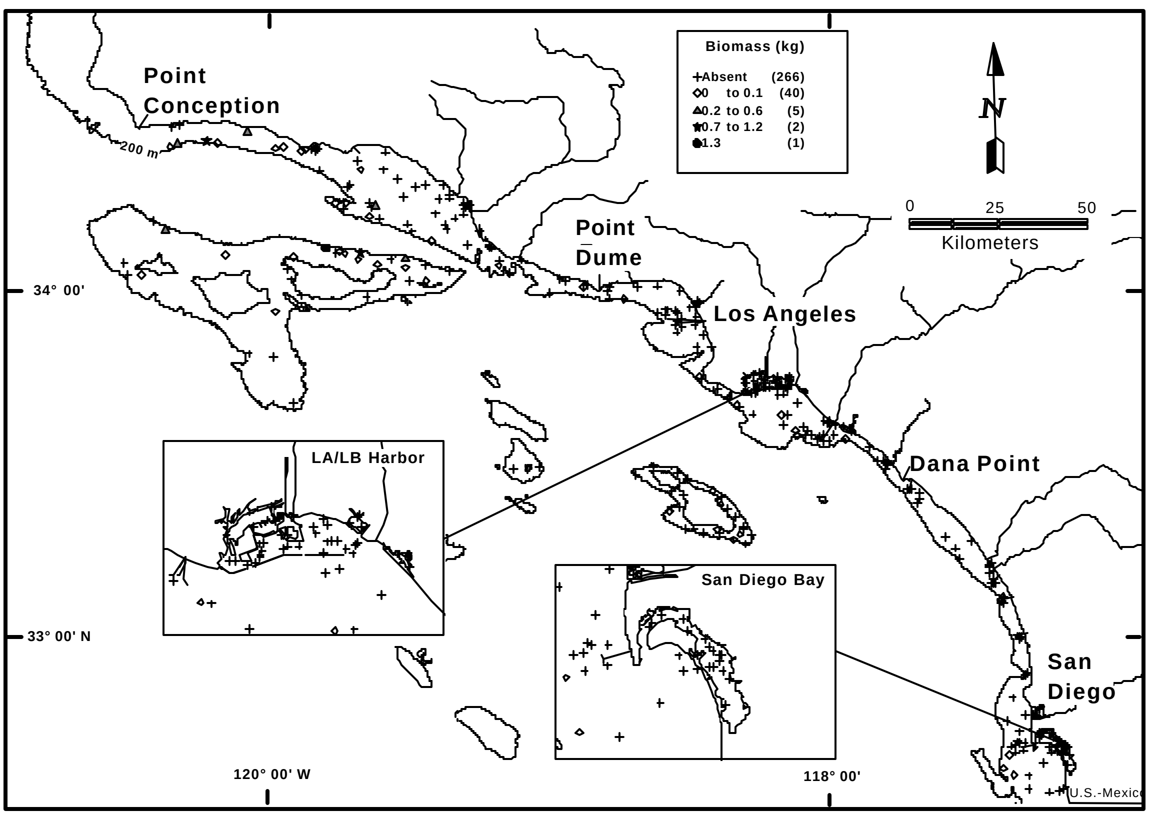


Appendix D24. Distribution of New Zealand paperbubble (*Philine auriformis*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)

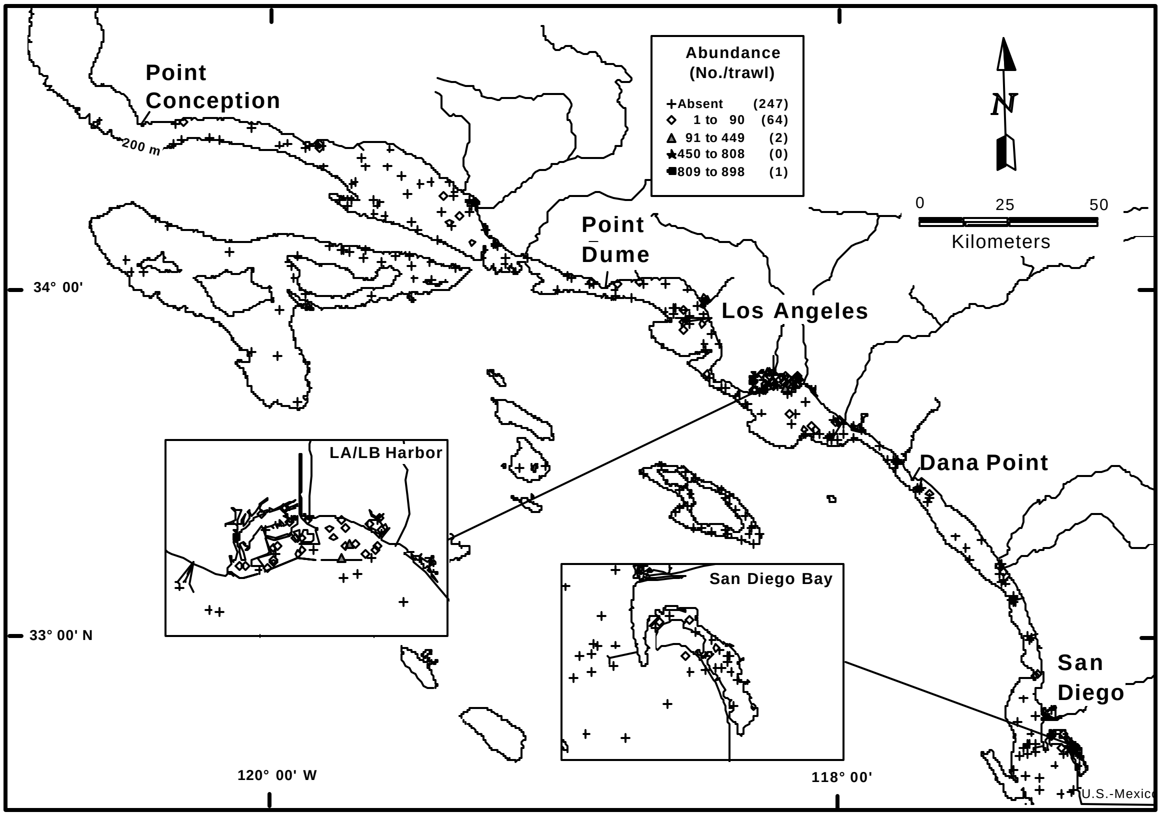


b)

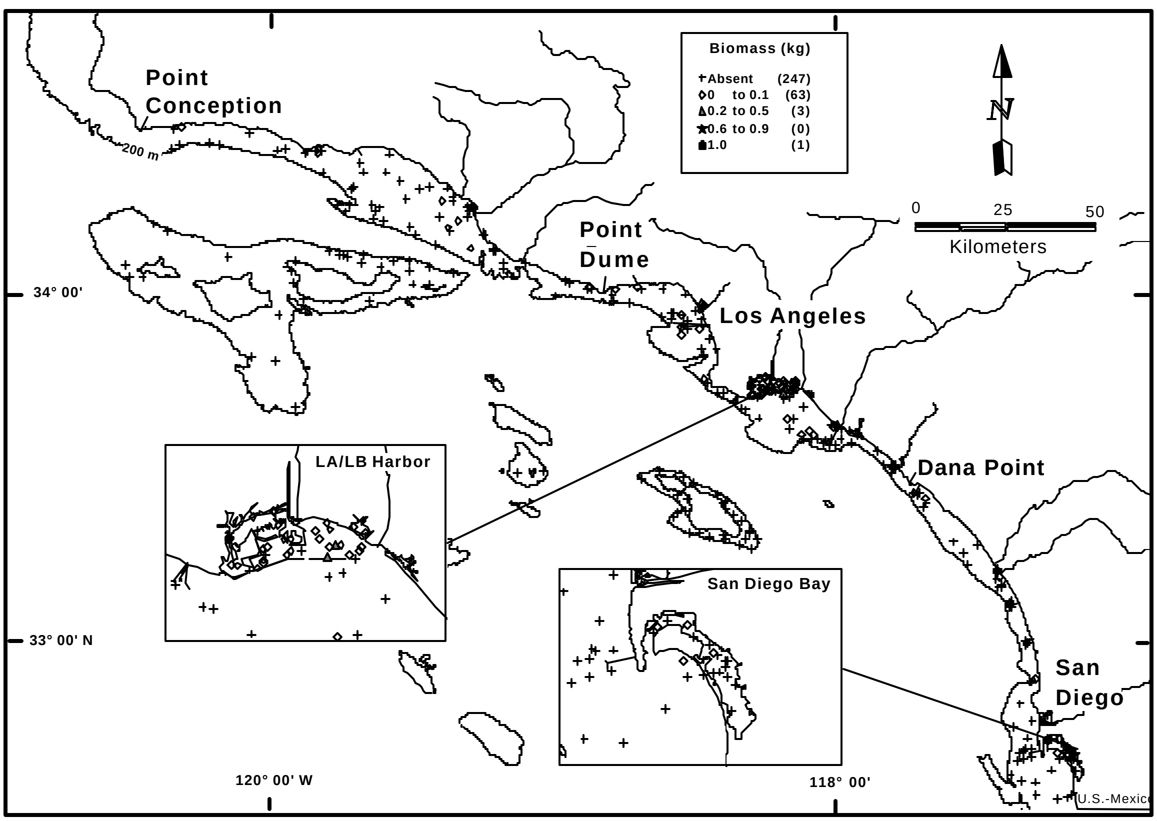


Appendix D25. Distribution of California sea slug (*Pleurobranchaea californica*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

a)



b)



Appendix D26. Distribution of tuberculate pear crab (*Pyromaia tuberculata*) at depths of 2-202 m on the southern California shelf, July-September 1998: a) number of individuals per trawl, and b) biomass (kg) per trawl.

APPENDIX E

APPENDIX E. ASSEMBLAGES

Appendix E1. Abundance of demersal fish species in each site cluster on the southern California shelf at depths of 2-202 m, July-September 1998. (B&H = Bays and Harbors; N = North; C = Central; S = South).

			SITE CLUSTER								
			1	2	3	4	5	6	7	8	Total
			Outer Shelf	Outer / Middle Shelf	Middle Shelf	Middle / Inner Shelf C/S	Inner Shelf N	Inner Shelf B&H C/S	Inner Shelf B&H N/C	B&H C/S	
		Number of Stations	19	66	34	54	19	48	45	23	308
Species Cluster	Common Name	Scientific Name									
A	black croaker	*Cheilotrema saturnum*	-	-	-	-	-	32	-	27	59
	spotted sand bass	*Paralabrax maculatofasciatus*	-	-	-	-	-	2	-	131	133
	round stingray	*Urolophus halleri*	-	-	-	-	-	5	-	196	201
B	spotfin croaker	*Roncador stearnsii*	-	-	-	-	-	73	-	-	73
	deepbody anchovy	*Anchoa compressa*	-	-	-	-	-	516	4	-	520
	bat ray	*Myliobatis californica*	-	-	-	-	-	23	1	6	30
	slough anchovy	*Anchoa delicatissima*	-	-	-	-	-	45	-	64	109
	diamond turbot	*Pleuronichthys guttulatus*	-	-	-	-	-	54	2	36	92
	kelp bass	*Paralabrax clathratus*	-	-	-	-	-	19	-	-	19
	black perch	*Embiotoca jacksoni*	-	1	-	-	-	31	2	-	34
	white seaperch	*Phanerodon furcatus*	-	59	-	2	3	104	132	-	300
	shiner perch	*Cymatogaster aggregata*	-	1	-	47	-	121	208	28	405
	shovelnose guitarfish	*Rhinobatos productus*	-	-	-	-	-	11	-	4	15
	thornback	*Platyrhinoidis triseriata*	-	-	-	-	-	20	-	-	20
	walleye surfperch	*Hyperprosopon argenteum*	-	-	-	-	-	75	2	-	77
	yellowfin croaker	*Umbrina roncador*	-	-	-	-	-	53	-	-	53
	cutlassfish	*Trichiurus lepturus*	-	-	1	-	-	20	-	-	21
	California corbina	*Menticirrhus undulatus*	-	-	-	-	-	35	2	-	37
	barcheek pipefish	*Syngnathus exilis*	1	-	-	-	-	11	-	-	12
C	spotted turbot	*Pleuronichthys ritteri*	-	-	2	1	-	47	58	38	146
	California halibut	*Paralichthys californicus*	-	4	13	55	9	150	93	148	472
	barred sand bass	*Paralabrax nebulifer*	-	-	11	6	3	190	42	186	438
	speckled sanddab	*Citharichthys stigmaeus*	-	425	25	118	258	211	66	-	1103
	fantail sole	*Xystreurys liolepis*	-	5	11	29	-	36	29	-	110
	Pacific pompano	*Peprilus simillimus*	-	-	-	-	-	3	29	-	32
	Pacific sardine	*Sardinops sagax*	-	-	1	1	-	249	68	-	319
	northern anchovy	*Engraulis mordax*	1	13	1	7	-	2697	382	4	3105
	specklefin midshipman	*Porichthys myriaster*	-	5	42	13	3	21	93	19	196
	white croaker	*Genyonemus lineatus*	-	40	440	44	1	3355	13549	13	17442
	queenfish	*Seriphus politus*	-	4	96	-	-	1328	2404	22	3854
D	California scorpionfish	*Scorpaena guttata*	1	25	14	66	-	6	4	-	116
	California skate	*Raja inornata*	2	4	18	13	-	3	4	-	44
	yellowchin sculpin	*Icelinus quadriseriatus*	-	658	778	291	2	18	-	-	1747
	hornyhead turbot	*Pleuronichthys verticalis*	1	57	94	123	27	45	46	-	393
	bigmouth sole	*Hippoglossina stomata*	10	113	90	168	2	12	1	-	396
	longfin sanddab	*Citharichthys xanthostigma*	-	347	1125	2020	5	77	5	-	3579
	California lizardfish	*Synodus lucioceps*	1	221	949	3608	314	258	215	7	5573
	California tonguefish	*Symphurus atricaudus*	-	178	521	502	25	78	522	36	1862
E	longspine combfish	*Zaniolepis latipinnis*	7	243	470	39	-	-	-	-	759
	pink seaperch	*Zalembius rosaceus*	14	155	278	91	-	-	-	-	538
	English sole	*Parophrys vetulus*	58	173	104	18	19	10	15	-	397
	plainfin midshipman	*Porichthys notatus*	176	451	821	6	-	2	2	-	1458
	Dover sole	*Microstomus pacificus*	470	835	329	-	-	-	-	-	1634
	Pacific sanddab	*Citharichthys sordidus*	517	4654	1022	205	51	-	1	-	6450
	shortspine combfish	*Zaniolepis frenata*	223	500	51	-	-	-	-	-	774
	stripetail rockfish	*Sebastes saxicola*	212	549	59	2	-	-	-	-	822
	lumptail searobin	*Prionotus stephanophrys*	-	7	36	-	-	-	-	-	43
	gulf sanddab	*Citharichthys fragilis*	8	102	12	26	-	8	-	-	156
	Pacific argentine	*Argentina sialis*	4	208	149	-	-	-	-	-	361
	bay goby	*Lepidogobius lepidus*	-	415	51	11	-	1	2	-	480
	greenblotched rockfish	*Sebastes rosenblatti*	5	45	1	-	-	-	-	-	51

Appendix E1 (continued)

Species Cluster	Common Name	Scientific Name	SITE CLUSTER 1 Outer Shelf	2 Outer / Middle Shelf	3 Middle Shelf	4 Middle / Inner Shelf C/S	5 Inner Shelf N	6 Inner Shelf B&H C/S	7 Inner Shelf B&H N/C	8 B&H C/S	Total
		Number of Stations	19	66	34	54	19	48	45	23	308
F	pygmy poacher	*Odontopyxis trispinosa*	-	23	22	-	-	-	-	-	45
	copper rockfish	*Sebastes caurinus*	-	10	-	-	-	-	-	-	10
	vermilion rockfish	*Sebastes miniatus*	-	10	-	-	-	-	-	-	10
	curlfin sole	*Pleuronichthys decurrens*	-	60	-	-	-	-	-	-	60
	roughback sculpin	*Chitonotus pugetensis*	-	102	6	9	1	-	-	-	118
	blackeye goby	*Coryphopterus nicholsii*	-	22	-	-	-	-	-	-	22
	halfbanded rockfish	*Sebastes semicinctus*	6	155	-	-	-	-	-	-	161
	spotfin sculpin	*Icelinus tenuis*	7	289	1	-	-	-	-	-	297
	spotted cusk-eel	*Chilara taylori*	23	42	9	1	-	-	-	-	75
	bluespotted poacher	*Xeneretmus triacanthus*	2	29	-	-	-	-	-	-	31
	pink rockfish	*Sebastes eos*	5	10	5	-	-	-	-	-	20
	greenstriped rockfish	*Sebastes elongatus*	5	35	-	-	-	-	-	-	40
	greenspotted rockfish	*Sebastes chlorostictus*	2	18	4	-	-	-	-	-	24
G	bluebarred prickleback	*Plectobranchus evides*	14	4	-	-	-	-	-	-	18
	bearded eelpout	*Lyconema barbatum*	22	1	-	-	-	-	-	-	23
	spotted ratfish	*Hydrolagus colliei*	5	12	1	-	-	-	-	-	18
	rex sole	*Glyptocephalus zachirus*	65	2	-	-	-	-	-	-	67
	blackbelly eelpout	*Lycodes pacificus*	247	69	-	1	-	-	-	-	317
	slender sole	*Lyopsetta exilis*	2368	576	4	-	-	-	-	-	2948
	blacktip poacher	*Xeneretmus latifrons*	220	39	-	-	-	-	-	-	259
	Pacific hake	*Merluccius productus*	34	4	-	-	-	-	-	-	38
	splitnose rockfish	*Sebastes diploproa*	190	2	-	-	-	-	-	-	192

Appendix E2. Frequency of occurrence (number of stations) of demersal fish in each site cluster on the southern California shelf at depths of 2-202 m, July-September 1998. (B&H = Bays and Harbors; N = North; C = Central; S = South)

Species Cluster	Common Name	Scientific Name	SITE CLUSTER 1 Outer Shelf	2 Outer / Middle Shelf	3 Middle Shelf	4 Middle / Inner Shelf C/S	5 Inner Shelf N	6 Inner Shelf B&H C/S	7 Inner Shelf B&H N/C	8 B&H C/S	Total
		Number of Stations	19	66	34	54	19	48	45	23	308
A	black croaker	*Cheilotrema saturnum*	-	-	-	-	-	3	-	7	10
	spotted sand bass	*Paralabrax maculatofasciatus*	-	-	-	-	-	1	-	17	18
	round stingray	*Urolophus halleri*	-	-	-	-	-	4	-	13	17
B	spotfin croaker	*Roncador stearnsii*	-	-	-	-	-	5	-	-	5
	deepbody anchovy	*Anchoa compressa*	-	-	-	-	-	12	1	-	13
	bat ray	*Myliobatis californica*	-	-	-	-	-	10	1	2	13
	slough anchovy	*Anchoa delicatissima*	-	-	-	-	-	1	-	7	8
	diamond turbot	*Pleuronichthys guttulatus*	-	-	-	-	-	9	2	11	22
	kelp bass	*Paralabrax clathratus*	-	-	-	-	-	8	-	-	8
	black perch	*Embiotoca jacksoni*	-	1	-			5	1	-	7
	white seaperch	*Phanerodon furcatus*	-	1	-	1	2	15	18	-	37
	shiner perch	*Cymatogaster aggregata*	-	1	-	2	-	13	13	1	30
	shovelnose guitarfish	*Rhinobatos productus*	-	-	-	-	-	7	-	2	9
	thornback	*Platyrhinoidis triseriata*	-	-	-	-	-	15	-	-	15
	walleye surfperch	*Hyperprosopon argenteum*	-	-	-	-	-	7	2	-	9
	yellowfin croaker	*Umbrina roncador*	-	-	-	-	-	8	-	-	8
	cutlassfish	*Trichiurus lepturus*	-	-	1	-	-	7	-	-	8
	California corbina	*Menticirrhus undulatus*	-	-	-	-	-	15	2	-	17
	barcheek pipefish	*Syngnathus exilis*	1	-	-	-	-	6	-	-	7
C	spotted turbot	*Pleuronichthys ritteri*	-	-	1	1	-	15	15	8	40
	California halibut	*Paralichthys californicus*	-	3	10	24	7	34	23	18	119
	barred sand bass	*Paralabrax nebulifer*	-	-	1	5	2	22	15	20	65
	speckled sanddab	*Citharichthys stigmaeus*	-	13	5	19	19	17	9	-	82
	fantail sole	*Xystreurys liolepis*	-	5	7	19	-	14	15	-	60
	Pacific pompano	*Peprilus simillimus*	-	-	-	-	-	2	10	-	12
	Pacific sardine	*Sardinops sagax*	-	-	1	1	-	6	10	-	18
	northern anchovy	*Engraulis mordax*	1	1	1	2	-	13	16	1	35
	specklefin midshipman	*Porichthys myriaster*	-	3	12	10	2	7	16	3	53
	white croaker	*Genyonemus lineatus*	-	1	10	5	1	31	40	3	91
	queenfish	*Seriphus politus*	-	2	3	-	-	21	35	1	62
D	California scorpionfish	*Scorpaena guttata*	1	14	7	25	-	3	2	-	52
	California skate	*Raja inornata*	2	3	11	13	-	3	2	-	34
	yellowchin sculpin	*Icelinus quadriseriatus*	-	24	33	30	1	1	-	-	89
	hornyhead turbot	*Pleuronichthys verticalis*	1	17	26	38	8	11	11	-	112
	bigmouth sole	*Hippoglossina stomata*	3	34	28	43	1	5	1	-	115
	longfin sanddab	*Citharichthys xanthostigma*	-	17	25	54	3	7	3	-	109
	California lizardfish	*Synodus lucioceps*	1	20	31	50	13	21	27	4	167
	California tonguefish	*Symphurus atricaudus*	-	14	29	44	10	11	29	3	140
E	longspine combfish	*Zaniolepis latipinnis*	3	27	27	9	-	-	-	-	66
	pink seaperch	*Zalembius rosaceus*	8	37	25	14	-	-	-	-	84
	English sole	*Parophrys vetulus*	10	28	19	11	5	3	5	-	81
	plainfin midshipman	*Porichthys notatus*	15	42	22	4	-	1	1	-	85
	Dover sole	*Microstomus pacificus*	18	47	12	-	-	-	-	-	77
	Pacific sanddab	*Citharichthys sordidus*	17	62	23	20	2	-	1	-	125
	shortspine combfish	*Zaniolepis frenata*	16	39	3	-	-	-	-	-	58
	stripetail rockfish	*Sebastes saxicola*	13	39	17	1	-	-	-	-	70
	lumptail searobin	*Prionotus stephanophrys*	-	4	11	-	-	-	-	-	15
	gulf sanddab	*Citharichthys fragilis*	2	15	7	7	-	1	-	-	32
	Pacific argentine	*Argentina sialis*	3	16	8	-	-	-	-	-	27
	bay goby	*Lepidogobius lepidus*	-	11	13	5	-	1	2	-	32
	greenblotched rockfish	*Sebastes rosenblatti*	3	17	1	-	-	-	-	-	21
F	pygmy poacher	*Odontopyxis trispinosa*	-	5	14	-	-	-	-	-	19
	copper rockfish	*Sebastes caurinus*	-	7	-	-	-	-	-	-	7
	vermilion rockfish	*Sebastes miniatus*	-	8	-	-	-	-	-	-	8
	curlfin sole	*Pleuronichthys decurrens*	-	11	-	-	-	-	-	-	11

Appendix E2 (continued)

			SITE CLUSTER								
			1	2	3	4	5	6	7	8	Total
			Outer Shelf	Outer / Middle Shelf	Middle Shelf	Middle / Inner Shelf C/S	Inner Shelf N	Inner Shelf B&H C/S	Inner Shelf B&H N/C	B&H C/S	
		Number of Stations	19	66	34	54	19	48	45	23	308
Species Cluster	Common Name	Scientific Name									
F	roughback sculpin	*Chitonotus pugetensis*	-	17	5	3	1	-	-	-	26
	blackeye goby	*Coryphopterus nicholsii*	-	6	-	-	-	-	-	-	6
	halfbanded rockfish	*Sebastes semicinctus*	4	14	-	-	-	-	-	-	18
	spotfin sculpin	*Icelinus tenuis*	3	20	1	-	-	-	-	-	24
	spotted cusk-eel	*Chilara taylori*	8	11	4	1	-	-	-	-	24
	bluespotted poacher	*Xeneretmus triacanthus*	1	10	-	-	-	-	-	-	11
	pink rockfish	*Sebastes eos*	4	8	3	-	-	-	-	-	15
	greenstriped rockfish	*Sebastes elongatus*	3	12	-	-	-	-	-	-	15
	greenspotted rockfish	*Sebastes chlorostictus*	2	8	4	-	-	-	-	-	14
G	bluebarred prickleback	*Plectobranchus evides*	7	2	-	-	-	-	-	-	9
	bearded eelpout	*Lyconema barbatum*	5	1	-	-	-	-	-	-	6
	spotted ratfish	*Hydrolagus colliei*	5	2	1	-	-	-	-	-	8
	rex sole	*Glyptocephalus zachirus*	15	2	-	-	-	-	-	-	17
	blackbelly eelpout	*Lycodes pacificus*	14	9	-	1	-	-	-	-	24
	slender sole	*Lyopsetta exilis*	19	29	2	-	-	-	-	-	50
	blacktip poacher	*Xeneretmus latifrons*	12	6	-	-	-	-	-	-	18
	Pacific hake	*Merluccius productus*	10	3	-	-	-	-	-	-	13
	splitnose rockfish	*Sebastes diploproa*	10	2	-	-	-	-	-	-	12

Appendix E3. Frequency of occurrence (percent of stations) of demersal fish species in each site cluster on the southern California shelf at depths of 2-202 m, July-September 1998. (B&H = Bays and Harbors; N = North; C = Central; S = South)

Species Cluster	Common Name	Scientific Name	SITE CLUSTER 1 Outer Shelf	2 Outer / Middle Shelf	3 Middle Shelf	4 Middle / Inner Shelf C/S	5 Inner Shelf N	6 Inner Shelf B&H C/S	7 Inner Shelf B&H N/C	8 B&H C/S
		Number of Stations	19	66	34	54	19	48	45	23
	black croaker	*Cheilotrema saturnum*	-	-	-	-	-	6	-	30
A	spotted sand bass	*Paralabrax maculatofasciatus*	-	-	-	-	-	2	-	74
	round stingray	*Urolophus halleri*	-	-	-	-	-	8	-	57
	spotfin croaker	*Roncador stearnsii*	-	-	-	-	-	10	-	-
	deepbody anchovy	*Anchoa compressa*	-	-	-	-	-	25	2	-
	bat ray	*Myliobatis californica*	-	-	-	-	-	21	2	9
	slough anchovy	*Anchoa delicatissima*	-	-	-	-	-	2	-	30
	diamond turbot	*Pleuronichthys guttulatus*	-	-	-	-	-	19	4	48
	kelp bass	*Paralabrax clathratus*	-	-	-	-	-	17	-	-
	black perch	*Embiotoca jacksoni*	-	2	-	-	-	10	2	-
	white seaperch	*Phanerodon furcatus*	-	2	-	2	11	31	40	-
B	shiner perch	*Cymatogaster aggregata*	-	2	-	4	-	27	29	4
	shovelnose guitarfish	*Rhinobatos productus*	-	-	-	-	-	15	-	9
	thornback	*Platyrhinoidis triseriata*	-	-	-	-	-	31	-	-
	walleye surfperch	*Hyperprosopon argenteum*	-	-	-	-	-	15	4	-
	yellowfin croaker	*Umbrina roncador*	-	-	-	-	-	17	-	-
	cutlassfish	*Trichiurus lepturus*	-	-	3	-	-	15	-	-
	California corbina	*Menticirrhus undulatus*	-	-	-	-	-	31	4	-
	barcheek pipefish	*Syngnathus exilis*	5	-	-	-	-	13	-	-
	spotted turbot	*Pleuronichthys ritteri*	-	-	3	2	-	31	33	35
	California halibut	*Paralichthys californicus*	-	5	29	44	37	71	51	78
	barred sand bass	*Paralabrax nebulifer*	-	-	3	9	11	46	33	87
	speckled sanddab	*Citharichthys stigmaeus*	-	20	15	35	100	35	20	-
	fantail sole	*Xystreurys liolepis*	-	8	21	35	-	29	33	-
C	Pacific pompano	*Peprilus simillimus*	-	-	-	-	-	4	22	-
	Pacific sardine	*Sardinops sagax*	-	-	3	2	-	13	22	-
	northern anchovy	*Engraulis mordax*	5	2	3	4	-	27	36	4
	specklefin midshipman	*Porichthys myriaster*	-	5	35	19	11	15	36	13
	white croaker	*Genyonemus lineatus*	-	2	29	9	5	65	89	13
	queenfish	*Seriphus politus*	-	3	9	-	-	44	78	4
	California scorpionfish	*Scorpaena guttata*	5	21	21	46	-	6	4	-
	California skate	*Raja inornata*	11	5	32	24	-	6	4	-
	yellowchin sculpin	*Icelinus quadriseriatus*	-	36	97	56	5	2	-	-
	hornyhead turbot	*Pleuronichthys verticalis*	5	26	76	70	42	23	24	-
D	bigmouth sole	*Hippoglossina stomata*	16	52	82	80	5	10	2	-
	longfin sanddab	*Citharichthys xanthostigma*	-	26	74	100	16	15	7	-
	California lizardfish	*Synodus lucioceps*	5	30	91	93	68	44	60	17
	California tonguefish	*Symphurus atricaudus*	-	21	85	81	53	23	64	13
	longspine combfish	*Zaniolepis latipinnis*	16	41	79	17	-	-	-	-
	pink seaperch	*Zalembius rosaceus*	42	56	74	26	-	-	-	-
	English sole	*Parophrys vetulus*	53	42	56	20	26	6	11	-
	plainfin midshipman	*Porichthys notatus*	79	64	65	7	-	2	2	-
	Dover sole	*Microstomus pacificus*	95	71	35	-	-	-	-	-
	Pacific sanddab	*Citharichthys sordidus*	89	94	68	37	11	-	2	-
E	shortspine combfish	*Zaniolepis frenata*	84	59	9	-	-	-	-	-
	stripetail rockfish	*Sebastes saxicola*	68	59	50	2	-	-	-	-
	lumptail searobin	*Prionotus stephanophrys*	-	6	32	-	-	-	-	-
	gulf sanddab	*Citharichthys fragilis*	11	23	21	13	-	2	-	-
	Pacific argentine	*Argentina sialis*	16	24	24	-	-	-	-	-
	bay goby	*Lepidogobius lepidus*	-	17	38	9	-	2	4	-
	greenblotched rockfish	*Sebastes rosenblatti*	16	26	3	-	-	-	-	-

Appendix E3 (continued)

Species Cluster	Common Name	Scientific Name	1 Outer Shelf	2 Outer / Middle Shelf	3 Middle Shelf	4 Middle / Inner Shelf C/S	5 Inner Shelf N	6 Inner Shelf B&H C/S	7 Inner Shelf B&H N/C	8 B&H C/S
		Number of Stations	19	66	34	54	19	48	45	23
F	pygmy poacher	*Odontopyxis trispinosa*	-	8	41	-	-	-	-	-
	copper rockfish	*Sebastes caurinus*	-	11	-	-	-	-	-	-
	vermilion rockfish	*Sebastes miniatus*	-	12	-	-	-	-	-	-
	curlfin sole	*Pleuronichthys decurrens*	-	17	-	-	-	-	-	-
	roughback sculpin	*Chitonotus pugetensis*	-	26	15	6	5	-	-	-
	blackeye goby	*Coryphopterus nicholsii*	-	9	-	-	-	-	-	-
	halfbanded rockfish	*Sebastes semicinctus*	21	21	-	-	-	-	-	-
	spotfin sculpin	*Icelinus tenuis*	16	30	3	-	-	-	-	-
	spotted cusk-eel	*Chilara taylori*	42	17	12	2	-	-	-	-
	bluespotted poacher	*Xeneretmus triacanthus*	5	15	-	-	-	-	-	-
	pink rockfish	*Sebastes eos*	21	12	9	-	-	-	-	-
	greenstriped rockfish	*Sebastes elongatus*	16	18	-	-	-	-	-	-
	greenspotted rockfish	*Sebastes chlorostictus*	11	12	12	-	-	-	-	-
G	bluebarred prickleback	*Plectobranchus evides*	37	3	-	-	-	-	-	-
	bearded eelpout	*Lyconema barbatum*	26	2	-	-	-	-	-	-
	spotted ratfish	*Hydrolagus colliei*	26	3	3	-	-	-	-	-
	rex sole	*Glyptocephalus zachirus*	79	3	-	-	-	-	-	-
	blackbelly eelpout	*Lycodes pacificus*	74	14	-	2	-	-	-	-
	slender sole	*Lyopsetta exilis*	100	44	6	-	-	-	-	-
	blacktip poacher	*Xeneretmus latifrons*	63	9	-	-	-	-	-	-
	Pacific hake	*Merluccius productus*	53	5	-	-	-	-	-	-
	splitnose rockfish	*Sebastes diploproa*	53	3	-	-	-	-	-	-

Appendix E4. Abundance of megabenthic invertebrate species in each site cluster on the southern California shelf at depths of 2-202 m, July-September 1998. (B&H = Bays and Harbors; N = North; C = Central; S = South)

Species Cluster	Common Name	Scientific Name	SITE CLUSTER 1 Outer Shelf	2 Outer / Middle Shelf Island	3 Outer / Middle Shelf Mainland	4 Middle / Inner Shelf	5 Inner Shelf B&H C	6 Inner Shelf B&H River	7 B&H C/S	8 B&H S	Total
		Number of Stations	11	56	35	75	10	48	36	6	277
	yellow-green sea squirt	*Ciona intestinalis*	-	-	-	-	-	-	256	2	258
	sea squirt	*Styela* sp	-	-	-	2	-	-	86	12	100
	longstalk sea squirt	*Styela montereyensis*	-	-	-	-	-	1	57	-	58
	Mediterranean mussel	*Mytilus galloprovincialis*	-	-	-	-	-	-	360	-	360
	sea squirt	*Ciona* sp	-	1	-	-	-	-	15	-	16
	ringed doris	*Diaulula sandiegensis*	-	-	-	-	-	-	14	-	14
A	festive murex	*Pteropurpura festiva*	-	1	-	-	-	1	18	-	20
	California bubble	*Bulla gouldiana*	-	-	-	-	-	26	680	-	706
	Pacific calico scallop	*Argopecten ventricosus*	-	-	-	-	-	2	16	24	42
	mat mussel	*Musculista senhousia*	-	-	-	-	-	2	830	200	1032
	cobblestone sea squirt	*Styela plicata*	-	-	-	-	-	-	40	-	40
	"oyster"	*Ostrea* sp	-	-	-	-	-	-	166	-	166
	scaly tunicate	*Microcosmus squamiger*	-	-	-	-	-	-	501	1	502
	blackspotted bay shrimp	*Crangon nigromaculata*	-	-	5	1	20	332	571	-	929
	tuberculate pear crab	*Pyromaia tuberculata*	-	4	1	27	29	696	1035	-	1792
B	spiny sand star	*Astropecten armatus*	-	2	-	9	46	31	4	-	92
	yellowleg shrimp	*Farfantepenaeus californiensis*	-	2	-	3	129	131	186	1	452
	fat western nassa	*Nassarius perpinguis*	-	-	-	1	-	18	-	-	19
	bat star	*Asterina miniata*	-	36	2	57	-	-	4	-	99
	xantus swimming crab	*Portunus xantusii*	-	-	-	11	-	15	23	-	49
	purple sea hare	*Aplysia californica*	-	-	-	8	-	6	-	-	14
	Hemphill neck crab	*Podochela hemphillii*	-	-	-	24	-	-	4	-	28
	warty sea cucumber	*Parastichopus parvimensis*	-	-	-	2	-	2	29	-	33
	California cone	*Conus californicus*	-	-	-	2	-	2	15	-	19
	California aglaja	*Navanax inermis*	-	-	2	-	-	11	53	-	66
	yellow rock crab	*Cancer anthonyi*	1	1	1	-	-	56	-	-	59
	northern kelp crab	*Pugettia producta*	-	-	-	1	-	15	4	-	20
	giant frond-aeolis	*Dendronotus iris*	-	5	-	1	-	2	4	-	12
	"isopod"	*Nerocila acuminata*	-	13	-	-	-	6	-	-	19
	rock crab	*Cancer* sp	-	-	-	-	-	17	-	-	17
	California spiny lobster	*Panulirus interruptus*	-	-	-	1	-	22	-	-	23
	golden gorgonian	*Muricea californica*	-	-	-	2	-	7	-	-	9
C	Pacific purple sea urchin	*Strongylocentrotus purpuratus*	-	1	-	4	-	3	4	-	12
	sandflat elbow crab	*Heterocrypta occidentalis*	-	1	-	27	-	5	3	-	36
	polished mantis shrimp	*Schmittius politus*	-	2	-	17	-		-	-	19
	Eastern Pacific bobtail	*Rossia pacifica*	8	1	2	22	-	1	-	-	34
	California armina	*Armina californica*	-	9	-	1	-	2	1	-	13
	armed box crab	*Platymera gaudichaudii*	-	18	-	4	-	1	-	-	23
	shortspined sea star	*Pisaster brevispinus*	-	1	-	2	-	8	4	-	15
	spotwrist hermit	*Pagurus spilocarpus*	-	2	-	6	-	9	-	-	17
	sheep crab	*Loxorhynchus grandis*	1	1	-	4	-	14	-	-	20
	Alaska bay shrimp	*Crangon alaskensis*	-	-	-	26	-	-	-	-	26
	digger hermit	*Paguristes bakeri*	-	-	-	16	-	-	-	-	16
	tower snail	*Megasurcula carpenteriana*	2	5	8	74	-	-	-	-	89
	globose sand crab	*Randallia ornata*	-	-	-	2	-	5	1	-	8
	Kellet whelk	*Kelletia kelletii*	-	3	-	17	-	1	-	-	21
	blueleg mantis shrimp	*Hemisquilla ensigera californiensis*	-	1	-	12	-	1	-	-	14
	rosy tritonia	*Tritonia diomedea*	1	7	-	2	-	-	1	-	11
	thinbeak neck crab	*Podochela lobifrons*	-	7	-	14	-	-	1	-	22
	seapen spindle snail	*Neosimnia barbarensis*	-	13	-	3	-	2	-	-	18
	fringed sand star	*Luidia asthenosoma*	-	43	1	14	-	-	-	-	58
	"gorgonian"	*Heterogorgia tortuosa*	-	-	-	212	-	-	-	-	212
D	yellow sea twig	*Thesea* sp B	-	25	5	265	-	-	-	-	295
	California blade barnacle	*Hamatoscalpellum californicum*	30	101	48	578	-	-	-	-	757
	"aeolis"	*Dendronotus* sp	-	-	-	10	-	-	-	-	10
	Santa Barbara spindle	*Fusinus barbarensis*	2	8	-	13	-	-	-	-	23
	slender sea pen	*Stylatula elongata*	2	32	96	27	-	5	3	-	165
	mosaic sand star	*Luidia armata*	1	29	8	93	-	1	-	-	132
	Spanish shawl	*Flabellina iodinea*	-	1	-	14	-	-	-	-	15

Appendix E4 (continued)

Species Cluster	Common Name	Scientific Name	1 Outer Shelf	2 Outer / Middle Shelf Island	3 Outer / Middle Shelf Main-land	4 Middle / Inner Shelf	5 Inner Shelf B&H C	6 Inner Shelf B&H River	7 B&H C/S	8 B&H S	Total
		Number of Stations	11	56	35	75	10	48	36	6	277
E	Pacific spiny brittlestar	*Ophiothrix spiculata*	8	1006	33	86	-	2	16	-	1151
	California sand star	*Astropecten verrilli*	10	371	309	1116	5	93	47	-	1951
	New Zealand paper bubble	*Philine auriformis*	4	77	169	323	-	254	361	-	1188
	ridgeback rock shrimp	*Sicyonia ingentis*	2044	5934	6105	7106	-	32	-	-	21221
	California sea cucumber	*Parastichopus californicus*	51	351	140	333	-	24	49	-	948
	white sea urchin	*Lytechinus pictus*	1763	35701	6787	24164	2	1876	462	-	70755
	trailtip sea pen	*Acanthoptilum* sp	28	672	11	119	-	19	4	-	853
	brokenspine brittlestar	*Ophiura luetkenii*	-	298	6	52	-	-	-	-	356
	California sea slug	*Pleurobranchaea californica*	35	104	3	25	-	7	5	-	179
	gray sand star	*Luidia foliolata*	121	160	16	58	-	-	-	-	355
	red octopus	*Octopus rubescens*	6	23	17	30	-	5	1	-	82
	California market squid	*Loligo opalescens*	11	12	14	32	-	4	4	-	77
F	fleshy sea pen	*Ptilosarcus gurneyi*	8	22	-	4	-	-	-	-	34
	gigantic anemone	*Metridium farcimen*	16	10	-	40	-	3	-	-	69
	slenderclaw hermit	*Paguristes turgidus*	4	79	-	1	-	1	-	-	85
	red sea star	*Mediaster aequalis*	-	179	-	7	-	-	-	-	186
	banded sea star	*Sclerasterias heteropaes*	-	11	-	-	-	-	-	-	11
	California lamp shell	*Laqueus californianus*	-	13010	-	3	-	-	-	-	13013
	pelagic red crab	*Pleuroncodes planipes*	9	94	-	2	-	-	2	-	107
	California heart urchin	*Spatangus californicus*	15	278	2	5	-	-	-	-	300
	orange sand star	*Astropecten ornatissimus*	-	757	2	28	-	-	-	-	787
	fragile sea urchin	*Allocentrotus fragilis*	900	3469	13	308	-	-	-	-	4690
	California king crab	*Paralithodes californiensis*	-	24	-	-	-	-	-	-	24
	moss crab	*Loxorhynchus crispatus*	-	2	-	11	-	-	-	-	13
	roughspine brittlestar	*Ophiopholis bakeri*	-	396	-	2	-	-	2	-	400
	"brittlestar"	*Ophiacantha* sp	-	19	-	-	-	-	-	-	19
	basket star	*Gorgonocephalus eucnemis*	-	227	-	7	-	-	-	-	234
G	orange bigeye octopus	*Octopus californicus*	9	3	-	-	-	-	-	-	12
	Pacific heart urchin	*Brissopsis pacifica*	16	-	-	-	-	-	-	-	16
	northern heart urchin	*Brisaster latifrons*	215	10	6	2	-	-	-	-	233
	mustache bay shrimp	*Neocrangon zacae*	536	30	27	-	-	-	-	-	593
	flagnose bay shrimp	*Neocrangon resima*	86	3	4	-	-	-	-	-	93
	blossom shrimp	*Solenocera mutator*	153	-	2	5	-	-	-	-	160
	spot shrimp	*Pandalus platyceros*	35	2	-	3	-	-	-	-	40
	hinged shrimp	*Pantomus affinis*	1084	4	23	-	-	-	-	-	1111
	slender blade shrimp	*Spirontocaris holmesi*	51	-	-	-	-	-	-	-	51
	southern spinyhead	*Metacrangon spinosissima*	22	-	2	-	-	-	-	-	24

Appendix E5. Frequency of occurrence (number of stations) of megabenthic invertebrate species in each site cluster on the southern California shelf at depths of 2-202 m, July-September 1998. (B&H = Bays and Harbors; N = North; C = Central; S = South)

			SITE CLUSTER								Total
			1	2	3	4	5	6	7	8	
			Outer Shelf	Outer / Middle Shelf Island	Outer / Middle Shelf Main-land	Middle / Inner Shelf	Inner Shelf B&H C	Inner Shelf B&H River	B&H C/S	B&H S	
		Number of Stations	11	56	35	75	10	48	36	6	277
Species Cluster	Common Name	Scientific Name									
	yellow-green sea squirt	*Ciona intestinalis*	-	-	-	-	-	-	9	1	10
	sea squirt	*Styela* sp	-	-	-	2	-	-	10	1	13
	longstalk sea squirt	*Styela montereyensis*	-	-	-	-	-	1	9	-	10
	Mediterranean mussel	*Mytilus galloprovincialis*	-	-	-	-	-	-	11	-	11
	sea squirt	*Ciona* sp	-	1	-	-	-	-	5	-	6
	ringed doris	*Diaulula sandiegensis*	-	-	-	-	-	-	5	-	5
A	festive murex	*Pteropurpura festiva*	-	1	-	-	-	1	4	-	6
	California bubble	*Bulla gouldiana*	-	-	-	-	-	2	6	-	8
	Pacific calico scallop	*Argopecten ventricosus*	-	-	-	-	-	1	7	6	14
	mat mussel	*Musculista senhousia*	-	-	-	-	-	1	10	5	16
	cobblestone sea squirt	*Styela plicata*	-	-	-	-	-	-	5	-	5
	"oyster"	*Ostrea* sp	-	-	-	-	-	-	6	-	6
	scaly tunicate	*Microcosmus squamiger*	-	-	-	-	-	-	11	1	12
	blackspotted bay shrimp	*Crangon nigromaculata*	-	-	1	1	6	29	4	-	41
	tuberculate pear crab	*Pyromaia tuberculata*	-	4	1	10	8	25	16	-	64
B	spiny sand star	*Astropecten armatus*	-	1	-	5	10	10	2	-	28
	yellowleg shrimp	*Farfantepenaeus californiensis*	-	1	-	2	6	17	11	1	38
	fat western nassa	*Nassarius perpinguis*	-	-	-	1	-	5	-	-	6
	bat star	*Asterina miniata*	-	4	2	3	-	-	2	-	11
	xantus swimming crab	*Portunus xantusii*	-	-	-	4	-	7	4	-	15
	purple sea hare	*Aplysia californica*	-	-	-	6	-	2	-	-	8
	Hemphill neck crab	*Podochela hemphillii*	-	-	-	12	-	-	1	-	13
	warty sea cucumber	*Parastichopus parvimensis*	-	-	-	2	-	1	5	-	8
	California cone	*Conus californicus*	-	-	-	2	-	1	3	-	6
	California aglaja	*Navanax inermis*	-	-	1	-	-	5	15	-	21
	yellow rock crab	*Cancer anthonyi*	1	1	1	-	-	7	-	-	10
	northern kelp crab	*Pugettia producta*	-	-	-	1	-	4	2	-	7
	giant frond-aeolis	*Dendronotus iris*	-	2	-	1	-	1	1	-	5
	"isopod"	*Nerocila acuminata*	-	5	-	-	-	2	-	-	7
	rock crab	*Cancer* sp	-	-	-	-	-	6	-	-	6
	California spiny lobster	*Panulirus interruptus*	-	-	-	1	-	5	-	-	6
	golden gorgonian	*Muricea californica*	-	-	-	2		3		-	5
C	Pacific purple sea urchin	*Strongylocentrotus purpuratus*	-	1	-	2		1	2	-	6
	sandflat elbow crab	*Heterocrypta occidentalis*	-	1	-	9		3	2	-	15
	polished mantis shrimp	*Schmittius politus*	-	2	-	9		-	-	-	11
	Eastern Pacific bobtail	*Rossia pacifica*	3	1	2	14		1	-	-	21
	California armina	*Armina californica*	-	7	-	1		1	1	-	10
	armed box crab	*Platymera gaudichaudii*	-	11	-	3		1		-	15
	shortspined sea star	*Pisaster brevispinus*	-	1	-	2		4	2	-	9
	spotwrist hermit	*Pagurus spilocarpus*	-	2	-	5		5	-	-	12
	sheep crab	*Loxorhynchus grandis*	1	1	-	4		7	-	-	13
	Alaska bay shrimp	*Crangon alaskensis*	-	-	-	7		-	-	-	7
	digger hermit	*Paguristes bakeri*	-	-	-	11		-	-	-	11
	tower snail	*Megasurcula carpenteriana*	1	4	6	11		-	-	-	22
	globose sand crab	*Randallia ornata*	-	-	-	2		5	1	-	8
	Kellet whelk	*Kelletia kelletii*	-	1	-	7		1	-	-	9
	blueleg mantis shrimp	*Hemisquilla ensigera californiensis*	-	1	-	11		1	-	-	13
	rosy tritonia	*Tritonia diomedea*	1	6	-	2	-	-	1	-	10
	thinbeak neck crab	*Podochela lobifrons*	-	3	-	10	-	-	1	-	14
	seapen spindle snail	*Neosimnia barbarensis*	-	9	-	3	-	1	-	-	13
	fringed sand star	*Luidia asthenosoma*	-	8	1	10	-	-	-	-	19
	"gorgonian"	*Heterogorgia tortuosa*	-	-	-	13	-	-	-	-	13
D	yellow sea twig	*Thesea* sp B	-	14	4	36	-	-	-	-	54
	California blade barnacle	*Hamatoscalpellum californicum*	3	11	6	34	-	-	-	-	54
	"aeolis"	*Dendronotus* sp	-	-	-	8	-	-	-	-	8
	Santa Barbara spindle	*Fusinus barbarensis*	1	6	-	3	-	-	-	-	10
	slender sea pen	*Stylatula elongata*	1	5	7	11	-	3	1	-	28
	mosaic sand star	*Luidia armata*	1	5	4	27	-	1	-	-	38
	Spanish shawl	*Flabellina iodinea*	-	1	-	4	-	-	-	-	5

Appendix E5 (continued)

			SITE CLUSTER								
			1	2	3	4	5	6	7	8	Total
			Outer Shelf	Outer / Middle Shelf Island	Outer / Middle Shelf Main-land	Middle / Inner Shelf	Inner Shelf B&H C	Inner Shelf B&H River	B&H C/S	B&H S	
		Number of Stations	11	56	35	75	10	48	36	6	277
Species Cluster	Common Name	Scientific Name					-	-		-	
E	Pacific spiny brittlestar	*Ophiothrix spiculata*	2	12	6	21	-	2	4	-	47
	California sand star	*Astropecten verrilli*	4	29	24	65	3	11	4	-	140
	New Zealand paper bubble	*Philine auriformis*	3	18	10	37	-	11	10	-	89
	ridgeback rock shrimp	*Sicyonia ingentis*	11	34	23	50	-	4	-	-	122
	California sea cucumber	*Parastichopus californicus*	7	23	12	34	-	2	6	-	84
	white sea urchin	*Lytechinus pictus*	5	33	13	42	1	4	3	-	101
	trailtip sea pen	*Acanthoptilum* sp	2	25	3	24	-	2	2	-	58
	brokenspine brittlestar	*Ophiura luetkenii*	-	18	3	17	-	-	-	-	38
	California sea slug	*Pleurobranchaea californica*	11	20	2	9	-	2	2	-	46
	gray sand star	*Luidia foliolata*	7	29	9	19	-	-	-	-	64
	red octopus	*Octopus rubescens*	3	17	6	16	-	1	1	-	44
	California market squid	*Loligo opalescens*	3	8	8	13	-	3	1	-	36
F	fleshy sea pen	*Ptilosarcus gurneyi*	3	7	-	2	-	-	-	-	12
	gigantic anemone	*Metridium farcimen*	2	6	-	6	-	1	-	-	15
	slender claw hermit	*Paguristes turgidus*	1	10	-	1	-	1	-	-	13
	red sea star	*Mediaster aequalis*	-	27	-	4	-	-	-	-	31
	banded sea star	*Sclerasterias heteropaes*	-	6	-	-	-	-	-	-	6
	California lamp shell	*Laqueus californianus*	-	7	-	1	-	-	-	-	8
	pelagic red crab	*Pleuroncodes planipes*	3	6	-	2	-	-	1	-	12
	California heart urchin	*Spatangus californicus*	5	11	2	1	-	-	-	-	19
	orange sand star	*Astropecten ornatissimus*	-	17	2	2	-	-	-	-	21
	fragile sea urchin	*Allocentrotus fragilis*	9	23	1	3	-	-	-	-	36
	California king crab	*Paralithodes californiensis*	-	6	-	-	-	-	-	-	6
	moss crab	*Loxorhynchus crispatus*	-	2	-	5	-	-	-	-	7
	roughspine brittlestar	*Ophiopholis bakeri*	-	12	-	1	-	-	1	-	14
	"brittlestar"	*Ophiacantha* sp	-	10	-	-	-	-	-	-	10
	basket star	*Gorgonocephalus eucnemis*	-	8	-	2	-	-	-	-	10
G	orange bigeye octopus	*Octopus californicus*	6	3	-	-	-	-	-	-	9
	Pacific heart urchin	*Brissopsis pacifica*	5	-	-	-	-	-	-	-	5
	northern heart urchin	*Brisaster latifrons*	9	3	2	1	-	-	-	-	15
	mustache bay shrimp	*Neocrangon zacae*	9	7	3	-	-	-	-	-	19
	flagnose bay shrimp	*Neocrangon resima*	6	3	3	-	-	-	-	-	12
	blossom shrimp	*Solenocera mutator*	3	-	2	4	-	-	-	-	9
	spot shrimp	*Pandalus platyceros*	3	2	-	3	-	-	-	-	8
	hinged shrimp	*Pantomus affinis*	7	2	3	-	-	-	-	-	12
	slender blade shrimp	*Spirontocaris holmesi*	5	-	-	-	-	-	-	-	5
	southern spinyhead	*Metacrangon spinosissima*	4	-	2	-	-	-	-	-	6

Appendix E6. Frequency of occurrence (percent of stations) of megabenthic invertebrate species in each site cluster on the southern California shelf at depths of 2-202 m, July-September 1998. (B&H = Bays and Harbors; N = North; C = Central; S = South)

			SITE CLUSTER							
			1	2	3	4	5	6	7	8
			Outer Shelf	Outer / Middle Shelf Island	Outer / Middle Shelf Main-land	Middle / Inner Shelf	Inner Shelf B&H C	Inner Shelf B&H River	B&H C/S	B&H S
		Number of Stations	11	56	35	75	10	48	36	6
Species Cluster	Common Name	Scientific Name								
A	yellow-green sea squirt	*Ciona intestinalis*	-	-	-	-	-	-	25	17
	sea squirt	*Styela* sp	-	-	-	3	-	-	28	17
	longstalk sea squirt	*Styela montereyensis*	-	-	-	-	-	2	25	-
	Mediterranean mussel	*Mytilus galloprovincialis*	-	-	-	-	-	-	31	-
	sea squirt	*Ciona* sp	-	2	-	-	-	-	14	-
	ringed doris	*Diaulula sandiegensis*	-	-	-	-	-	-	14	-
	festive murex	*Pteropurpura festiva*	-	2	-	-	-	2	11	-
	California bubble	*Bulla gouldiana*	-	-	-	-	-	4	17	-
	Pacific calico scallop	*Argopecten ventricosus*	-	-	-	-	-	2	19	100
	mat mussel	*Musculista senhousia*	-	-	-	-	-	2	28	83
	cobblestone sea squirt	*Styela plicata*	-	-	-	-	-	-	14	-
	"oyster"	*Ostrea* sp	-	-	-	-	-	-	17	-
	scaly tunicate	*Microcosmus squamiger*	-	-	-	-	-	-	31	17
B	blackspotted bay shrimp	*Crangon nigromaculata*	-	-	3	1	60	60	11	-
	tuberculate pear crab	*Pyromaia tuberculata*	-	7	3	13	80	52	44	-
	spiny sand star	*Astropecten armatus*	-	2	-	7	100	21	6	-
	yellowleg shrimp	*Farfantepenaeus californiensis*	-	2	-	3	60	35	31	17
	fat western nassa	*Nassarius perpinguis*	-	-	-	1	-	10	-	-
C	bat star	*Asterina miniata*	-	7	6	4	-	-	6	-
	xantus swimming crab	*Portunus xantusii*	-	-	-	5	-	15	11	-
	purple sea hare	*Aplysia californica*	-	-	-	8	-	4	-	-
	Hemphill neck crab	*Podochela hemphillii*	-	-	-	16	-	-	3	-
	warty sea cucumber	*Parastichopus parvimensis*	-	-	-	3	-	2	14	-
	California cone	*Conus californicus*	-	-	-	3	-	2	8	-
	California aglaja	*Navanax inermis*	-	-	3	-	-	10	42	-
	yellow rock crab	*Cancer anthonyi*	9	2	3	-	-	15	-	-
	northern kelp crab	*Pugettia producta*	-	-	-	1	-	8	6	-
	giant frond-aeolis	*Dendronotus iris*	-	4	-	1	-	2	3	-
	"isopod"	*Nerocila acuminata*	-	9	-	-	-	4	-	-
	rock crab	*Cancer* sp	-	-	-	-	-	13	-	-
	California spiny lobster	*Panulirus interruptus*	-	-	-	1	-	10	-	-
	golden gorgonian	*Muricea californica*	-	-	-	3	-	6	-	-
	Pacific purple sea urchin	*Strongylocentrotus purpuratus*	-	2	-	3	-	2	6	-
	sandflat elbow crab	*Heterocrypta occidentalis*	-	2	-	12	-	6	6	-
	polished mantis shrimp	*Schmittius politus*	-	4	-	12	-	-	-	-
	Eastern Pacific bobtail	*Rossia pacifica*	27	2	6	19	-	2	-	-
	California armina	*Armina californica*	-	13	-	1	-	2	3	-
	armed box crab	*Platymera gaudichaudii*	-	20	-	4	-	2	-	-
	shortspined sea star	*Pisaster brevispinus*	-	2	-	3	-	8	6	-
	spotwrist hermit	*Pagurus spilocarpus*	-	4	-	7	-	10	-	-
	sheep crab	*Loxorhynchus grandis*	9	2	-	5	-	15	-	-
	Alaska bay shrimp	*Crangon alaskensis*	-	-	-	9	-	-	-	-
	digger hermit	*Paguristes bakeri*	-	-	-	15	-	-	-	-
	tower snail	*Megasurcula carpenteriana*	9	7	17	15	-	-	-	-
	globose sand crab	*Randallia ornata*	-	-	-	3	-	10	3	-
	Kellet whelk	*Kelletia kelletii*	-	2	-	9	-	2	-	-
	blueleg mantis shrimp	*Hemisquilla ensigera californiensis*	-	2	-	15	-	2	-	-

Appendix E6 (continued)

Species Cluster	Common Name	Scientific Name	SITE CLUSTER 1: Outer Shelf	2: Outer / Middle Shelf Island	3: Outer / Middle Shelf Main-land	4: Middle / Inner Shelf	5: Inner Shelf B&H C	6: Inner Shelf B&H River	7: B&H C/S	8: B&H S
		Number of Stations	11	56	35	75	10	48	36	6
	rosy tritonia	*Tritonia diomedea*	9	11	-	3	-	-	3	-
	thinbeak neck crab	*Podochela lobifrons*	-	5	-	13	-	-	3	-
	seapen spindle snail	*Neosimnia barbarensis*	-	16	-	4	-	2	-	-
	fringed sand star	*Luidia asthenosoma*	-	14	3	13	-	-	-	-
	"gorgonian"	*Heterogorgia tortuosa*	-	-	-	17	-	-	-	-
D	yellow sea twig	*Thesea* sp B	-	25	11	48	-	-	-	-
	California blade barnacle	*Hamatoscalpellum californicum*	27	20	17	45	-	-	-	-
	"aeolis"	*Dendronotus* sp	-	-	-	11	-	-	-	-
	Santa Barbara spindle	*Fusinus barbarensis*	9	11	-	4	-	-	-	-
	slender sea pen	*Stylatula elongata*	9	9	20	15	-	6	3	-
	mosaic sand star	*Luidia armata*	9	9	11	36	-	2	-	-
	Spanish shawl	*Flabellina iodinea*	-	2	-	5	-	-	-	-
	Pacific spiny brittlestar	*Ophiothrix spiculata*	18	21	17	28	-	4	11	-
	California sand star	*Astropecten verrilli*	36	52	69	87	30	23	11	-
	New Zealand paper bubble	*Philine auriformis*	27	32	29	49	-	23	28	-
	ridgeback rock shrimp	*Sicyonia ingentis*	100	61	66	67	-	8	-	-
	California sea cucumber	*Parastichopus californicus*	64	41	34	45	-	4	17	-
E	white sea urchin	*Lytechinus pictus*	45	59	37	56	10	8	8	-
	trailtip sea pen	*Acanthoptilum* sp	18	45	9	32	-	4	6	-
	brokenspine brittlestar	*Ophiura luetkenii*	-	32	9	23	-	-	-	-
	California sea slug	*Pleurobranchaea californica*	100	36	6	12	-	4	6	-
	gray sand star	*Luidia foliolata*	64	52	26	25	-	-	-	-
	red octopus	*Octopus rubescens*	27	30	17	21	-	2	3	-
	California market squid	*Loligo opalescens*	27	14	23	17	-	6	3	-
	fleshy sea pen	*Ptilosarcus gurneyi*	27	13	-	3	-	-	-	-
	gigantic anemone	*Metridium farcimen*	18	11	-	8	-	2	-	-
	slender claw hermit	*Paguristes turgidus*	9	18	-	1	-	2	-	-
	red sea star	*Mediaster aequalis*	-	48	-	5	-	-	-	-
	banded sea star	*Sclerasterias heteropaes*	-	11	-	-	-	-	-	-
	California lamp shell	*Laqueus californianus*	-	13	-	1	-	-	-	-
	pelagic red crab	*Pleuroncodes planipes*	27	11	-	3	-	-	-	-
F	California heart urchin	*Spatangus californicus*	45	20	6	1	-	-	-	-
	orange sand star	*Astropecten ornatissimus*	-	30	6	3	-	-	-	-
	fragile sea urchin	*Allocentrotus fragilis*	82	41	3	4	-	-	-	-
	California king crab	*Paralithodes californiensis*	-	11	-	-	-	-	-	-
	moss crab	*Loxorhynchus crispatus*	-	4	-	7	-	-	-	-
	roughspine brittlestar	*Ophiopholis bakeri*	-	21	-	1	-	-	3	-
	"brittlestar"	*Ophiacantha* sp	-	18	-	-	-	-	-	-
	basket star	*Gorgonocephalus eucnemis*	-	14	-	3	-	-	-	-
	orange bigeye octopus	*Octopus californicus*	55	5	-	-	-	-	-	-
	Pacific heart urchin	*Brissopsis pacifica*	45	-	-	-	-	-	-	-
	northern heart urchin	*Brisaster latifrons*	82	5	6	1	-	-	-	-
	mustache bay shrimp	*Neocrangon zacae*	82	13	9	-	-	-	-	-
G	flagnose bay shrimp	*Neocrangon resima*	55	5	9	-	-	-	-	-
	blossom shrimp	*Solenocera mutator*	27	-	6	5	-	-	-	-
	spot shrimp	*Pandalus platyceros*	27	4	-	4	-	-	-	-
	hinged shrimp	*Pantomus affinis*	64	4	9	-	-	-	-	-
	slender blade shrimp	*Spirontocaris holmesi*	45	-	-	-	-	-	-	-
	southern spinyhead	*Metacrangon spinosissima*	36	-	6	-	-	-	-	-

Appendix E7. Recurrent groups of demersal fish and megabenthic invertebrates occurring at single sites on the southern California shelf at depths of 2-202 m, July-September 1998.

Group 1
giant rock scallop (*Crassadoma gigantea*)
white slippersnail (*Crepidula perforans*)
Monterey sea-lemon (*Archidoris montereyensis*)

Group 3
mussel blenny (*Hypsoblennius jenkinsi*)
giant spined star (*Pisaster giganteus capitatus*)

Group 5
salted yellow doris (*Doriopsilla albopunctata*)
"sponge" (Porifera sp SD 8)

Group 6
mudflat snapping shrimp (*Alpheus californiensis*)
gray smoothhound (*Mustelus californicus*)

Group 8
bluebanded goby (*Lythrypnus dalli*)
zebra goby (*Lythrypnus zebra*)

Group 9
Catalina forreria (*Austrotrophon catalinensis*)
sharpnose crab (*Scyra acutifrons*)
"dirona" (*Dirona* sp)

Group 10
brooding anemone (*Epiactis prolifera*)
California drillia (*Crassispira semiinflata*)

Group 11
California sheephead (*Semicossyphus pulcher*)
"sponge" (*Plocamia karykina*)
northern squat lobster (*Munida quadrispina*)

Group 12
slender coastal shrimp (*Heptacarpus tenuissimus*)
"gorgonian" (Alcyonacea sp SD 1)

Group 13
parchment tube worm (*Chaetopterus variopedatus* Cmpl)
jack mackerel (*Trachurus symmetricus)*

Group 14
sea spider (*Anoplodactylus erectus*)
"sponge" (Porifera sp. SD 3)

Group 16
"left-handed hermit" (*Paguristes* sp A)
Loebbeck spindlesnail (*Neosimnia loebbeckeana*)

Group 17
stripedfin ronquil (*Rathbunella alleni*)
white lamp shell (*Terebratalia transversa*)
spiny scallop (*Chlamys hastata*)

Group 20
speckletail flounder (*Engyophrys sanctilaurentii*)
bristle squat lobster (*Munida hispida*)

Group 21
"sea twig" (*Thesea* sp A)
honeycomb rockfish (*Sebastes umbrosus*)

Group 25
"nestling sea cucumber" (*Cucumaria* sp.)
smooth western nassa (*Nassarius insculptus*)

Group 26
Vidler spindlesnail (*Neosimnia aequalis*)
California sidegill slug (*Berthella californica*)

Group 28
Hudson spiny doris (*Acanthodoris hudsoni*)
eggcase limpet (*Addisonia brophyi*)

Group 29
"right-handed hermit" (*Enallopaguropsis guatemoci*)
scaly sea cucumber (*Psolus squamatus*)
"trophon" (*Scabrotrophon grovesi*)
blacklip dragonet (*Synchiropus atrilabiatus*)

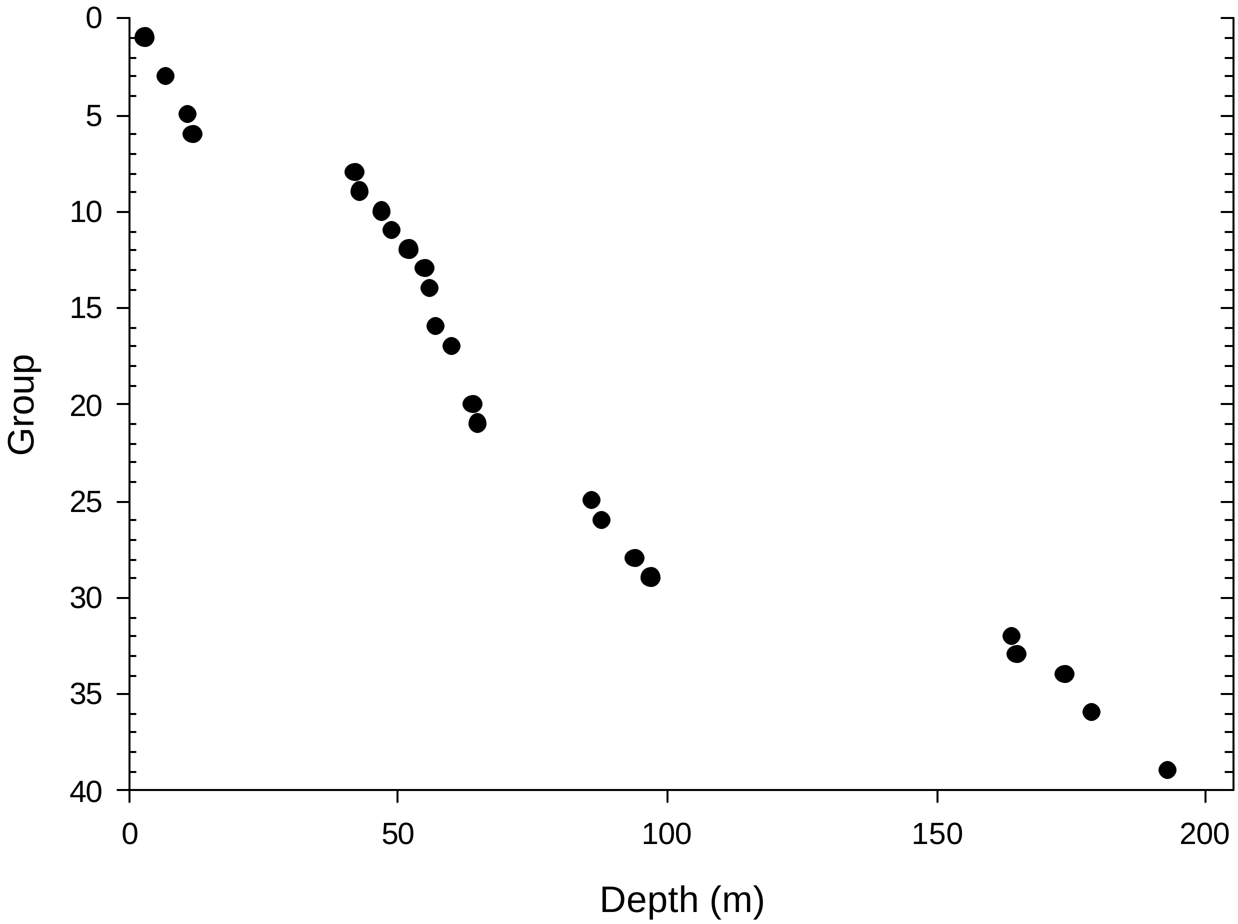
Group 32
"cup coral" (*Caryophyllia alaskensis*)
slim sculpin (*Rhadulinus asprellus*)
cloud sponge (*Aphrocallistes vastus*)
"cookie star" (*Ceramaster* sp)
longhorn decorator crab (*Chorilia longipes*)
spiny sea star (*Poraniopsis inflata*)
"sponge" (*Sphincturella* sp A)

Group 33
sablefish (*Anoplopoma fimbria*)
globose hooked cucumber (*Pentamera pseudocalcigera*)

Group 34
gray shrimp (*Neocrangon communis*)
helmet puncturella (*Puncturella galeata*)

Group 36
white lamp shell (*Terebratulina crossei*)
"gorgonian" (*Parastenella doederleini*)

Group 39
sea dandelion (*Dromalia alexandri*)
hundred-fathom codling (*Physiculus rastrelliger*)
shortspine thornyhead (*Sebastolobus alascanus*)
brownspot octopus (*Octopus veligero*)
Colombian longbeak shrimp (*Plesionika trispinus*)
big skate (*Raja binoculata*)



Appendix E8. Bathymetric distribution of demersal fish and megabenthic invertebrate recurrent groups occurring at single sites on the southern California shelf at depths of 2-202 m, July-September 1998.

Appendix E9. Abundance of demersal fish and megabenthic invertebrate species in each site cluster on the southern California shelf at depths of 2-202 m, July-September 1998. (B&H = Bays and Harbors; N = North; C = Central; S = South)

			Site Cluster									
			1	2	3	4	5	6	7	8	9	
			Outer Shelf	Outer / Middle Shelf Island	Middle Shelf	Middle Shelf C/S	Middle/ Inner Shelf B&H Island	B&H C Ports Marinas	Inner Shelf B&H Rivers	Inner Shelf N	B&H S	Total
		Number of Stations	33	40	54	38	31	26	62	13	15	312
Species Cluster	Common Name	Scientific Name										
	ringed doris	*Diaulula sandiegensis*	-	-	-	-	-	8	-	-	6	14
	festive murex	*Pteropurpura festiva*	-	-	1	-	-	6	1	-	16	24
	black croaker	*Cheilotrema saturnum*	-	-	-	-	-	6	33	-	20	59
	sea squirt	*Ciona* sp	-	1	-	-	-	10	-	-	5	16
	scaly tunicate	*Microcosmus squamiger*	-	-	-	-	26	98	-	-	378	502
	"oyster"	*Ostrea* sp	-	-	-	-	-	8	-	-	158	166
A	cobblestone sea squirt	*Styela plicata*	-	-	-	-	-	2	-	-	38	40
	diamond turbot	*Pleuronichthys guttulatus*	-	-	-	-	8	62	6	-	16	92
	California bubble	*Bulla gouldiana*	-	-	-	-	26	544	-	-	136	706
	mat mussel	*Musculista senhousia*	-	-	-	-	-	32	2	-	998	1032
	spotted sand bass	*Paralabrax maculatofasciatus*	-	-	-	-	2	4	2	-	125	133
	round stingray	*Urolophus halleri*	-	-	-	-	-	6	27	-	168	201
	Pacific calico scallop	*Argopecten ventricosus*	-	-	-	-	10	6	-	-	26	42
	northern anchovy	*Engraulis mordax*	1	-	17	4	-	2554	529	-	-	3105
	Pacific sardine	*Sardinops sagax*	-	-	1	1	-	232	85	-	-	319
	white croaker	*Genyonemus lineatus*	1	-	351	173	840	2222	13782	69	4	17442
	queenfish	*Seriphus politus*	-	-	78	22	34	202	3516	2	-	3854
	blackspotted bay shrimp	*Crangon nigromaculata*	-	-	8	3	4	582	346	-	-	943
	tuberculate pear crab	*Pyromaia tuberculata*	-	-	5	9	47	1034	694	4	2	1795
	bat ray	*Myliobatis californica*	-	-	-	-	6	16	6	2	-	30
	yellowleg shrimp	*Farfantepenaeus californiensis*	-	-	-	1	52	164	237	1	3	458
	barred sand bass	*Paralabrax nebulifer*	-	-	1	15	79	186	54	2	103	440
B	California halibut	*Paralichthys californicus*	-	-	24	40	47	127	148	9	79	474
	spotted turbot	*Pleuronichthys ritteri*	-	-	11	3	10	44	58	-	20	146
	spiny sand star	*Astropecten armatus*	-	1	2	-	1	11	61	22	-	98
	California aglaja	*Navanax inermis*	-	2	-	-	23	38	1	-	2	66
	New Zealand paper bubble	*Philine auriformis*	9	165	272	103	32	424	184	1	-	1190
	specklefin midshipman	*Porichthys myriaster*	-	2	34	20	8	66	64	-	2	196
	Mediterranean mussel	*Mytilus galloprovincialis*	-	-	-	-	6	354	-	-	-	360
	longstalk sea squirt	*Styela montereyensis*	-	-	-	-	-	52	1	-	5	58
	sea squirt	*Styela* sp	-	-	-	2	6	78	2	-	12	100
	yellow-green sea squirt	*Ciona intestinalis*	-	-	-	-	10	246	-	-	2	258
	shiner perch	*Cymatogaster aggregata*	-	-	-	47	103	142	112	1	-	405
	white seaperch	*Phanerodon furcatus*	-	-	2	1	123	98	78	-	-	302
	black perch	*Embiotoca jacksoni*	-	-	-	-	31	-	3	-	-	34
	yellow rock crab	*Cancer anthonyi*	1	-	1	-	49	-	8	-	-	59
	northern kelp crab	*Pugettia producta*	-	-	-	-	20	4	1	-	-	25
	walleye surfperch	*Hyperprosopon argenteum*	-	-	-	-	-	-	77	-	-	77
	yellowfin croaker	*Umbrina roncador*	-	-	-	-	-	36	17	-	-	53
	golden gorgonian	*Muricea* cf. *californica*	-	-	-	2	-	-	8	-	-	10
	California corbina	*Menticirrhus undulatus*	-	-	-	-	-	-	37	-	-	37
	cutlassfish	*Trichiurus lepturus*	-	-	-	1	4	-	16	-	-	21
	thornback	*Platyrhinoidis triseriata*	-	-	1	-	1	-	18	-	-	20
	shovelnose guitarfish	*Rhinobatos productus*	-	-	-	-	-	-	13	-	2	15
C	deepbody anchovy	*Anchoa compressa*	-	-	-	-	464	14	42	-	-	520
	spotfin croaker	*Roncador stearnsii*	-	-	-	-	66	6	1	-	-	73
	California spiny lobster	*Panulirus interruptus*	-	-	-	-	9	12	3	-	-	24
	slough anchovy	*Anchoa delicatissima*	-	-	-	-	-	64	45	-	-	109
	barcheek pipefish	*Syngnathus exilis*	1	-	-	-	-	1	10	-	-	12
	rock crab	*Cancer* sp	-	-	1	-	6	-	10	-	-	17
	blueleg mantis shrimp	*Hemisquilla ensigera californiensis*	-	1	8	6	-	-	-	-	-	15
	Kellet whelk	*Kelletia kelletii*	1	3	16	-	-	-	2	-	-	22
	globose sand crab	*Randallia ornata*	-	-	3	-	1	-	6	-	-	10
	tower snail	*Megasurcula carpenteriana*	5	1	75	3	5	-	-	-	-	89
	digger hermit	*Paguristes bakeri*	1	-	14	1	-	-	-	-	-	16
	lumptail searobin	*Prionotus stephanophrys*	3	-	40	-	-	-	-	-	-	43
	Alaska bay shrimp	*Crangon alaskensis*	-	-	12	-	14	-	-	-	-	26

Appendix E9 (continued)

Species Cluster	Common Name	Scientific Name	Site Cluster 1: Outer Shelf	2: Outer / Middle Shelf Island	3: Middle Shelf	4: Middle Shelf C/S	5: Middle/ Inner Shelf B&H Island	6: B&H C Ports Marinas	7: Inner Shelf B&H Rivers	8: Inner Shelf N	9: B&H S	Total
		Number of Stations	33	40	54	38	31	26	62	13	15	312
	polished mantis shrimp	*Schmittius politus*	-	1	17	1	-	-	-	-	-	19
	sheep crab	*Loxorhynchus grandis*	1	-	7	-	1	-	14	-	-	23
	spotwrist hermit	*Pagurus spilocarpus*	-	-	9	1	-	4	4	-	-	18
	shortspined sea star	*Pisaster brevispinus*	-	-	10	-	1	4	-	-	-	15
	armed box crab	*Platymera gaudichaudii*	-	7	13	3	-	-	-	-	-	23
	California armina	*Armina californica*	-	5	4	-	1	3	-	-	-	13
	sandflat elbow crab	*Heterocrypta occidentalis*	-	-	1	4	19	2	11	2	-	39
	Pacific purple sea urchin	*Strongylocentrotus purpuratus*	-	1	-	-	4	4	3	-	-	12
	fat western nassa	*Nassarius perpinguis*	-	-	-	-	-	-	20	-	-	20
	Pacific pompano	*Peprilus simillimus*	-	-	-	-	-	6	26	-	-	32
	moss crab	*Loxorhynchus crispatus*	-	2	3	-	8	-	-	-	-	13
C	California king crab	*Paralithodes californiensis*	1	6	-	-	17	-	-	-	-	24
	spot shrimp	*Pandalus platyceros*	35	1	2	-	2	-	-	-	-	40
	blossom shrimp	*Solenocera mutator*	153	2	5	-	-	-	-	-	-	160
	Eastern Pacific bobtail	*Rossia pacifica*	11	-	16	6	1	-	-	-	-	34
	gulf sanddab	*Citharichthys fragilis*	49	11	83	5	8	-	-	-	-	156
	kelp bass	*Paralabrax clathratus*	-	-	-	1	17	-	1	-	-	19
	California cone	*Conus californicus*	-	-	1	-	14	4	-	-	-	19
	warty sea cucumber	*Parastichopus parvimensis*	1	-	-	-	28	4	-	-	-	33
	Hemphill neck crab	*Podochela hemphillii*	-	1	3	4	20	-	1	-	-	29
	purple sea hare	*Aplysia californica*	1	-	-	-	13	-	-	-	-	14
	Xantus swimming crab	*Portunus xantusii*	-	-	3	-	10	23	16	-	-	52
	giant frond-aeolis	*Dendronotus iris*	-	5	-	-	1	6	-	-	-	12
	"isopod"	*Nerocila acuminata*	1	10	-	-	4	4	-	-	-	19
	curlfin sole	*Pleuronichthys decurrens*	-	59	1	-	-	-	-	-	-	60
	fringed sand star	*Luidia asthenosoma*	5	39	7	7	-	-	-	-	-	58
	seapen spindle snail	*Neosimnia barbarensis*	4	10	1	1	-	-	2	-	-	18
	thinbeak neck crab	*Podochela lobifrons*	2	12	2	4	2	-	-	-	-	22
	rosy tritonia	*Tritonia diomedea*	2	7	1	-	1	-	-	-	-	11
	slenderclaw hermit	*Paguristes turgidus*	59	23	5	-	-	-	-	-	-	87
	bat star	*Asterina miniata*	-	36	-	3	56	4	-	-	-	99
	fleshy sea pen	*Ptilosarcus gurneyi*	9	25	-	-	-	-	-	-	-	34
	roughback sculpin	*Chitonotus pugetensis*	-	61	16	-	41	-	-	-	-	118
	halfbanded rockfish	*Sebastes semicinctus*	59	102	-	-	-	-	-	-	-	161
	blackeye goby	*Coryphopterus nicholsii*	-	17	-	-	4	-	1	-	-	22
	basket star	*Gorgonocephalus eucnemis*	7	227	-	-	-	-	-	-	-	234
	"brittlestar"	*Ophiacantha* sp	-	18	-	1	-	-	-	-	-	19
	roughspine brittlestar	*Ophiopholis bakeri*	4	394	-	-	2	-	-	-	-	400
	California lamp shell	*Laqueus californianus*	-	13013	-	-	-	-	-	-	-	13013
D	banded sea star	*Sclerasterias heteropaes*	-	10	-	-	1	-	-	-	-	11
	California heart urchin	*Spatangus californicus*	267	33	-	-	-	-	-	-	-	300
	orange sand star	*Astropecten ornatissimus*	40	746	1	-	-	-	-	-	-	787
	spotfin sculpin	*Icelinus tenuis*	3	293	1	-	-	-	-	-	-	297
	red sea star	*Mediaster aequalis*	4	176	5	1	-	-	-	-	-	186
	bluespotted poacher	*Xeneretmus triacanthus*	7	25			-	-	-	-	-	32
	slender sole	*Lyopsetta exilis*	2457	432	57	3	-	-	-	-	-	2949
	fragile sea urchin	*Allocentrotus fragilis*	2651	2037	2	-	-	-	-	-	-	4690
	spotted cusk-eel	*Chilara taylori*	22	51	2	-	-	-	-	-	-	75
	rex sole	*Glyptocephalus zachirus*	61	6	-	-	-	-	-	-	-	67
	blackbelly eelpout	*Lycodes pacificus*	260	43	13	-	1	-	-	-	-	317
	Pacific hake	*Merluccius productus*	35	3	-	-	-	-	-	-	-	38
	greenstriped rockfish	*Sebastes elongatus*	15	23	1	1	-	-	-	-	-	40
	pink rockfish	*Sebastes eos*	9	1	10	-	-	-	-	-	-	20
	greenblotched rockfish	*Sebastes rosenblatti*	9	30	12	-	-	-	-	-	-	51
	spotted ratfish	*Hydrolagus colliei*	5	12	1	-	-	-	-	-	-	18
	bluebarred prickleback	*Plectobranchus evides*	18	-	-	-	-	-	-	-	-	18
	pelagic red crab	*Pleuroncodes planipes*	100	4	1	-	2	-	-	-	-	107

Appendix E9 (continued)

Species Cluster	Common Name	Scientific Name	1 Outer Shelf	2 Outer / Middle Shelf Island	3 Middle Shelf	4 Middle Shelf C/S	5 Middle/ Inner Shelf B&H Island	6 B&H C Ports Marinas	7 Inner Shelf B&H Rivers	8 Inner Shelf N	9 B&H S	Total
		Number of Stations	33	40	54	38	31	26	62	13	15	312
E	Pacific spiny brittlestar	*Ophiothrix spiculata*	16	631	441	14	43	6	-	-	-	1151
	vermilion rockfish	*Sebastes miniatus*	-	3	7	-	-	-	-	-	-	10
	copper rockfish	*Sebastes caurinus*	2	1	3	-	4	-	-	-	-	10
	mosaic sand star	*Luidia armata*	2	2	60	61	7	-	-	-	-	132
	slender sea pen	*Stylatula elongata*	4	38	97	23	-	3	-	1	-	166
	California blade barnacle	*Hamatoscalpellum californicum*	88	65	147	443	12	-	2	-	-	757
	yellow sea twig	*Thesea* sp B	11	14	60	209	2	-	-	-	-	296
	"gorgonian"	*Heterogorgia tortuosa*	-	-	7	205	-	-	-	-	-	212
F	bigmouth sole	*Hippoglossina stomata*	10	69	166	91	52	-	8	-	-	396
	California sand star	*Astropecten verrilli*	64	135	525	803	363	7	52	10	-	1959
	California lizardfish	*Synodus lucioceps*	10	26	1827	2608	574	79	295	152	2	5573
	longfin sanddab	*Citharichthys xanthostigma*	25	122	1870	1258	273	-	25	6	-	3579
	hornyhead turbot	*Pleuronichthys verticalis*	3	17	147	75	57	-	85	9	-	393
	California tonguefish	*Symphurus atricaudus*	7	8	674	402	190	152	416	11	2	1862
	fantail sole	*Xystreurys liolepis*	-	-	26	18	22	12	31	1	-	110
	speckled sanddab	*Citharichthys stigmaeus*	-	286	182	45	305	38	181	68	-	1105
	California skate	*Raja inornata*	4	-	19	11	3	-	7	-	-	44
	California scorpionfish	*Scorpaena guttata*	2	11	32	51	10	2	8	-	-	116
G	yellowchin sculpin	*Icelinus quadriseriatus*	103	563	858	139	82	-	2	-	-	1747
	pink seaperch	*Zalembius rosaceus*	18	113	285	117	5	-	-	-	-	538
	longspine combfish	*Zaniolepis latipinnis*	115	96	512	25	11	-	-	-	-	759
	white sea urchin	*Lytechinus pictus*	7757	41175	13209	6695	1907	-	13	1	-	70757
	California sea cucumber	*Parastichopus californicus*	134	319	355	57	59	24	1	-	-	949
	bay goby	*Lepidogobius lepidus*	15	404	55	1	2	-	3	-	-	480
	Pacific argentine	*Argentina sialis*	17	237	107	-	-	-	-	-	-	361
	California market squid	*Loligo opalescens*	18	11	27	7	6	2	2	-	4	77
	red octopus	*Octopus rubescens*	20	22	34	4	3	-	-	-	-	83
	gray sand star	*Luidia foliolata*	167	125	28	27	7	-	-	1	-	355
	California sea slug	*Pleurobranchaea californica*	62	43	62	3	10	-	-	-	-	180
	Dover sole	*Microstomus pacificus*	706	567	355	7	-	-	-	-	-	1635
	plainfin midshipman	*Porichthys notatus*	349	353	740	8	6	2	-	-	-	1458
	Pacific sanddab	*Citharichthys sordidus*	1231	3687	1136	108	286	-	1	1	-	6450
	shortspine combfish	*Zaniolepis frenata*	309	460	4	-	1	-	-	-	-	774
	brokenspine brittlestar	*Ophiura luetkenii*	40	257	51	6	2	-	-	-	-	356
	trailtip sea pen	*Acanthoptilum* sp	207	554	55	33	2	2	-	-	-	853
	English sole	*Parophrys vetulus*	161	26	146	31	9	-	20	4	-	397
	stripetail rockfish	*Sebastes saxicola*	366	125	326	5	-	-	-	-	-	822
	ridgeback rock shrimp	*Sicyonia ingentis*	14794	2242	2960	1129	91	-	5	-	-	21221
H	bearded eelpout	*Lyconema barbatum*	23	-	-	-	-	-	-	-	-	23
	Pacific heart urchin	*Brissopsis pacifica*	16	-	-	-	-	-	-	-	-	16
	orange bigeye octopus	*Octopus californicus*	9	3	-	-	-	-	-	-	-	12
	flagnose bay shrimp	*Neocrangon resima*	93	-	-	-	-	-	-	-	-	93
	mustache bay shrimp	*Neocrangon zacae*	590	3	-	-	-	-	-	-	-	593
	blacktip poacher	*Xeneretmus latifrons*	258	1	-	-	-	-	-	-	-	259
	northern heart urchin	*Brisaster latifrons*	233	-	-	-	-	-	-	-	-	233
	southern spinyhead	*Metacrangon spinosissima*	24	-	-	-	-	-	-	-	-	24
	slender blade shrimp	*Spirontocaris holmesi*	51	-	-	-	-	-	-	-	-	51
	hinged shrimp	*Pantomus affinis*	1087	2	22	-	-	-	-	-	-	1111
	splitnose rockfish	*Sebastes diploproa*	192	-	-	-	-	-	-	-	-	192

Appendix E10. Frequency of occurrence (number of stations) of demersal fish and megabenthic invertebrate species in each site cluster on the southern California shelf at depths of 2-202 m, July-September 1998. (B&H = Bays and Harbors; N = North; C = Central; S = South)

Species Cluster	Common Name	Scientific Name	Site Cluster 1 Outer Shelf	2 Outer / Middle Shelf Island	3 Middle Shelf	4 Middle Shelf C/S	5 Middle/ Inner Shelf B&H Island	6 B&H C Ports Marinas	7 Inner Shelf B&H Rivers	8 Inner Shelf N	9 B&H S	Total
		Number of Stations	33	40	54	38	31	26	62	13	15	312
A	ringed doris	*Diaulula sandiegensis*	-	-	-	-	-	3	-	-	2	5
A	festive murex	*Pteropurpura festiva*	-	-	1	-	-	2	1	-	3	7
A	black croaker	*Cheilotrema saturnum*	-	-	-	-	-	2	4	-	4	10
A	sea squirt	*Ciona* sp	-	1	-	-	-	3	-	-	2	6
A	scaly tunicate	*Microcosmus squamiger*	-	-	-	-	2	4	-	-	6	12
A	"oyster"	*Ostrea* sp	-	-	-	-	-	2	-	-	4	6
A	cobblestone sea squirt	*Styela plicata*	-	-	-	-	-	1	-	-	4	5
A	diamond turbot	*Pleuronichthys guttulatus*	-	-	-	-	3	7	5	-	7	22
A	California bubble	*Bulla gouldiana*	-	-	-	-	2	2	-	-	4	8
A	mat mussel	*Musculista senhousia*	-	-	-	-	-	3	1	-	12	16
A	spotted sand bass	*Paralabrax maculatofasciatus*	-	-	-	-	1	1	1	-	15	18
A	round stingray	*Urolophus halleri*	-	-	-	-	-	3	5	-	9	17
A	Pacific calico scallop	*Argopecten ventricosus*	-	-	-	-	3	3	-	-	8	14
B	northern anchovy	*Engraulis mordax*	1	-	3	1	-	5	25	-	-	35
B	Pacific sardine	*Sardinops sagax*	-	-	1	1	-	3	13	-	-	18
B	white croaker	*Genyonemus lineatus*	1	-	10	6	8	13	51	1	1	91
B	queenfish	*Seriphus politus*	-	-	4	1	4	8	43	2	-	62
B	blackspotted bay shrimp	*Crangon nigromaculata*	-	-	3	2	2	5	38	-	-	50
B	tuberculate pear crab	*Pyromaia tuberculata*	-	-	5	7	8	14	28	4	1	67
B	bat ray	*Myliobatis californica*	-	-	-	-	2	4	5	2	-	13
B	yellowleg shrimp	*Farfantepenaeus californiensis*	-	-	-	1	4	12	23	1	2	43
B	barred sand bass	*Paralabrax nebulifer*	-	-	1	4	9	15	22	1	14	66
B	California halibut	*Paralichthys californicus*	-	-	16	19	10	19	38	7	11	120
B	spotted turbot	*Pleuronichthys ritteri*	-	-	3	1	2	8	21	-	5	40
B	spiny sand star	*Astropecten armatus*	-	1	1	-	1	5	21	5	-	34
B	California aglaja	*Navanax inermis*	-	1	-	-	6	12	1	-	1	21
B	New Zealand paper bubble	*Philine auriformis*	6	17	25	16	10	8	8	1	-	91
B	specklefin midshipman	*Porichthys myriaster*	-	2	11	10	5	7	17	-	1	53
B	Mediterranean mussel	*Mytilus galloprovincialis*	-	-	-	-	1	10	-	-	-	11
B	longstalk sea squirt	*Styela montereyensis*	-	-	-	-	-	7	1	-	2	10
B	sea squirt	*Styela* sp	-	-	-	2	1	8	1	-	1	13
B	yellow-green sea squirt	*Ciona intestinalis*	-	-	-	-	1	8	-	-	1	10
C	shiner perch	*Cymatogaster aggregata*	-	-	-	2	6	5	16	1	-	30
C	white seaperch	*Phanerodon furcatus*	-	-	1	1	6	11	19	-	-	38
C	black perch	*Embiotoca jacksoni*	-	-	-	-	5	-	2	-	-	7
C	yellow rock crab	*Cancer anthonyi*	1	-	1	-	3	-	5	-	-	10
C	northern kelp crab	*Pugettia producta*	-	-	-	-	7	2	1	-	-	10
C	walleye surfperch	*Hyperprosopon argenteum*	-	-	-	-	-	-	9	-	-	9
C	yellowfin croaker	*Umbrina roncador*	-	-	-	-	-	4	4	-	-	8
C	golden gorgonian	*Muricea* cf. *californica*	-	-	-	2	-	-	4	-	-	6
C	California corbina	*Menticirrhus undulatus*	-	-	-	-	-	-	17	-	-	17
C	cutlassfish	*Trichiurus lepturus*	-	-	-	1	1	-	6	-	-	8
C	thornback	*Platyrhinoidis triseriata*	-	-	1	-	1	-	13	-	-	15
C	shovelnose guitarfish	*Rhinobatos productus*	-	-	-	-	-	-	8	-	1	9
C	deepbody anchovy	*Anchoa compressa*	-	-	-	-	3	4	6	-	-	13
C	spotfin croaker	*Roncador stearnsii*	-	-	-	-	3	1	1	-	-	5
C	California spiny lobster	*Panulirus interruptus*	-	-	-	-	2	2	3	-	-	7
C	slough anchovy	*Anchoa delicatissima*	-	-	-	-	-	7	1	-	-	8
C	barcheek pipefish	*Syngnathus exilis*	1	-	-	-	-	1	5	-	-	7
C	rock crab	*Cancer* sp	-	-	1	-	2	-	3	-	-	6
C	blueleg mantis shrimp	*Hemisquilla ensigera californiensis*	-	1	7	6	-	-	-	-	-	14
C	Kellet whelk	*Kelletia kelletii*	1	1	6	-	-	-	2	-	-	10
C	globose sand crab	*Randallia ornata*	-	-	3	-	1	-	6	-	-	10
C	tower snail	*Megasurcula carpenteriana*	4	1	11	3	3	-	-	-	-	22
C	digger hermit	*Paguristes bakeri*	1	-	9	1	-	-	-	-	-	11
C	lumptail searobin	*Prionotus stephanophrys*	2	-	13	-	-	-	-	-	-	15
C	Alaska bay shrimp	*Crangon alaskensis*	-	-	6	-	1	-	-	-	-	7
C	polished mantis shrimp	*Schmittius politus*	-	1	9	1	-	-	-	-	-	11
C	sheep crab	*Loxorhynchus grandis*	1	-	7	-	1	-	7	-	-	16

Species Cluster	Common Name	Scientific Name	Site Cluster 1 Outer Shelf	2 Outer / Middle Shelf Island	3 Middle Shelf	4 Middle Shelf C/S	5 Middle/ Inner Shelf B&H Island	6 B&H C Ports Marinas	7 Inner Shelf B&H Rivers	8 Inner Shelf N	9 B&H S	Total
		Number of Stations	33	40	54	38	31	26	62	13	15	312
C	fat western nassa	*Nassarius perpinguis*	-	-	-	-	-	-	7	-	-	7
	Pacific pompano	*Peprilus simillimus*	-	-	-	-	-	1	11	-	-	12
	moss crab	*Loxorhynchus crispatus*	-	2	1	-	4	-	-	-	-	7
	California king crab	*Paralithodes californiensis*	1	4	-	-	1	-	-	-	-	6
	spot shrimp	*Pandalus platyceros*	3	1	2	-	2	-	-	-	-	8
	blossom shrimp	*Solenocera mutator*	3	2	4	-	-	-	-	-	-	9
	Eastern Pacific bobtail	*Rossia pacifica*	6	-	10	4	1	-	-	-	-	21
	gulf sanddab	*Citharichthys fragilis*	8	6	15	2	1	-	-	-	-	32
	kelp bass	*Paralabrax clathratus*	-	-	-	1	6	-	1	-	-	8
	California cone	*Conus californicus*	-	-	1	-	3	2	-	-	-	6
	warty sea cucumber	*Parastichopus parvimensis*	1	-	-	-	5	2	-	-	-	8
	Hemphill neck crab	*Podochela hemphillii*	-	1	2	3	7	-	1	-	-	14
	purple sea hare	*Aplysia californica*	1	-	-	-	7	-	-	-	-	8
	Xantus swimming crab	*Portunus xantusii*	-	-	2	-	3	4	9	-	-	18
D	giant frond-aeolis	*Dendronotus iris*	-	2	-	-	1	2	-	-	-	5
	"isopod"	*Nerocila acuminata*	1	3	-	-	1	2	-	-	-	7
	curlfin sole	*Pleuronichthys decurrens*	-	10	1	-	-	-	-	-	-	11
	fringed sand star	*Luidia asthenosoma*	3	6	6	4	-	-		-	-	19
	seapen spindle snail	*Neosimnia barbarensis*	4	6	1	1	-	-	1	-	-	13
	thinbeak neck crab	*Podochela lobifrons*	1	5	2	4	2	-	-	-	-	14
	rosy tritonia	*Tritonia diomedea*	2	6	1	-	1	-	-	-	-	10
	slenderclaw hermit	*Paguristes turgidus*	2	8	4	-		-	-	-	-	14
	bat star	*Asterina miniata*	-	4	-	3	2	2	-	-	-	11
	fleshy sea pen	*Ptilosarcus gurneyi*	4	8	-	-	-	-	-	-	-	12
	roughback sculpin	*Chitonotus pugetensis*	-	13	10	-	3	-	-	-	-	26
	halfbanded rockfish	*Sebastes semicinctus*	10	8	-	-	-	-	-	-	-	18
	blackeye goby	*Coryphopterus nicholsii*	-	4	-	-	1	-	1	-	-	6
	basket star	*Gorgonocephalus eucnemis*	2	8	-	-	-	-	-	-	-	10
	"brittlestar"	*Ophiacantha* sp	-	9	-	1	-	-	-	-	-	10
	roughspine brittlestar	*Ophiopholis bakeri*	2	11	-	-	1	-	-	-	-	14
	California lamp shell	*Laqueus californianus*	-	8	-	-	-	-	-	-	-	8
	banded sea star	*Sclerasterias heteropaes*	-	5	-	-	1	-	-	-	-	6
	California heart urchin	*Spatangus californicus*	14	5	-	-	-	-	-	-	-	19
	orange sand star	*Astropecten ornatissimus*	7	13	1	-	-	-	-	-	-	21
	spotfin sculpin	*Icelinus tenuis*	2	21	1	-	-	-	-	-	-	24
	red sea star	*Mediaster aequalis*	4	23	3	1	-	-	-	-	-	31
	bluespotted poacher	*Xeneretmus triacanthus*	4	8	-	-	-	-	-	-	-	12
	slender sole	*Lyopsetta exilis*	30	16	4	1	-	-	-	-	-	51
	fragile sea urchin	*Allocentrotus fragilis*	20	15	1	-	-	-	-	-	-	36
	spotted cusk-eel	*Chilara taylori*	7	15	2	-	-	-	-	-	-	24
	rex sole	*Glyptocephalus zachirus*	13	4	-	-	-	-	-	-	-	17
	blackbelly eelpout	*Lycodes pacificus*	16	4	3	-	1	-	-	-	-	24
	Pacific hake	*Merluccius productus*	10	3	-	-	-	-	-	-	-	13
	greenstriped rockfish	*Sebastes elongatus*	7	6	1	1	-	-	-	-	-	15
	pink rockfish	*Sebastes eos*	8	1	6	-	-	-	-	-	-	15
	greenblotched rockfish	*Sebastes rosenblatti*	7	9	5	-	-	-	-	-	-	21
	spotted ratfish	*Hydrolagus colliei*	5	2	1	-	-	-	-	-	-	8
	bluebarred prickleback	*Plectobranchus evides*	9	-	-	-	-	-	-	-	-	9
	pelagic red crab	*Pleuroncodes planipes*	7	3	1	-	1	-	-	-	-	12
	gigantic anemone	*Metridium farcimen*	8	2	4	-	1	-	-	-	-	15
	greenspotted rockfish	*Sebastes chlorostictus*	6	5	3	-	-	-	-	-	-	14
E	"aeolis"	*Dendronotus* sp	2	-	2	3	1	-	-	-	-	8
	Santa Barbara spindle	*Fusinus barbarensis*	5	3	2	-		-	-	-	-	10
	spanish shawl	*Flabellina iodinea*	-	-	2	-	3	-	-	-	-	5
	pygmy poacher	*Odontopyxis trispinosa*	1	4	12	1	1	-	-	-	-	19
	Pacific spiny brittlestar	*Ophiothrix spiculata*	6	10	16	7	6	2	-	-	-	47
	vermilion rockfish	*Sebastes miniatus*	-	2	6	-	-	-	-	-	-	8
	copper rockfish	*Sebastes caurinus*	2	1	2	-	2	-	-	-	-	7
	mosaic sand star	*Luidia armata*	2	2	14	17	3	-	-	-	-	38
	slender sea pen	*Stylatula elongata*	3	3	13	8	-	1	-	1	-	29
	California blade barnacle	*Hamatoscalpellum californicum*	9	9	14	19	2	-	1	-	-	54

Appendix E10 (continued)

Species Cluster	Common Name	Scientific Name	Site Cluster 1 Outer Shelf	2 Outer / Middle Shelf Island	3 Middle Shelf	4 Middle Shelf C/S	5 Middle/ Inner Shelf B&H Island	6 B&H C Ports Marinas	7 Inner Shelf B&H Rivers	8 Inner Shelf N	9 B&H S	Total
		Number of Stations	33	40	54	38	31	26	62	13	15	312
E	yellow sea twig	*Thesea* sp B	6	10	19	18	2	-	-	-	-	55
	"gorgonian"	*Heterogorgia tortuosa*	-	-	3	10	-	-	-	-	-	13
F	bigmouth sole	*Hippoglossina stomata*	7	22	45	30	9	-	2	-	-	115
	California sand star	*Astropecten verrilli*	15	18	45	38	14	1	10	4	-	145
	California lizardfish	*Synodus lucioceps*	4	7	50	33	19	10	33	10	1	167
	longfin sanddab	*Citharichthys xanthostigma*	3	4	45	36	10	-	8	3	-	109
	hornyhead turbot	*Pleuronichthys verticalis*	3	9	39	26	12	-	19	4	-	112
	California tonguefish	*Symphurus atricaudus*	2	2	45	32	16	8	28	6	1	140
	fantail sole	*Xystreurys liolepis*	-	-	15	12	10	6	16	1	-	60
	speckled sanddab	*Citharichthys stigmaeus*	-	5	16	11	17	2	20	12	-	83
	California skate	*Raja inornata*	4	-	13	11	2	-	4	-	-	34
	California scorpionfish	*Scorpaena guttata*	2	8	14	19	5	1	3	-	-	52
G	yellowchin sculpin	*Icelinus quadriseriatus*	6	12	44	20	6	-	1	-	-	89
	pink seaperch	*Zalembius rosaceus*	14	25	34	9	2	-	-	-	-	84
	longspine combfish	*Zaniolepis latipinnis*	15	11	33	5	2	-	-	-	-	66
	white sea urchin	*Lytechinus pictus*	14	27	29	17	11	-	4	1	-	103
	California sea cucumber	*Parastichopus californicus*	21	17	21	15	7	3	1	-	-	85
	bay goby	*Lepidogobius lepidus*	2	9	15	1	2	-	3	-	-	32
	Pacific argentine	*Argentina sialis*	7	13	7	-	-	-	-	-	-	27
	California market squid	*Loligo opalescens*	7	8	10	5	3	1	1	-	1	36
	red octopus	*Octopus rubescens*	11	12	15	4	3	-	-	-	-	45
	gray sand star	*Luidia foliolata*	21	19	11	10	2	-	-	1	-	64
	California sea slug	*Pleurobranchaea californica*	20	13	9	1	4	-	-	-	-	47
	Dover sole	*Microstomus pacificus*	31	31	15	1	-	-	-	-	-	78
	plainfin midshipman	*Porichthys notatus*	29	24	25	3	3	1			-	85
	Pacific sanddab	*Citharichthys sordidus*	31	39	34	13	6	-	1	1	-	125
	shortspine combfish	*Zaniolepis frenata*	27	28	2	-	1	-	-	-	-	58
	brokenspine brittlestar	*Ophiura luetkenii*	10	13	10	4	1	-	-	-	-	38
	trailtip sea pen	*Acanthoptilum* sp	14	21	13	8	1	1	-	-	-	58
	English sole	*Parophrys vetulus*	21	12	23	10	5	-	6	4	-	81
	stripetail rockfish	*Sebastes saxicola*	27	19	23	1	-	-	-	-	-	70
	ridgeback rock shrimp	*Sicyonia ingentis*	31	21	44	16	7	-	3	-	-	122
H	bearded eelpout	*Lyconema barbatum*	6	-	-	-	-	-	-	-	-	6
	Pacific heart urchin	*Brissopsis pacifica*	5	-	-	-	-	-	-	-	-	5
	orange bigeye octopus	*Octopus californicus*	6	3	-	-	-	-	-	-	-	9
	flagnose bay shrimp	*Neocrangon resima*	12	-	-	-	-	-	-	-	-	12
	mustache bay shrimp	*Neocrangon zacae*	17	2	-	-	-	-	-	-	-	19
	blacktip poacher	*Xeneretmus latifrons*	17	1	-	-	-	-	-	-	-	18
	northern heart urchin	*Brisaster latifrons*	15	-	-	-	-	-	-	-	-	15
	sorthern spinyhead	*Metacrangon spinosissima*	6	-	-	-	-	-	-	-	-	6
	slender blade shrimp	*Spirontocaris holmesi*	5	-	-	-	-	-	-	-	-	5
	hinged shrimp	*Pantomus affinis*	9	1	2	-	-	-	-	-	-	12
	splitnose rockfish	*Sebastes diploproa*	12	-	-	-	-	-	-	-	-	12

Appendix E11. Frequency of occurrence (percent of stations) of demersal fish and megabenthic invertebrate species in each site cluster on the southern California shelf at depths of 2-202 m, July-September 1998. (B&H = Bays and Harbors; N = North; C = Central; S = South)

			Site Cluster								
			1	2	3	4	5	6	7	8	9
			Outer Shelf	Outer / Middle Shelf Island	Middle Shelf	Middle Shelf C/S	Middle/ Inner Shelf B&H Island	B&H C Ports Marinas	Inner Shelf B&H Rivers	Inner Shelf N	B&H S
		Number of Stations	33	40	54	38	31	26	62	13	15
Species Cluster	Common Name	Scientific Name									
	ringed doris	*Diaulula sandiegensis*	-	-	-	-	-	12	-	-	13
	festive murex	*Pteropurpura festiva*	-	-	2	-	-	8	2	-	20
	black croaker	*Cheilotrema saturnum*	-	-	-	-	-	8	6	-	27
	sea squirt	*Ciona* sp	-	3	-	-	-	12	-	-	13
	scaly tunicate	*Microcosmus squamiger*	-	-	-	-	6	15	-	-	40
	"oyster"	*Ostrea* sp	-	-	-	-	-	8	-	-	27
A	cobblestone sea squirt	*Styela plicata*	-	-	-	-	-	4	-	-	27
	diamond turbot	*Pleuronichthys guttulatus*	-	-	-	-	10	27	8	-	47
	California bubble	*Bulla gouldiana*	-	-	-	-	6	8	-	-	27
	mat mussel	*Musculista senhousia*	-	-	-	-	-	12	2	-	80
	spotted sand bass	*Paralabrax maculatofasciatus*	-	-	-	-	3	4	2	-	100
	round stingray	*Urolophus halleri*	-	-	-	-	-	12	8	-	60
	Pacific calico scallop	*Argopecten ventricosus*	-	-	-	-	10	12	-	-	53
	northern anchovy	*Engraulis mordax*	3	-	6	3	-	19	40	-	-
	Pacific sardine	*Sardinops sagax*	-	-	2	3	-	12	21	-	-
	white croaker	*Genyonemus lineatus*	3	-	19	16	26	50	82	8	7
	queenfish	*Seriphus politus*	-	-	7	3	13	31	69	15	-
	blackspotted bay shrimp	*Crangon nigromaculata*	-	-	6	5	6	19	61	-	-
	tuberculate pear crab	*Pyromaia tuberculata*	-	-	9	18	26	54	45	31	7
	bat ray	*Myliobatis californica*	-	-	-	-	6	15	8	15	-
	yellowleg shrimp	*Farfantepenaeus californiensis*	-	-	-	3	13	46	37	8	13
	barred sand bass	*Paralabrax nebulifer*	-	-	2	11	29	58	35	8	93
B	California halibut	*Paralichthys californicus*	-	-	30	50	32	73	61	54	73
	spotted turbot	*Pleuronichthys ritteri*	-	-	6	3	6	31	34	-	33
	spiny sand star	*Astropecten armatus*	-	3	2	-	3	19	34	38	-
	California aglaja	*Navanax inermis*	-	3	-	-	19	46	2	-	7
	New Zealand paper bubble	*Philine auriformis*	18	43	46	42	32	31	13	8	-
	specklefin midshipman	*Porichthys myriaster*	-	5	20	26	16	27	27	-	7
	Mediterranean mussel	*Mytilus galloprovincialis*	-	-	-	-	3	38	-	-	-
	longstalk sea squirt	*Styela montereyensis*	-	-	-	-	-	27	2	-	13
	sea squirt	*Styela* sp	-	-	-	5	3	31	2	-	7
	yellow-green sea squirt	*Ciona intestinalis*	-	-	-	-	3	31	-	-	7
	shiner perch	*Cymatogaster aggregata*	-	-	-	5	19	19	26	8	-
	white seaperch	*Phanerodon furcatus*	-	-	2	3	19	42	31	-	-
	black perch	*Embiotoca jacksoni*	-	-	-	-	16	-	3	-	-
	yellow rock crab	*Cancer anthonyi*	3	-	2	-	10	-	8	-	-
	northern kelp crab	*Pugettia producta*	-	-	-	-	23	8	2	-	-
	walleye surfperch	*Hyperprosopon argenteum*	-	-	-	-	-	-	15	-	-
	yellowfin croaker	*Umbrina roncador*	-	-	-	-	-	15	6	-	-
	golden gorgonian	*Muricea* cf. *californica*	-	-	-	5	-	-	6	-	-
	California corbina	*Menticirrhus undulatus*	-	-	-	-	-	-	27	-	-
	cutlassfish	*Trichiurus lepturus*	-	-	-	3	3	-	10	-	-
	thornback	*Platyrhinoidis triseriata*	-	-	2	-	3	-	21	-	-
	shovelnose guitarfish	*Rhinobatos productus*	-	-	-	-	-	-	13	-	7
C	deepbody anchovy	*Anchoa compressa*	-	-	-	-	10	15	10	-	-
	spotfin croaker	*Roncador stearnsii*	-	-	-	-	10	4	2	-	-
	California spiny lobster	*Panulirus interruptus*	-	-	-	-	6	8	5	-	-
	slough anchovy	*Anchoa delicatissima*	-	-	-	-	-	27	2	-	-
	barcheek pipefish	*Syngnathus exilis*	3	-	-	-	-	4	8	-	-
	rock crab	*Cancer* sp	-	-	2	-	6	-	5	-	-
	blueleg mantis shrimp	*Hemisquilla ensigera californiensis*	-	3	13	16	-	-	-	-	-
	Kellet whelk	*Kelletia kelletii*	3	3	11	-	-	-	3	-	-
	globose sand crab	*Randallia ornata*	-	-	6	-	3	-	10	-	-
	tower snail	*Megasurcula carpenteriana*	12	3	20	8	10	-	-	-	-
	digger hermit	*Paguristes bakeri*	3	-	17	3	-	-	-	-	-
	lumptail searobin	*Prionotus stephanophrys*	6	-	24	-	-	-	-	-	-
	Alaska bay shrimp	*Crangon alaskensis*	-	-	11	-	3	-	-	-	-

Appendix E11 (continued)

Species Cluster	Common Name	Scientific Name	1 Outer Shelf	2 Outer / Middle Shelf Island	3 Middle Shelf	4 Middle Shelf C/S	5 Middle/ Inner Shelf B&H Island	6 B&H C Ports Marinas	7 Inner Shelf B&H Rivers	8 Inner Shelf N	9 B&H S
		Number of Stations	33	40	54	38	31	26	62	13	15
C	polished mantis shrimp	*Schmittius politus*	-	3	17	3	-	-	-	-	-
	sheep crab	*Loxorhynchus grandis*	3	-	13	-	3	-	11	-	-
	spotwrist hermit	*Pagurus spilocarpus*	-	-	15	3	-	8	3	-	-
	shortspined sea star	*Pisaster brevispinus*	-	-	11	-	3	8	-	-	-
	armed box crab	*Platymera gaudichaudii*	-	13	15	5	-	-	-	-	-
	California armina	*Armina californica*	-	8	7	-	3	8	-	-	-
	sandflat elbow crab	*Heterocrypta occidentalis*	-	-	2	11	16	4	8	15	-
	Pacific purple sea urchin	*Strongylocentrotus purpuratus*	-	3	-	-	6	8	2	-	-
	fat western nassa	*Nassarius perpinguis*	-	-	-	-	-	-	11	-	-
	Pacific pompano	*Peprilus simillimus*	-	-	-	-	-	4	18	-	-
	moss crab	*Loxorhynchus crispatus*	-	5	2	-	13	-	-	-	-
	California king crab	*Paralithodes californiensis*	3	10	-	-	3	-	-	-	-
	spot shrimp	*Pandalus platyceros*	9	3	4	-	6	-	-	-	-
	blossom shrimp	*Solenocera mutator*	9	5	7	-	-	-	-	-	-
	Eastern Pacific bobtail	*Rossia pacifica*	18	-	19	11	3	-	-	-	-
	gulf sanddab	*Citharichthys fragilis*	24	15	28	5	3	-	-	-	-
	kelp bass	*Paralabrax clathratus*	-	-	-	3	19	-	2	-	-
	California cone	*Conus californicus*	-	-	2	-	10	8	-	-	-
	warty sea cucumber	*Parastichopus parvimensis*	3	-	-	-	16	8	-	-	-
	Hemphill neck crab	*Podochela hemphillii*	-	3	4	8	23	-	2	-	-
	purple sea hare	*Aplysia californica*	3	-	-	-	23	-	-	-	-
	Xantus swimming crab	*Portunus xantusii*	-	-	4	-	10	15	15	-	-
D	giant frond-aeolis	*Dendronotus iris*	-	5	-	-	3	8	-	-	-
	"isopod"	*Nerocila acuminata*	3	8	-	-	3	8	-	-	-
	curlfin sole	*Pleuronichthys decurrens*	-	25	2	-	-	-	-	-	-
	fringed sand star	*Luidia asthenosoma*	9	15	11	11	-	-	-	-	-
	seapen spindle snail	*Neosimnia barbarensis*	12	15	2	3	-	-	2	-	-
	thinbeak neck crab	*Podochela lobifrons*	3	13	4	11	6	-	-	-	-
	rosy tritonia	*Tritonia diomedea*	6	15	2	-	3	-	-	-	-
	slenderclaw hermit	*Paguristes turgidus*	6	20	7	-	-	-	-	-	-
	bat star	*Asterina miniata*	-	10	-	8	6	8	-	-	-
	fleshy sea pen	*Ptilosarcus gurneyi*	12	20	-	-	-	-	-	-	-
	roughback sculpin	*Chitonotus pugetensis*	-	33	19	-	10	-	-	-	-
	halfbanded rockfish	*Sebastes semicinctus*	30	20	-	-	-	-	-	-	-
	blackeye goby	*Coryphopterus nicholsii*	-	10	-	-	3	-	2	-	-
	basket star	*Gorgonocephalus eucnemis*	6	20	-	-	-	-	-	-	-
	"brittlestar"	*Ophiacantha* sp	-	23	-	3	-	-	-	-	-
	roughspine brittlestar	*Ophiopholis bakeri*	6	28	-	-	3	-	-	-	-
	California lamp shell	*Laqueus californianus*	-	20	-	-	-	-	-	-	-
	banded sea star	*Sclerasterias heteropaes*	-	13	-	-	3	-	-	-	-
	California heart urchin	*Spatangus californicus*	42	13	-	-	-	-	-	-	-
	orange sand star	*Astropecten ornatissimus*	21	33	2	-	-	-	-	-	-
	spotfin sculpin	*Icelinus tenuis*	6	53	2	-	-	-	-	-	-
	red sea star	*Mediaster aequalis*	12	58	6	3	-	-	-	-	-
	bluespotted poacher	*Xeneretmus triacanthus*	12	20	-	-	-	-	-	-	-
	slender sole	*Lyopsetta exilis*	91	40	7	3	-	-	-	-	-
	fragile sea urchin	*Allocentrotus fragilis*	61	38	2	-	-	-	-	-	-
	spotted cusk-eel	*Chilara taylori*	21	38	4	-	-	-	-	-	-
	rex sole	*Glyptocephalus zachirus*	39	10	-	-	-	-	-	-	-
	blackbelly eelpout	*Lycodes pacificus*	48	10	6	-	3	-	-	-	-
	Pacific hake	*Merluccius productus*	30	8	-	-	-	-	-	-	-
	greenstriped rockfish	*Sebastes elongatus*	21	15	2	3	-	-	-	-	-
	pink rockfish	*Sebastes eos*	24	3	11	-	-	-	-	-	-
	greenblotched rockfish	*Sebastes rosenblatti*	21	23	9	-	-	-	-	-	-
	spotted ratfish	*Hydrolagus colliei*	15	5	2	-	-	-	-	-	-
	bluebarred prickleback	*Plectobranchus evides*	27	-	-	-	-	-	-	-	-
	pelagic red crab	*Pleuroncodes planipes*	21	8	2	-	3	-	-	-	-
	gigantic anemone	*Metridium farcimen*	24	5	7	-	3	-	-	-	-

Appendix E11 (continued)

Species Cluster	Common Name	Scientific Name	Site Cluster 1 Outer Shelf	2 Outer / Middle Shelf Island	3 Middle Shelf	4 Middle Shelf C/S	5 Middle/ Inner Shelf B&H Island	6 B&H C Ports Marinas	7 Inner Shelf B&H Rivers	8 Inner Shelf N	9 B&H S
		Number of Stations	33	40	54	38	31	26	62	13	15
D	greenspotted rockfish	*Sebastes chlorostictus*	18	13	6	-	-	-	-	-	-
E	"aeolis"	*Dendronotus* sp	6	-	4	8	3	-	-	-	-
	Santa Barbara spindle	*Fusinus barbarensis*	15	8	4	-	-	-	-	-	-
	spanish shawl	*Flabellina iodinea*	-	-	4	-	10	-	-	-	-
	pygmy poacher	*Odontopyxis trispinosa*	3	10	22	3	3	-	-	-	-
	Pacific spiny brittlestar	*Ophiothrix spiculata*	18	25	30	18	19	8	-	-	-
	vermilion rockfish	*Sebastes miniatus*	-	5	11	-	-	-	-	-	-
	copper rockfish	*Sebastes caurinus*	6	3	4	-	6	-	-	-	-
	mosaic sand star	*Luidia armata*	6	5	26	45	10	-	-	-	-
	slender sea pen	*Stylatula elongata*	9	8	24	21	-	-	-	8	-
	California blade barnacle	*Hamatoscalpellum californicum*	27	23	26	50	6	-	2	-	-
	yellow sea twig	*Thesea* sp B	18	25	35	47	6	-	-	-	-
	"gorgonian"	*Heterogorgia tortuosa*	-	-	6	26	-	-	-	-	-
F	bigmouth sole	*Hippoglossina stomata*	21	55	83	79	29	-	3	-	-
	California sand star	*Astropecten verrilli*	45	45	83	100	45	4	16	31	-
	California lizardfish	*Synodus lucioceps*	12	18	93	87	61	38	53	77	7
	longfin sanddab	*Citharichthys xanthostigma*	9	10	83	95	32	-	13	23	-
	hornyhead turbot	*Pleuronichthys verticalis*	9	23	72	68	39	-	31	31	-
	California tonguefish	*Symphurus atricaudus*	6	5	83	84	52	31	45	46	7
	fantail sole	*Xystreurys liolepis*	-	-	28	32	32	23	26	8	-
	speckled sanddab	*Citharichthys stigmaeus*	-	13	30	29	55	8	32	92	-
	California skate	*Raja inornata*	12	-	24	29	6	-	6	-	-
	California scorpionfish	*Scorpaena guttata*	6	20	26	50	16	4	5	-	-
G	yellowchin sculpin	*Icelinus quadriseriatus*	18	30	81	53	19	-	2	-	-
	pink seaperch	*Zalembius rosaceus*	42	63	63	24	6	-	-	-	-
	longspine combfish	*Zaniolepis latipinnis*	45	28	61	13	6	-	-	-	-
	white sea urchin	*Lytechinus pictus*	42	68	54	45	35	-	6	8	-
	California sea cucumber	*Parastichopus californicus*	64	43	39	39	23	12	2	-	-
	bay goby	*Lepidogobius lepidus*	6	23	28	3	6	-	5	-	-
	Pacific argentine	*Argentina sialis*	21	33	13	-	-	-	-	-	-
	California market squid	*Loligo opalescens*	21	20	19	13	10	4	2	-	7
	red octopus	*Octopus rubescens*	33	30	28	11	10	-	-	-	-
	gray sand star	*Luidia foliolata*	64	48	20	26	6	-	-	8	-
	California sea slug	*Pleurobranchaea californica*	61	33	17	3	13	-	-	-	-
	Dover sole	*Microstomus pacificus*	94	78	28	3	-	-	-	-	-
	plainfin midshipman	*Porichthys notatus*	88	60	46	8	10	4	-	-	-
	Pacific sanddab	*Citharichthys sordidus*	94	98	63	34	19	-	2	8	-
	shortspine combfish	*Zaniolepis frenata*	82	70	4	-	3	-	-	-	-
	brokenspine brittlestar	*Ophiura luetkenii*	30	33	19	11	3	-	-	-	-
	trailtip sea pen	*Acanthoptilum* sp	42	53	24	21	3	4	-	-	-
	English sole	*Parophrys vetulus*	64	30	43	26	16	-	10	31	-
	stripetail rockfish	*Sebastes saxicola*	82	48	43	3	-	-	-	-	-
	ridgeback rock shrimp	*Sicyonia ingentis*	94	53	81	42	23	-	5	-	-
H	bearded eelpout	*Lyconema barbatum*	18	-	-	-	-	-	-	-	-
	Pacific heart urchin	*Brissopsis pacifica*	15	-	-	-	-	-	-	-	-
	orange bigeye octopus	*Octopus californicus*	18	8	-	-	-	-	-	-	-
	flagnose bay shrimp	*Neocrangon resima*	36	-	-	-	-	-	-	-	-
	mustache bay shrimp	*Neocrangon zacae*	52	5	-	-	-	-	-	-	-
	blacktip poacher	*Xeneretmus latifrons*	52	3	-	-	-	-	-	-	-
	northern heart urchin	*Brisaster latifrons*	45	-	-	-	-	-	-	-	-
	southern spinyhead	*Metacrangon spinosissima*	18	-	-	-	-	-	-	-	-
	slender blade shrimp	*Spirontocaris holmesi*	15	-	-	-	-	-	-	-	-
	hinged shrimp	*Pantomus affinis*	27	3	4	-	-	-	-	-	-
	splitnose rockfish	*Sebastes diploproa*	36	-	-	-	-	-	-	-	-

Appendix E12. Biointegrity index values and response levels for Fish Foraging Guild Index (FFG), Fish Response Index (FRI), Trawl Response Index (TRI), and Invertebrate Response Index (IRI) at stations in the Southern California Bight 1998 Regional Survey, July-September 1998.

	Response Index Value				Response Level[a]			
Station	FFG[b]	FRI	TRI	IRI	FFG[b]	FRI	TRI	IRI
2065	3.00	41.78	43.74	38.78	-	Reference	Reference	Reference
2067	3.00	13.99	25.22	17.57	-	Reference	Reference	Reference
2069	4.33	7.29	12.93	13.33	Reference	Reference	Reference	Reference
2070	4.33	25.72	0.25	5.10	Reference	Reference	Reference	Reference
2071	3.00	20.12	36.39	34.20	Nonreference	Reference	Reference	Reference
2072	5.00	16.56	37.27	31.58	-	Reference	Reference	Reference
2073	4.33	15.97	20.00	16.07	Reference	Reference	Reference	Reference
2074	3.67	17.63	36.29	31.65	-	Reference	Reference	Reference
2075	5.00	16.75	33.34	28.49	Reference	Reference	Reference	Reference
2076	5.00	6.71	11.56	7.97	-	Reference	Reference	Reference
2077	4.33	21.89	34.48	36.59	Reference	Reference	Reference	Reference
2078	4.33	2.31	28.44	27.65	Reference	Reference	Reference	Reference
2079	5.00	17.79	29.88	27.12	Reference	Reference	Reference	Reference
2082	5.00	11.33	25.20	23.01	Reference	Reference	Reference	Reference
2084	4.33	18.24	2.67	-0.45	Reference	Reference	Reference	Reference
2085	3.00	18.52	37.59	42.04	-	Reference	Reference	Reference
2087	3.67	13.66	25.39	24.72	Reference	Reference	Reference	Reference
2088	5.00	22.45	26.94	21.00	Reference	Reference	Reference	Reference
2089	5.00	16.66	24.21	20.17	Reference	Reference	Reference	Reference
2090	5.00	6.71	24.25	22.92	-	Reference	Reference	Reference
2091	5.00	14.36	25.21	22.10	Reference	Reference	Reference	Reference
2092	4.33	4.84	23.31	18.58	-	Reference	Reference	Reference
2093	4.33	26.96	10.83	7.71	Reference	Reference	Reference	Reference
2094	3.67	10.08	26.42	26.30	-	Reference	Reference	Reference
2095	4.33	-8.86	7.29	10.53	-	Reference	Reference	Reference
2096	3.00	13.74	20.73	18.71	-	Reference	Reference	Reference
2097	3.00	28.08	37.42	35.69	-	Reference	Reference	Reference
2098	4.33	20.52	38.98	33.47	-	Reference	Reference	Reference
2099	3.67	28.40	37.47	35.45	-	Reference	Reference	Reference
2100	3.67	33.89	41.38	35.52	-	Reference	Reference	Reference
2101	2.33	28.31	38.09	37.90	-	Reference	Reference	Reference
2102	1.67	30.79	43.13	44.58	-	Reference	Reference	Reference
2103	2.33	42.97	47.83	47.30	-	Reference	Reference	Nonreference
2104	2.33	22.10	50.24	52.98	-	Reference	Reference	Nonreference
2105	3.00	33.55	41.30	39.97	-	Reference	Reference	Reference
2108	2.33	37.47	49.30	51.21	-	Reference	Reference	Nonreference
2110	3.00	17.02	37.57	34.93	-	Reference	Reference	Reference
2111	4.33	17.33	33.75	25.26	-	Reference	Reference	Reference
2112	3.67	11.72	32.74	25.94	-	Reference	Reference	Reference
2113	3.00	30.22	47.23	41.56	-	Reference	Reference	Reference
2114	3.00	10.59	33.50	28.10	-	Reference	Reference	Reference
2115	5.00	18.63	32.60	31.66	Reference	Reference	Reference	Reference
2116	3.67	30.65	41.84	36.27	-	Reference	Reference	Reference
2117	3.67	36.23	52.37	51.82	-	Reference	Nonreference	Nonreference
2118	5.00	18.43	25.28	22.02	Reference	Reference	Reference	Reference
2119	2.33	41.06	49.09	45.05	-	Reference	Reference	Reference
2122	5.00	28.28	43.58	43.85	-	Reference	Reference	Reference
2129	2.33	81.55	80.66	27.25	-	Nonreference	Nonreference	Reference
2147	3.67	18.90	33.06	-	-	Reference	Reference	-
2152	3.67	22.49	39.05	61.75	-	Reference	Reference	Nonreference
2153	2.33	25.56	49.57	46.47	-	Reference	Reference	Nonreference
2155	3.67	31.73	55.27	37.54	-	Reference	Nonreference	Reference
2158	2.33	30.42	58.89	47.32	-	Reference	Nonreference	Nonreference

Appendix E12 (continued)

	Response Index Value				Response Level[a]			
Station	FFG[b]	FRI	TRI	IRI	FFG[b]	FRI	TRI	IRI
2162	3.67	35.70	62.22	56.86	-	Reference	Nonreference	Nonreference
2167	3.67	28.83	47.14	60.17	-	Reference	Reference	Nonreference
2168	3.67	28.36	58.28	58.26	-	Reference	Nonreference	Nonreference
2180	3.67	48.77	57.23	22.33	-	Nonreference	Nonreference	Reference
2186	3.67	40.79	56.39	65.56	-	Reference	Nonreference	Nonreference
2189	3.67	25.69	27.03	20.07	Reference	Reference	Reference	Reference
2190	5.00	10.80	30.95	30.13	Reference	Reference	Reference	Reference
2191	4.33	20.02	28.21	24.24	Reference	Reference	Reference	Reference
2192	5.00	9.51	35.07	36.35	Reference	Reference	Reference	Reference
2194	5.00	7.42	38.91	40.01	Reference	Reference	Reference	Reference
2195	3.00	12.00	29.58	27.77	Nonreference	Reference	Reference	Reference
2197	3.67	9.55	30.60	30.09	Reference	Reference	Reference	Reference
2198	3.67	14.50	23.48	18.44	Reference	Reference	Reference	Reference
2200	5.00	15.99	28.52	24.06	Reference	Reference	Reference	Reference
2201	3.67	32.72	48.16	54.71	Reference	Reference	Reference	Nonreference
2202	4.33	19.47	35.43	44.50	Reference	Reference	Reference	Reference
2204	4.33	26.16	43.23	52.93	Reference	Reference	Reference	Nonreference
2205	4.33	16.13	31.68	30.90	Reference	Reference	Reference	Reference
2206	5.00	17.84	26.48	22.59	Reference	Reference	Reference	Reference
2207	3.67	26.68	21.95	15.48	Reference	Reference	Reference	Reference
2208	4.33	21.32	25.26	19.14	Reference	Reference	Reference	Reference
2209	5.00	14.95	28.34	25.22	Reference	Reference	Reference	Reference
2210	5.00	18.60	25.93	22.29	Reference	Reference	Reference	Reference
2211	5.00	11.07	25.88	24.06	Reference	Reference	Reference	Reference
2212	5.00	21.12	28.90	15.71	Reference	Reference	Reference	Reference
2213	5.00	18.59	27.42	21.91	Reference	Reference	Reference	Reference
2214	5.00	21.84	34.11	31.64	Reference	Reference	Reference	Reference
2215	5.00	18.54	26.98	23.68	Reference	Reference	Reference	Reference
2216	3.67	23.64	32.61	26.76	Reference	Reference	Reference	Reference
2217	5.00	21.55	28.81	24.96	Reference	Reference	Reference	Reference
2218	5.00	18.26	34.17	30.93	Reference	Reference	Reference	Reference
2219	3.00	22.66	21.73	21.03	Nonreference	Reference	Reference	Reference
2230	2.33	11.86	31.00	-	-	Reference	Reference	-
2231	2.33	11.86	53.26	36.14	-	Reference	Nonreference	Reference
2233	3.67	11.78	61.38	56.05	-	Reference	Nonreference	Nonreference
2239	3.67	11.11	31.78	-	-	Reference	Reference	-
2241	3.67	11.11	31.52	-	-	Reference	Reference	-
2242	3.67	11.78	30.52	-	-	Reference	Reference	-
2243	3.67	11.78	30.26	-	-	Reference	Reference	-
2244	2.33	11.63	28.52	-	-	Reference	Reference	-
2249	2.33	10.60	34.53	-	-	Reference	Reference	-
2254	3.67	11.11	66.17	58.05	-	Reference	Nonreference	Nonreference
2256	3.67	10.90	62.48	130.42	-	Reference	Nonreference	Nonreference
2258	3.67	26.81	107.10	130.42	-	Reference	Nonreference	Nonreference
2262	3.67	11.11	30.59	-	-	Reference	Reference	-
2266	3.00	1.29	30.01	30.27	Nonreference	Reference	Reference	Reference
2267	2.33	24.83	43.17	46.47	-	Reference	Reference	Nonreference
2268	4.33	33.57	39.72	38.94	-	Reference	Reference	Reference
2273	3.00	44.51	49.75	-	-	Reference	Reference	-
2274	3.67	17.22	29.74	10.11	-	Reference	Reference	Reference
2275	2.33	37.64	73.33	69.88	-	Reference	Nonreference	Nonreference
2276	2.33	28.93	37.01	-	-	Reference	Reference	-
2277	5.00	15.18	29.67	21.79	Reference	Reference	Reference	Reference
2278	5.00	20.91	35.36	33.15	Reference	Reference	Reference	Reference
2279	2.33	11.49	37.62	-	-	Reference	Reference	-

Appendix E12 (continued)

	Response Index Value				Response Level[a]			
Station	FFG[b]	FRI	TRI	IRI	FFG[b]	FRI	TRI	IRI
2280	5.00	42.46	51.96	21.79	Reference	Reference	Nonreference	Reference
2281	4.33	19.96	28.94	17.78	Reference	Reference	Reference	Reference
2282	3.67	27.32	41.61	33.21	-	Reference	Reference	Reference
2283	3.67	19.42	24.08	22.24	Reference	Reference	Reference	Reference
2284	3.67	24.86	38.20	26.15	Reference	Reference	Reference	Reference
2285	5.00	18.29	31.90	29.94	Reference	Reference	Reference	Reference
2286	3.67	14.59	33.07	-	-	Reference	Reference	-
2287	4.33	23.14	32.74	27.15	Reference	Reference	Reference	Reference
2288	4.33	19.61	32.17	28.40	Reference	Reference	Reference	Reference
2289	5.00	14.12	28.44	24.75	Reference	Reference	Reference	Reference
2290	5.00	19.88	42.73	45.21	-	Reference	Reference	Reference
2291	5.00	13.60	29.62	28.01	Reference	Reference	Reference	Reference
2292	3.67	21.56	35.11	31.46	-	Reference	Reference	Reference
2293	3.67	22.40	34.63	35.67	-	Reference	Reference	Reference
2294	5.00	21.57	25.83	20.27	Reference	Reference	Reference	Reference
2295	5.00	20.17	30.20	24.30	Reference	Reference	Reference	Reference
2296	3.67	16.33	32.84	21.79	-	Reference	Reference	Reference
2297	3.67	43.95	64.83	69.22	-	Reference	Nonreference	Nonreference
2298	3.67	28.18	53.59	62.66	-	Reference	Nonreference	Nonreference
2299	2.33	30.55	68.66	60.58	-	Reference	Nonreference	Nonreference
2301	2.33	44.78	40.69	38.27	-	Reference	Reference	Reference
2302	4.33	24.13	37.10	29.37	Reference	Reference	Reference	Reference
2303	5.00	27.81	37.65	21.85	Reference	Reference	Reference	Reference
2304	2.33	17.72	35.61	30.10	-	Reference	Reference	Reference
2306	4.33	37.07	55.85	39.91	-	Reference	Nonreference	Reference
2307	3.67	18.45	38.44	52.12	-	Reference	Reference	Nonreference
2310	3.67	49.25	55.12	21.79	-	Nonreference	Nonreference	Reference
2312	3.67	15.55	33.62	32.73	Reference	Reference	Reference	Reference
2314	3.67	19.58	43.52	43.37	-	Reference	Reference	Reference
2317	4.33	13.98	28.99	14.83	-	Reference	Reference	Reference
2318	3.67	47.22	65.51	61.49	-	Nonreference	Nonreference	Nonreference
2319	3.67	24.47	45.19	39.35	-	Reference	Reference	Reference
2320	3.67	27.46	56.52	64.22	-	Reference	Nonreference	Nonreference
2321	3.67	41.79	59.91	62.93	-	Reference	Nonreference	Nonreference
2322	3.67	15.85	41.45	41.06	-	Reference	Reference	Reference
2323	3.67	50.92	59.38	69.88	-	Nonreference	Nonreference	Nonreference
2324	3.67	25.66	63.47	74.16	-	Reference	Nonreference	Nonreference
2325	2.33	32.17	51.18	35.73	-	Reference	Nonreference	Reference
2326	3.00	28.22	58.78	67.32	-	Reference	Nonreference	Nonreference
2327	3.67	48.82	57.39	49.78	-	Nonreference	Nonreference	Nonreference
2328	3.67	59.19	81.02	-	-	Nonreference	Nonreference	-
2329	2.33	71.58	80.78	98.80	-	Nonreference	Nonreference	Nonreference
2330	2.33	69.93	70.07	98.80	-	Nonreference	Nonreference	Nonreference
2331	2.33	49.78	82.58	80.19	-	Nonreference	Nonreference	Nonreference
2332	3.67	67.70	95.54	81.90	-	Nonreference	Nonreference	Nonreference
2333	3.67	59.16	91.49	84.34	-	Nonreference	Nonreference	Nonreference
2334	3.67	36.73	54.43	41.93	-	Reference	Nonreference	Reference
2335	3.67	30.28	72.03	61.70	-	Reference	Nonreference	Nonreference
2338	3.00	57.69	84.36	-	-	Nonreference	Nonreference	-
2339	2.33	70.42	77.92	89.66	-	Nonreference	Nonreference	Nonreference
2340	2.33	87.96	88.16	98.80	-	Nonreference	Nonreference	Nonreference
2341	3.67	20.07	29.24	35.83	Reference	Reference	Reference	Reference
2342	2.33	11.11	32.33	40.31	Nonreference	Reference	Reference	Reference
2343	3.67	20.53	31.26	23.94	-	Reference	Reference	Reference
2344	4.33	16.02	33.92	41.69	Reference	Reference	Reference	Reference

Appendix E12 (continued)

	Response Index Value				Response Level[a]			
Station	FFG[b]	FRI	TRI	IRI	FFG[b]	FRI	TRI	IRI
2345	5.00	14.67	29.40	21.48	Reference	Reference	Reference	Reference
2346	5.00	13.43	30.88	31.06	Reference	Reference	Reference	Reference
2347	4.33	14.59	28.39	24.30	Reference	Reference	Reference	Reference
2348	5.00	13.87	32.03	40.83	Reference	Reference	Reference	Reference
2349	5.00	17.40	36.83	32.05	Reference	Reference	Reference	Reference
2350	5.00	17.69	29.78	27.10	Reference	Reference	Reference	Reference
2351	5.00	10.73	32.02	22.49	Reference	Reference	Reference	Reference
2352	5.00	20.41	29.81	28.13	Reference	Reference	Reference	Reference
2353	5.00	5.82	25.57	24.35	Reference	Reference	Reference	Reference
2354	3.67	30.19	45.30	40.24	-	Reference	Reference	Reference
2355	5.00	39.51	43.93	35.95	-	Reference	Reference	Reference
2356	5.00	24.45	33.71	29.62	Reference	Reference	Reference	Reference
2357	3.67	29.57	40.33	37.74	Reference	Reference	Reference	Reference
2358	3.67	28.13	41.19	37.45	Reference	Reference	Reference	Reference
2359	5.00	29.11	37.35	36.61	-	Reference	Reference	Reference
2360	5.00	21.36	30.31	27.36	Reference	Reference	Reference	Reference
2361	3.67	30.23	41.45	-	-	Reference	Reference	-
2362	3.67	17.03	35.34	38.65	Reference	Reference	Reference	Reference
2364	5.00	18.04	29.97	28.89	Reference	Reference	Reference	Reference
2365	3.67	13.84	36.10	36.89	Reference	Reference	Reference	Reference
2367	3.00	16.48	39.54	61.65	Nonreference	Reference	Reference	Nonreference
2368	3.67	21.21	43.19	51.88	Reference	Reference	Reference	Nonreference
2369	3.67	28.83	48.98	74.87	Reference	Reference	Reference	Nonreference
2370	2.33	55.47	52.13	98.80	-	Nonreference	Nonreference	Nonreference
2371	3.67	27.37	43.88	50.12	Reference	Reference	Reference	Nonreference
2372	3.00	21.27	35.40	31.56	Nonreference	Reference	Reference	Reference
2373	3.67	24.47	34.35	39.07	-	Reference	Reference	Reference
2374	3.00	21.42	36.48	32.60	Nonreference	Reference	Reference	Reference
2375	3.67	26.07	35.85	27.38	-	Reference	Reference	Reference
2376	3.67	26.07	32.39	26.46	-	Reference	Reference	Reference
2377	3.00	33.94	33.32	-	-	Reference	Reference	-
2378	3.67	16.35	31.64	27.85	-	Reference	Reference	Reference
2379	3.67	17.56	35.52	-	-	Reference	Reference	-
2380	3.67	23.79	40.36	43.15	-	Reference	Reference	Reference
2381	5.00	14.68	30.49	28.31	Reference	Reference	Reference	Reference
2382	4.33	18.84	29.88	19.32	-	Reference	Reference	Reference
2383	3.67	27.32	50.41	49.54	-	Reference	Reference	Nonreference
2384	4.33	7.54	33.30	33.39	Reference	Reference	Reference	Reference
2385	3.00	18.27	34.06	27.47	-	Reference	Reference	Reference
2386	4.33	16.84	35.24	37.48	-	Reference	Reference	Reference
2387	4.33	9.15	25.48	26.10	Reference	Reference	Reference	Reference
2391	3.00	29.45	58.35	78.08	-	Reference	Nonreference	Nonreference
2392	3.00	22.97	45.03	37.49	-	Reference	Reference	Reference
2393	3.67	20.10	37.28	28.19	-	Reference	Reference	Reference
2394	4.33	18.21	31.33	26.60	Reference	Reference	Reference	Reference
2396	3.67	26.45	32.42	30.27	Reference	Reference	Reference	Reference
2397	3.67	18.44	31.91	21.79	Reference	Reference	Reference	Reference
2398	4.33	14.70	29.30	22.08	Reference	Reference	Reference	Reference
2399	3.00	27.73	47.37	47.35	-	Reference	Reference	Nonreference
2400	5.00	17.07	29.73	28.28	Reference	Reference	Reference	Reference
2401	5.00	25.38	34.03	20.56	Reference	Reference	Reference	Reference
2402	4.33	20.58	37.37	38.53	-	Reference	Reference	Reference
2403	4.33	27.41	34.47	28.10	Reference	Reference	Reference	Reference
2404	3.67	12.86	36.00	42.57	-	Reference	Reference	Reference
2405	5.00	13.84	33.68	34.80	Reference	Reference	Reference	Reference

Appendix E12 (continued)

Station	Response Index Value FFG[b]	FRI	TRI	IRI	Response Level[a] FFG[b]	FRI	TRI	IRI
2406	3.67	27.94	61.56	98.80	-	Reference	Nonreference	Nonreference
2407	5.00	16.76	32.19	27.44	Reference	Reference	Reference	Reference
2408	5.00	9.52	30.81	34.48	Reference	Reference	Reference	Reference
2411	4.33	20.90	31.96	25.72	Reference	Reference	Reference	Reference
2412	5.00	15.45	32.46	29.69	Reference	Reference	Reference	Reference
2413	5.00	18.84	29.39	24.95	Reference	Reference	Reference	Reference
2414	2.33	60.43	69.75	69.00	-	Nonreference	Nonreference	Nonreference
2415	3.67	39.42	71.06	98.80	-	Reference	Nonreference	Nonreference
2416	3.67	29.14	57.32	98.80	-	Reference	Nonreference	Nonreference
2417	3.00	23.51	37.95	37.19	-	Reference	Reference	Reference
2418	5.00	12.35	29.11	29.54	Reference	Reference	Reference	Reference
2419	5.00	13.48	26.66	22.43	Reference	Reference	Reference	Reference
2420	2.33	72.37	36.82	20.97	-	Nonreference	Reference	Reference
2426	3.67	25.79	56.49	56.06	-	Reference	Nonreference	Nonreference
2427	2.33	26.33	57.81	66.73	-	Reference	Nonreference	Nonreference
2430	3.67	40.64	35.82	21.02	-	Reference	Reference	Reference
2435	3.67	20.04	47.38	60.43	-	Reference	Reference	Nonreference
2436	3.00	17.75	36.92	32.63	-	Reference	Reference	Reference
2443	3.67	12.70	33.61	27.38	-	Reference	Reference	Reference
2444	3.67	11.63	28.52	-	-	Reference	Reference	-
2446	3.67	11.11	66.09	50.63	-	Reference	Nonreference	Nonreference
2447	3.67	64.02	88.35	68.81	-	Nonreference	Nonreference	Nonreference
2448	3.67	25.88	58.07	69.88	-	Reference	Nonreference	Nonreference
2449	3.67	44.43	63.15	56.80	-	Reference	Nonreference	Nonreference
2450	2.33	26.43	61.31	61.36	-	Reference	Nonreference	Nonreference
2451	2.33	31.53	51.71	48.44	-	Reference	Nonreference	Nonreference
2452	2.33	36.63	50.63	62.09	-	Reference	Reference	Nonreference
2453	2.33	35.44	60.43	48.14	-	Reference	Nonreference	Nonreference
2461	3.00	29.71	33.74	34.87	-	Reference	Reference	Reference
2467	5.00	42.12	66.03	44.54	-	Reference	Nonreference	Reference
2472	2.33	22.98	34.19	23.14	-	Reference	Reference	Reference
2475	2.33	53.07	43.26	25.99	-	Nonreference	Reference	Reference
2480	3.67	-0.90	20.38	25.92	Reference	Reference	Reference	Reference
2483	3.00	28.38	34.73	30.93	Nonreference	Reference	Reference	Reference
2487	3.67	36.18	31.38	23.84	Reference	Reference	Reference	Reference
2490	5.00	27.14	33.31	25.29	Reference	Reference	Reference	Reference
2491	4.33	26.72	18.88	13.99	Reference	Reference	Reference	Reference
2492	5.00	28.45	35.67	32.64	Reference	Reference	Reference	Reference
2493	3.00	29.22	36.81	25.73	Nonreference	Reference	Reference	Reference
2494	2.33	25.40	24.48	9.86	-	Reference	Reference	Reference
2497	3.00	6.85	21.76	19.42	-	Reference	Reference	Reference
2499	3.00	28.14	36.46	31.53	-	Reference	Reference	Reference
2501	2.33	16.73	9.83	10.15	-	Reference	Reference	Reference
2502	3.67	-5.88	17.56	12.61	-	Reference	Reference	Reference
2512	5.00	20.25	25.39	28.13	Reference	Reference	Reference	Reference
2515	3.67	17.05	28.88	25.18	Reference	Reference	Reference	Reference
2516	3.67	21.17	30.69	25.84	Reference	Reference	Reference	Reference
2517	2.33	21.67	20.82	15.75	Nonreference	Reference	Reference	Reference
2518	2.33	6.76	22.96	18.96	-	Reference	Reference	Reference
2519	2.33	18.71	23.50	21.60	Nonreference	Reference	Reference	Reference
2520	4.33	18.27	29.57	26.38	Reference	Reference	Reference	Reference
2522	5.00	25.49	22.74	21.00	Reference	Reference	Reference	Reference
2523	2.33	-5.28	-13.33	1.67	Nonreference	Reference	Reference	Reference
2525	2.33	25.27	36.98	31.68	-	Reference	Reference	Reference
2526	3.67	14.95	22.43	19.93	Reference	Reference	Reference	Reference

Appendix E12 (continued)

	Response Index Value				Response Level[a]			
Station	FFG[b]	FRI	TRI	IRI	FFG[b]	FRI	TRI	IRI
2528	2.33	26.34	34.59	29.71	-	Reference	Reference	Reference
2531	3.67	35.50	44.50	38.32	-	Reference	Reference	Reference
2534	3.00	28.98	48.44	51.98	-	Reference	Reference	Nonreference
2537	3.00	26.41	38.95	36.25	-	Reference	Reference	Reference
2538	3.67	16.75	23.59	14.39	Reference	Reference	Reference	Reference
2554	5.00	14.45	28.10	25.03	Reference	Reference	Reference	Reference
2555	5.00	21.67	31.40	25.27	Reference	Reference	Reference	Reference
2556	5.00	14.20	32.56	30.40	Reference	Reference	Reference	Reference
2557	3.67	69.57	85.56	14.53	-	Nonreference	Nonreference	Reference
2558	3.00	23.39	43.55	27.38	-	Reference	Reference	Reference
2559	3.67	25.84	46.98	51.23	-	Reference	Reference	Nonreference
2560	3.67	29.53	51.85	55.95	-	Reference	Nonreference	Nonreference
2565	3.67	32.65	57.13	68.61	-	Reference	Nonreference	Nonreference
2566	3.67	30.76	53.76	42.05	-	Reference	Nonreference	Reference
2571	3.67	18.87	31.23	-	-	Reference	Reference	-
2573	3.67	27.06	55.22	98.80	-	Reference	Nonreference	Nonreference
2580	3.67	53.67	79.64	66.83	-	Nonreference	Nonreference	Nonreference
2585	2.33	47.01	75.44	-	-	Nonreference	Nonreference	-
2586	2.33	64.00	77.56	-	-	Nonreference	Nonreference	-
2590	3.67	15.00	51.62	74.93	-	Reference	Nonreference	Nonreference
2591	3.67	26.81	46.21	14.53	-	Reference	Reference	Reference
2592	3.00	11.11	61.44	77.67	-	Reference	Nonreference	Nonreference
2593	3.67	26.81	44.41	19.68	-	Reference	Reference	Reference
2594	2.33	-	31.89	14.53	-	No Index	Reference	Reference
2596	2.33	121.10	125.99	-	-	Nonreference	Nonreference	-
2597	3.67	42.32	54.91	27.89	-	Reference	Nonreference	Reference
2599	3.67	17.26	46.01	65.49	-	Reference	Reference	Nonreference
2600	3.67	48.45	57.86	56.86	-	Nonreference	Nonreference	Nonreference
2601	3.67	31.09	34.34	27.59	-	Reference	Reference	Reference
2602	2.33	12.43	33.46	-	-	Reference	Reference	-
2604	3.67	41.45	57.23	56.76	-	Reference	Nonreference	Nonreference
2605	3.67	40.89	56.41	52.04	-	Reference	Nonreference	Nonreference
2606	4.33	48.92	62.17	50.28	-	Nonreference	Nonreference	Nonreference
2607	4.33	22.19	29.32	26.06	-	Reference	Reference	Reference
2608	4.33	13.03	39.20	33.65	-	Reference	Reference	Reference
2609	3.00	23.32	39.54	34.40	-	Reference	Reference	Reference
2610	3.00	38.94	43.09	39.66	-	Reference	Reference	Reference
2611	5.00	12.39	28.34	27.13	Reference	Reference	Reference	Reference
2612	4.33	15.67	29.61	28.64	Reference	Reference	Reference	Reference

All indices are from Allen *et al.* 2001a.

[a]Biointegrity index response levels were assigned according to the following threshold values: FFG ≥ 3.67 (Reference), ≤ 1.83 (Impact); FRI ≤ 45 (Reference); TRI ≤ 51 (Reference); IRI ≤ 46 (Reference).

[b]FFG corresponds to the response index for pelagivores (Guild 2A), pelagobenthivores (Guild 2B), and extracting benthivores (Guild 2D1a) of the middle shelf only. See Figure 75 for representative guild species of the middle shelf from the Bight '98 regional trawl survey.

APPENDIX E13.

Comment on Cladistics Theory and Method

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Although the fish data in the Southern California Bight 1998 Regional Survey were analyzed separately for the purpose of comparing the results of a relatively small data set to other approaches herein, the results empirically seem to indicate that it is unnecessary to make an *a priori* partition of the data. Philosophically, the partitioning of the data requires some ad hoc assumption that the underlying processes are independent between these partitions or sets of data. The amount of congruence from the multiple results that follow from these analyses is deemed the measure of truth. Cladograms, on the other hand, are tested in the most severe manner. The parsimony criterion has been shown to maximize explanatory power by minimizing ad hoc hypotheses of character distribution by maximizing shared (congruent) derived states. Hence, by utilizing a total evidence approach, the entire suite of data is tested and the probability of shared-derived (synapomorphy) character refutation is increased. Thus the methods and philosophies are quite different. The partitioned approach in search of consensus is a verificationist approach while that of cladistic parsimony is one of refutation (see Kluge 1998 and references therein). For the inspired reader, see similar efforts termed "simultaneous unconstrained analysis" (Nixon and Carpenter 1993; Kitching 1998).

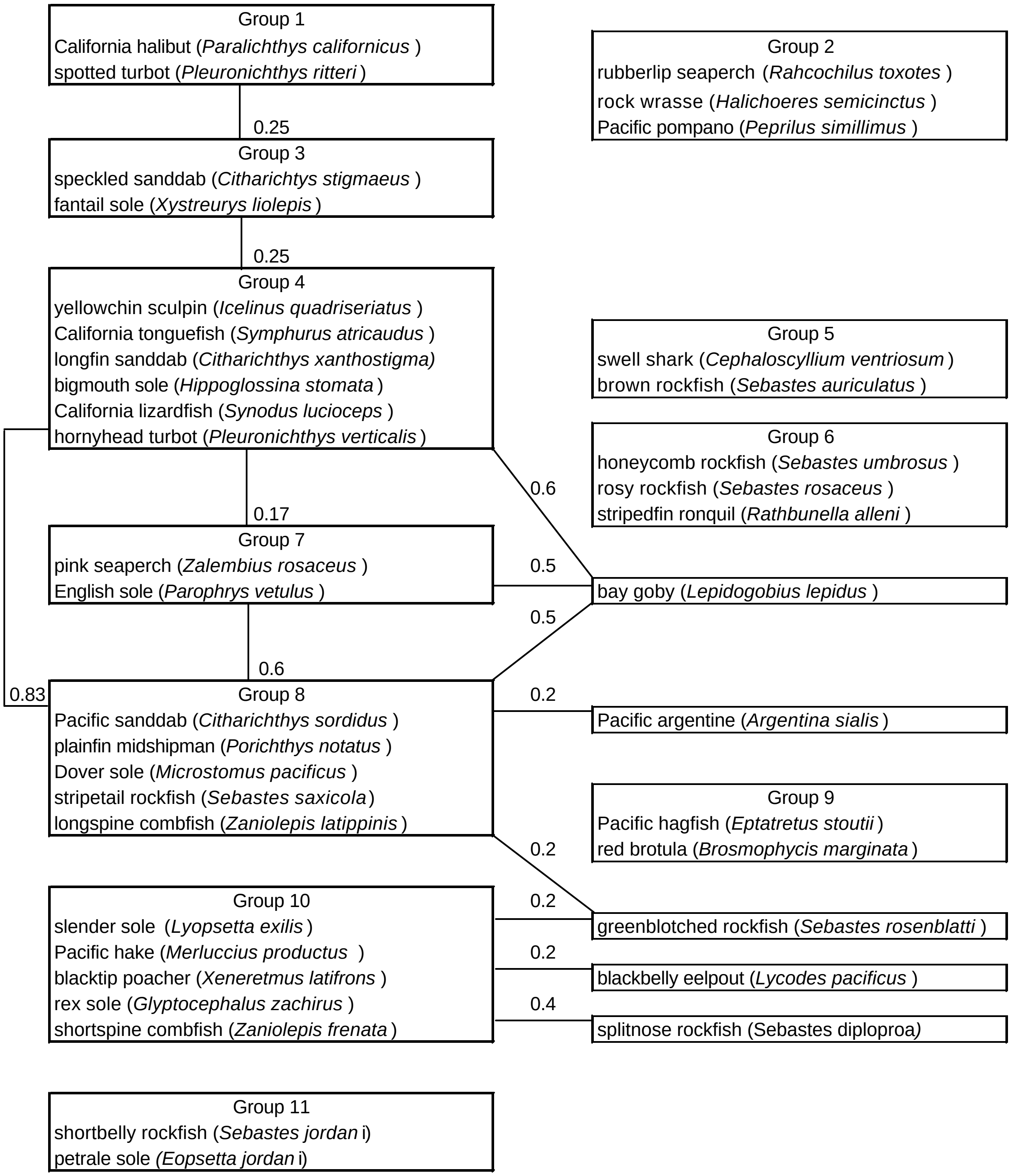
A major area for research within ecology has been the origin and development of species assemblages at small spatiotemporal scales, such as those of ecosystems or the local communities discussed herein. Systematists have paid little or no attention to the question of community assembly, primarily because the domain of systematics - species, speciation, and historical biogeography - is not considered to be applicable at this small scale. Scale aside, systematic data and interpretation may contribute to our understanding of how these small-scale species assemblages evolved (Cracraft 1994). Models assuming that community structure is a function of colonization most often explain species assemblage patterns. Indeed, for areas of endemism, the method for discovering hierarchical structure that is produced by biotic dispersion (not to be confused with dispersal) utilizes an out group devoid of taxa to accommodate this model (Bellan-Santini *et al.* 1994, Cracraft 1994, CLA,EMD 1994b, Lambshead 1986, Lambshead and Paterson 1986, Watanabe 1998, Masselot *et al.* 1997, Salen-Picard *et al.* 1996, Morrone 1994, Nel *et al.* 1998, Costa *et al.* 2000).

Behind any such model lies the assumption that the present distribution of organisms contains information relating to the process by which they are now found. Hence, the presence or absence of a species in a region can be regarded as a descriptor that changes not at random, but according to the model (Legendre 1986). In a study of the community structure of freshwater fishes, Legendre (1986) assumed glacial refugia where all species were present. This approach, antithetical to the above colonization model, necessitated the formation of an out-group in which all species were presumed present. Hence, contemporary community structure was defined by the derived absence of species, due to their supposed loss or extinction, caused by glaciation.

Community assembly on the small spatiotemporal scale reported herein is assumed to be a function of both biotic dispersion and exclusion processes. Because shared environmental conditions may exclude similar sets of species from dissimilar sites, shared absences may be especially informative (Lyons-Weiler and Tausch, 1997). Hence, an empirical out group using both the derived absence and derived presence of species to group stations (species assemblages) is the only model capable of accommodating both of these real and simultaneously occurring processes. Hence, a given species present in the out-group, but absent from a station in the in-group will be distinguished as a derived state, specifically a derived absence. This derived state shared by two or more monitoring stations (a synapomorphic-like relationship) will possess the type of information capable of defining particular groupings or relationships. Indeed, parsimony algorithms optimize both shared presences and absences simultaneously. Hence, the actual type of character agreement or similarity - derived absence and/or derived presence – of the given species or response variable, is simultaneously accommodated in the cladistic analysis. This methodological and conceptual modification has powerful implications in the determination of community relationships. Indeed, traditional community ordination and phenetic classification analyses do not deal with variance due to shared absences separately from the variance due to shared presences, (Lyons-Weiler and Tausch, 1997; Tamas *et al.* 2001), and shared absences especially if they can be inferred as secondary losses mean a great deal in ecology.

Finally, although somewhat novel, this approach (PAA) shows that even at fine spatiotemporal scales, species can be classified hierarchically within a series of nested subsets of areas of occupancy, and parsimony is the best tool for this approach (Myers and De Grave 2000).

Appendix E14. Recurrent groups of demersal fishes on the mainland shelf of southern California at depths of 10-200 m, July-August 1994. Index of affinity (I.A.) = 0.50. Lines show relationship between groups and associates, with values indicating the proportion of possible pairs with I.A. = 0.495 or greater. (Note: Recurrent group analysis in Allen and Moore 1997a and Allen *et al*. 1998 is based on 0.5, with values rounded from 0.45).



Appendix E15. Recurrent groups of megabenthic invertebrates on the mainland shelf of southern California at depths of 10-200 m, July-August 1994. Index of affinity (I.A.) = 0.50. Lines show relationship between groups and associates, with values indicating the proportion of possible pairs with I.A. = 0.495 or greater. (Note: Recurrent group analysis in Allen and Moore 1997b and Allen *et al*. 1998 is based on 0.5, with values rounded from 0.45).

Group 6
Hemphill neck crab (*Podochela hemphillii*)
ringed doris (*Diaulula sandiegnesis*)

Group 13
shortneck pear crab (*Erileptus spinosus*)
tubicolous hermit (*Orthopagurus minimus*)

— 0.5 — Olyroyd coralsnail (*Babelomurex oldroydi*)

Group 16
white sea urchin (*Lytechinus pictus*)
ridgeback rock shrimp (*Sicyonia ingentis*)
California sea cucumber (*Parastichopus californicus*)
California sand star (*Astropecten verrilli*)
gray sand star (*Luidia foliolata*)
Califonia sea slug (*Pleurobranchaea californica*)

— 0.5 — Pacific spiny brittlestar (*Ophiothrix spiculata*)
— 0.5 — brokenspine brittlestar (*Ophiura luetkenii*)

Group 17
six-arm sea star (*Leptasterias hexactis*)
banded sea star (*Sclerasterias heteropaes*)

| 0.33 (Group 17 – Group 19)

Group 19
brown cup coral (*Paracyathus stearnsii*)
white lamp shell (*Terebratulina crossei*)
frill-wing murex (*Pteropurpura macroptera*)

— 0.67 — ribbed lamp shell (*Terebratalia occidentalis*)

| 0.22 (Group 19 – Group 22)

Group 22
California lamp shell (*Laqueus californianus*)
slipper sea cucumber (*Psolus chitonoides*)
"brittlestar" (*Ophionereis eurybrachiplax*)

— 0.33 — spiny margarite (*Cidarina cidaris*)
— 0.33 — roughspine brittlestar (*Ophiopholis bakeri*)

Group 26
fragile sea urchin (*Allocentrotus fragilis*)
northern heart urchin (*Brisaster latifrons*)
Pacific heart urchin (*Brissopsis pacifica*)
moustache bay shrimp (*Neocrangon zacae*)

Group 28
California king crab (*Paralithodes californiensis*)
brown box crab (*Lopholithodes foraminatus*)

— 0.5 — flagnose bay shrimp (*Neocrangon resima*)

APPENDIX F

APPENDIX F. BIOACCUMULATION

NUMBER **PAGE**

NUMBER **PAGE**

Appendix F1. Concentrations of tDDT, tPCB, and tChlordane, and tPCB toxicity equivalence quotients for mammals and birds by whole fish composite of sanddab guild species at stations sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

			Age	Summed Results (µg/kg)			PCB TEQs (ng/kg)	
Station	CompID	Species	Class	tDDT	tPCB	tChlor.	Mammals	Birds
2065	1001	LE	1	28.77	3.85	0.00	0.00	0.00
2067	1004	CS	1	30.94	0.00	0.00	0.00	0.00
2067	1005	CS	2	19.00	0.00	0.00	0.00	0.00
2067	1006	LE	2	26.40	6.88	0.00	0.27	0.03
2069	1007	CS	1	15.78	0.00	0.00	0.00	0.00
2070	1010	CS	1	3.82	0.00	0.00	0.00	0.00
2071	1012	CS	1	16.08	0.00	0.00	0.00	0.00
2072	1013	CSt	1	11.04	0.00	0.00	0.00	0.00
2073	1015	CS	1	0.00	0.00	0.00	0.00	0.00
2074	1018	CS	1	2.02	0.00	0.00	0.00	0.00
2075	1021	CX	1	9.12	0.00	0.00	0.00	0.00
2076	1024	CS	2	18.48	0.31	0.00	0.00	0.00
2076	1025	CS	1	40.22	12.41	0.00	0.00	0.00
2076	1026	LE	2	42.20	0.00	0.00	0.00	0.00
2077	1027	CX	1	6.96	0.00	0.00	0.00	0.00
2078	1029	CS	1	11.30	0.00	0.00	0.00	0.00
2079	1032	CX	1	30.67	4.62	0.00	0.38	0.06
2082	1035	CS	1	19.16	0.55	0.00	0.00	0.00
2084	1039	CS	1	29.20	8.42	0.00	0.00	0.00
2085	1041	CS	1	62.00	27.66	0.00	0.00	0.00
2085	1042	LE	0	5.20	0.00	0.00	0.00	0.00
2085	1043	CS		6.50	0.00	0.00	0.00	0.00
2085	1044	LE		8.60	0.90	0.00	0.00	0.00
2087	1045	CX	1	16.82	0.00	0.00	0.00	0.00
2088	1048	CSt	1	65.66	0.00	0.00	0.00	0.00
2089	1050	CS	1	42.42	7.64	0.00	0.00	0.00
2090	1053	CS	1	26.38	0.00	0.00	0.00	0.00
2091	1056	CX	1	29.50	3.15	0.00	0.05	0.01
2092	1060	CS	1	16.12	0.00	0.00	0.00	0.00
2093	1062	CS	1	2.49	3.35	0.00	1.08	74.09
2094	1064	CS	1	33.88	0.43	0.00	0.00	0.00
2094	1065	LE		16.34	0.00	0.00	0.00	0.00
2094	1066	CS	2	19.40	0.00	0.00	0.00	0.00
2095	1068	CS	1	21.40	2.88	1.00	0.00	0.00
2096	1071	CS	2	28.80	6.52	0.00	0.00	0.00
2097	1072	LE	1	39.80	5.39	0.00	0.05	0.00
2098	1073	CS	1	30.34	0.00	0.00	0.00	0.00
2099	1075	CS	2	14.80	0.00	0.00	0.00	0.00
2099	1076	LE		12.80	0.00	0.00	0.00	0.00
2099	1078	CS	1	6.20	0.00	0.00	0.00	0.00
2099	1079	LE	1	5.90	0.00	0.00	0.00	0.00
2100	1080	CS	2	19.60	0.80	0.00	0.00	0.00
2100	1081	LE	1	30.40	3.40	0.00	0.08	0.01
2100	1083	CS	1	6.80	0.00	0.00	0.00	0.00
2100	1084	LE	2	8.00	0.00	0.00	0.00	0.00

Appendix F1 (continued)

Station	CompID	Species	Age Class	Summed Results (ug/kg) tDDT	tPCB	tChlor.	PCB TEQs (ng/kg) Mammals	Birds
2105	1085	LE	1	30.82	0.00	0.00	0.00	0.00
2110	1088	CS	1	56.26	5.80	0.00	0.00	0.00
2111	1090	CS	1	7.60	0.00	0.00	0.00	0.00
2112	1092	CS	1	42.76	4.10	0.00	0.00	0.00
2113	1094	CS	1	202.93	16.61	1.52	0.22	0.02
2113	1095	LE	1	96.74	21.21	0.00	0.37	92.02
2113	1096	CS	2	115.88	38.02	0.00	0.57	0.25
2113	1097	LE	2	128.76	12.16	3.02	0.18	0.02
2114	1098	CS	1	145.38	10.16	0.00	0.00	0.00
2114	1099	LE	1	166.40	0.00	10.10	0.00	0.00
2114	1100	CS	2	20.24	0.00	0.00	0.00	0.00
2114	1101	LE	2	139.91	15.54	0.00	0.00	0.00
2115	1102	CS	1	133.99	9.07	1.67	1.76	0.35
2116	1103	LE	1	217.64	48.43	1.99	0.51	0.05
2117	1104	LE	1	31.40	1.84	0.00	0.00	0.00
2118	1168	CS	1	1,061.44	105.44	0.00	1.63	0.56
2119	1109	LE	1	13.60	0.00	0.00	0.00	0.00
2120	1111	LE	1	14.60	1.00	0.00	0.00	0.00
2122	1114	LE	1	6.20	0.00	0.00	0.00	0.00
2147	1116	PC	1	234.66	34.94	4.72	2.91	0.58
2189	1117	CX	1	887.54	151.65	10.44	3.10	0.41
2190	1118	CX	1	394.56	57.79	0.00	5.57	280.99
2191	1120	CX	1	1,014.60	270.98	5.06	6.79	2.32
2191	1121	CS	1	454.48	133.60	0.00	2.21	0.85
2192	1123	CX	1	348.34	92.16	6.26	2.24	466.66
2194	1125	CX	1	628.68	132.63	2.30	1.97	0.62
2195	1127	CX	1	977.55	373.09	7.72	7.03	2.93
2195	1128	CSt	1	768.74	187.96	10.08	2.94	1.16
2197	1129	CX	1	953.20	0.00	0.00	0.00	0.00
2198	1130	CSt	1	200.46	67.73	14.58	1.03	0.38
2200	1131	CX	1	4,938.46	309.42	0.00	5.80	1.80
2201	1133	CS	1	8,017.88	473.24	0.00	8.71	2.89
2202	1134	CX	1	7,606.38	390.88	0.00	8.32	2.59
2204	1136	CS	1	10462.38	710.26	0.00	12.70	4.11
2205	1138	CX	1	2,843.58	187.76	0.00	2.62	0.91
2206	1139	CX	1	1,910.54	138.12	0.00	3.35	1.00
2206	1140	CSt	1	383.76	31.46	0.00	0.37	0.04
2207	1141	CSt	1	32.22	3.34	0.00	0.91	0.18
2208	1142	CX	1	70.40	11.54	0.00	0.00	0.00
2209	1144	CX	1	80.40	17.14	0.00	0.00	0.00
2210	1147	CX	1	59.00	14.36	0.00	0.00	0.00
2211	1149	CX	1	81.44	25.26	0.00	0.00	0.00
2212	1151	CX	1	74.98	38.16	0.00	0.45	0.04
2212	1152	CSt	1	26.14	3.00	0.00	0.00	0.00
2213	1154	CX	1	62.32	13.08	0.00	0.00	0.00
2213	1155	CS	1	39.10	10.12	0.00	0.00	0.00
2214	803981937	CX	1	20.00	0.00	0.00	0.00	0.00
2215	803981938	CX	1	34.00	0.00	0.00	0.00	0.00

Appendix F1 (continued)

Station	CompID	Species	Age Class	Summed Results (ug/kg) tDDT	tPCB	tChlor.	PCB TEQs (ng/kg) Mammals	Birds
2216	804981939	CX	1	28.00	0.00	0.00	0.00	0.00
2216	804981940	CS	1	16.80	0.00	0.00	0.00	0.00
2217	731981941	CX	1	26.00	0.00	0.00	0.00	0.00
2218	731981942	CX	1	13.50	0.00	0.00	0.00	0.00
2219	730981944	CS	1	28.00	0.00	0.00	0.00	0.00
2220	731981943	CX	1	18.40	0.00	0.00	0.00	0.00
2233	814981945	PC	1	70.00	309.90	0.00	2.80	0.28
2242	813981946	PC	1	40.00	323.00	0.00	3.00	0.30
2244	818981947	PC	1	32.00	240.00	0.00	2.20	0.22
2254	813981992	PC	1	18.10	248.30	0.00	2.80	0.28
2256	817981949	PC	1	42.00	254.00	0.00	2.40	0.24
2262	818981948	PC	1	19.00	62.80	0.00	0.00	0.00
2267	1179	CSt	1	2.80	0.00	0.00	0.00	0.00
2268	1181	CSt	1	2.80	0.00	0.00	0.00	0.00
2274	1183	CSt	1	5.20	0.00	0.00	0.00	0.00
2276	1184	CSt	1	10.20	0.00	0.00	0.00	0.00
2277	1185	CX	1	4.40	0.00	0.00	0.00	0.00
2278	1187	CX	1	6.80	0.00	0.00	0.00	0.00
2280	1189	CX	1	3.20	0.00	0.00	0.00	0.00
2281	1190	CX	1	5.00	0.00	0.00	0.00	0.00
2282	1192	CSt	0	5.00	0.00	0.00	0.00	0.00
2283	1193	CX	1	30.60	0.00	0.00	0.00	0.00
2284	1194	CX	1	7.00	0.00	0.00	0.00	0.00
2285	1195	CX	1	11.00	0.00	0.00	0.00	0.00
2286	1197	CX	1	3.60	0.00	0.00	0.00	0.00
2287	1198	CX	1	7.00	0.00	0.00	0.00	0.00
2288	1199	CX	1	3.80	0.00	0.00	0.00	0.00
2289	1200	CX	1	5.60	0.00	0.00	0.00	0.00
2290	1203	CX	1	9.40	0.00	0.00	0.00	0.00
2290	1204	CS	1	5.20	2.00	0.00	0.00	0.00
2291	1208	CX	1	4.20	0.00	0.00	0.00	0.00
2292	1210	CX	1	4.20	0.00	0.00	0.00	0.00
2292	1211	CS	1	5.20	0.00	0.00	0.00	0.00
2292	1212	LE		8.80	0.00	0.00	0.00	0.00
2293	1214	CSt	1	2.60	0.00	0.00	0.00	0.00
2294	1216	CX	1	6.40	0.00	0.00	0.00	0.00
2295	1217	CX	1	2.10	0.00	0.00	0.00	0.00
2296	1219	CX	1	4.00	0.00	0.00	0.00	0.00
2298	1220	PC	0	19.20	13.80	0.00	0.16	0.02
2302	1221	CX	1	4.20	0.00	0.00	0.00	0.00
2303	1222	CX	1	4.60	0.00	0.00	0.00	0.00
2306	1224	CSt	1	42.34	18.40	0.00	0.74	111.05
2312	1225	CX	1	130.70	16.47	0.00	0.25	0.03
2314	1227	CSt	1	48.17	11.29	0.00	0.18	0.02
2317	807981950	CSt	1	9.00	0.00	0.00	0.00	0.00
2319	1230	PC	1	22.80	4.00	0.00	0.00	0.00
2320	1231	PC	1	9.20	1.60	0.00	0.00	0.00
2322	1232	CSt	0	9.20	0.00	0.00	0.00	0.00

Appendix F1 (continued)

Station	CompID	Species	Age Class	Summed Results (ug/kg) tDDT	tPCB	tChlor.	PCB TEQs (ng/kg) Mammals	Birds
2324	1233	PC	1	24.80	0.00	0.00	0.00	0.00
2333	1234	PC	1	3.00	0.00	0.00	0.00	0.00
2341	1235	CSt	1	8.40	0.00	0.00	0.00	0.00
2343	1236	CSt	1	3.80	0.00	0.00	0.00	0.00
2344	1238	CX	1	36.80	4.60	0.00	0.14	0.01
2345	1239	CX	1	9.20	0.00	0.00	0.00	0.00
2346	1240	CX	1	6.20	0.00	0.00	0.00	0.00
2347	1243	CX	1	10.80	0.00	0.00	0.00	0.00
2348	1244	CX	1	4.80	0.00	0.00	0.00	0.00
2349	806981951	CX	1	20.00	0.00	0.00	0.00	0.00
2350	806981952	CX	1	18.00	0.00	0.00	0.00	0.00
2351	806981953	CX	1	22.00	0.00	0.00	0.00	0.00
2352	715981954	CX	1	18.20	0.00	0.00	0.00	0.00
2352	715981955	CSt	1	6.20	0.00	0.00	0.00	0.00
2353	115991956	CS	1	20.00	0.00	0.00	0.00	0.00
2354	1261	CSt	1	0.00	0.00	0.00	0.00	0.00
2355	1263	CSt	1	3.60	0.00	0.00	0.00	0.00
2356	1265	CS	1	25.80	19.44	0.00	0.00	0.00
2357	1267	CS	1	21.80	0.00	0.00	0.00	0.00
2358	1269	CS	1	26.60	1.40	0.00	0.00	0.00
2359	1271	CS	1	8.00	0.00	0.00	0.00	0.00
2359	1272	CSt	1	4.80	1.80	0.00	0.00	0.00
2360	1275	CS	1	7.20	0.00	0.00	0.00	0.00
2361	1277	CSt	0	2.60	0.00	0.00	0.00	0.00
2362	1278	CX	1	5.20	0.00	0.00	0.00	0.00
2364	1280	CX	1	11.00	0.00	0.00	0.00	0.00
2364	1281	CS	1	22.80	0.00	0.00	0.00	0.00
2364	1282	CSt	1	25.80	4.20	0.00	0.00	0.00
2365	1284	CSt	1	4.80	0.00	0.00	0.00	0.00
2368	1285	CX	1	8.40	0.00	0.00	0.00	0.00
2372	1286	CS	1	27.00	0.00	0.00	0.00	0.00
2373	1289	CSt	1	4.20	0.00	0.00	0.00	0.00
2374	1290	CS	1	25.60	2.00	0.00	0.00	0.00
2375	1292	CSt	1	14.00	0.00	0.00	0.00	0.00
2377	1293	CSt	1	8.80	0.00	0.00	0.00	0.00
2378	1294	CSt	1	10.20	0.00	0.00	0.00	0.00
2379	1296	CSt	0	9.80	0.00	0.00	0.00	0.00
2380	1297	CSt	1	30.21	1.39	0.00	0.00	0.00
2381	1298	CX	1	185.30	26.57	1.78	0.40	0.04
2382	1299	CX	1	184.26	36.05	0.00	0.37	0.04
2382	1300	CSt	1	35.22	11.02	0.00	0.14	0.01
2383	1301	CSt	1	43.82	3.30	0.00	0.00	0.00
2384	1302	CX	1	471.98	72.15	3.28	1.44	0.43
2385	1303	CSt	0	87.58	36.61	0.00	0.29	0.03
2386	1304	CSt	1	20.50	0.00	0.00	0.00	0.00
2387	1307	CX	0	845.24	101.20	0.00	30.89	3.46
2393	1309	CSt	0	34.40	0.00	0.00	0.00	0.00
2394	1310	CX	1	252.94	29.98	0.00	0.38	0.04

Appendix F1 (continued)

Station	CompID	Species	Age Class	Summed Results (ug/kg) tDDT	tPCB	tChlor.	PCB TEQs (ng/kg) Mammals	Birds
2396	1311	CSt	1	20.40	0.00	0.00	0.00	0.00
2397	1313	CSt	1	26.40	4.36	0.00	0.00	0.00
2398	1314	CSt	1	21.40	0.00	0.00	0.00	0.00
2400	1315	CX	1	17.60	2.80	0.00	0.00	0.00
2401	1316	CX	1	14.20	3.80	0.00	0.00	0.00
2402	1318	CX	1	2.80	0.00	0.00	0.00	0.00
2403	1320	CX	1	23.20	4.40	0.00	0.12	0.01
2404	1322	CX		8.60	0.00	0.00	0.00	0.00
2405	1323	CX	1	14.80	1.20	0.00	0.00	0.00
2406	1325	PC	1	4.20	0.00	0.00	0.00	0.00
2407	1326	CX	1	18.00	1.20	0.00	0.00	0.00
2408	1328	CX	1	16.20	2.00	0.00	0.00	0.00
2411	115991957	CX	1	26.00	0.00	0.00	0.00	0.00
2412	115991958	CX	1	16.20	0.00	0.00	0.00	0.00
2413	115991959	CX	1	14.80	0.00	0.00	0.00	0.00
2416	115991960	PC	1	22.00	0.00	0.00	0.00	0.00
2417	115991961	CSt	0	8.20	0.00	0.00	0.00	0.00
2418	115991962	CS	1	24.00	0.00	0.00	0.00	0.00
2419	115991963	CX	1	28.00	0.00	0.00	0.00	0.00
2419	115991964	CS	1	17.20	0.00	0.00	0.00	0.00
2426	1345	PC	0	26.00	16.40	0.00	0.20	0.02
2436	115991965	PC	1	36.00	160.00	0.00	1.78	0.18
2444	1347	PC	1	7.40	7.00	0.00	0.12	0.01
2446	1348	PC	1	8.80	10.80	0.00	0.16	0.02
2447	1349	PC	1	18.60	23.00	0.00	0.40	0.13
2448	1350	PC	1	35.20	50.20	2.40	0.64	0.23
2461	115991966	LE	2	15.00	0.00	0.00	0.00	0.00
2462	115991967	CS	1	12.20	0.00	0.00	0.00	0.00
2467	1354	CSt	1	6.77	9.28	0.00	0.00	0.00
2472	1356	CSt	1	11.60	1.62	11.36	0.16	0.02
2475	1357	CSt	1	7.08	0.00	0.00	0.00	0.00
2480	1358	CS	1	31.60	3.82	0.00	0.00	0.00
2483	1360	CS	0	5.16	0.00	0.00	0.00	0.00
2487	1361	CS	1	6.14	0.00	0.00	0.00	0.00
2487	1362	CSt	1	23.40	0.00	0.00	0.00	0.00
2490	1364	CS	1	16.98	0.00	0.00	0.00	0.00
2490	1365	CSt	1	12.22	0.00	0.00	0.00	0.00
2491	1368	CS	1	22.20	0.00	0.00	0.00	0.00
2492	1370	CS	1	25.76	0.29	0.00	0.00	0.00
2493	1373	CS	1	9.36	0.00	0.00	0.00	0.00
2493	1374	CSt	1	2.56	0.00	0.00	0.00	0.00
2494	1378	CS	2	32.20	0.00	0.00	0.00	0.00
2497	1380	CS	1	27.34	0.00	0.00	0.00	0.00
2499	1382	LE	1	35.66	1.57	0.00	0.16	0.02
2502	1385	CS	1	21.60	0.00	0.00	0.00	0.00
2512	1387	CS	1	160.23	69.83	0.60	1.80	437.38
2515	1392	CS	1	39.66	5.14	0.00	0.00	0.00
2516	1394	CS	1	23.10	0.00	0.00	0.00	0.00

Appendix F1 (continued)

Station	CompID	Species	Age Class	Summed Results (ug/kg) tDDT	tPCB	tChlor.	PCB TEQs (ng/kg) Mammals	Birds
2518	1397	CS	1	27.96	8.56	0.00	0.41	203.00
2519	1400	CSt	1	17.57	0.00	0.00	0.00	0.00
2520	1401	CS	1	41.20	7.27	0.00	0.82	0.16
2522	1403	CS	1	45.72	3.67	0.00	0.18	0.02
2523	1406	CS	1	15.12	1.88	0.00	0.19	93.80
2525	1408	CS	1	62.96	0.00	0.00	0.00	0.00
2526	1410	CS	1	25.99	3.08	0.00	0.00	0.00
2528	1413	CS	1	31.68	7.61	0.00	0.82	0.16
2528	1414	LE	1	14.60	1.69	0.00	0.84	0.17
2528	1416	CS	2	23.70	0.00	0.00	0.00	0.00
2528	1417	LE	2	47.77	16.29	0.00	0.84	269.30
2531	1418	LE	1	34.99	0.00	0.00	0.00	0.00
2534	1421	LE	1	16.62	0.00	0.00	0.00	0.00
2537	1422	CS	1	41.82	4.71	0.00	0.00	0.00
2537	1423	LE	1	38.39	0.00	0.00	0.00	0.00
2537	1424	CS	2	49.48	0.00	0.00	0.00	0.00
2537	1425	LE	2	55.56	4.28	0.00	0.43	0.33
2538	1426	CS	1	37.60	25.36	0.00	0.37	0.26
2554	826981982	CX	1	168.40	28.40	0.00	0.00	0.00
2555	826981983	CX	1	160.20	28.60	0.00	0.00	0.00
2556	115991968	CX	1	24.00	0.00	0.00	0.00	0.00
2558	827981985	PC	1	62.00	0.00	0.00	0.00	0.00
2559	827981986	PC	0	28.00	0.00	0.00	0.00	0.00
2580	821981987	PC	1	112.60	0.00	0.00	0.00	0.00
2591	826981984	PC	1	54.00	0.00	0.00	0.00	0.00
2593	1439	PC	1	187.24	103.32	5.20	1.34	0.34
2605	1440	CSt	1	11.83	0.00	0.00	0.00	0.00
2606	820981988	CSt	1	15.20	0.00	0.00	0.00	0.00
2607	820981989	CSt	1	0.00	0.00	0.00	0.00	0.00
2608	819981990	CS	1	32.00	0.00	0.00	0.00	0.00
2609	819981991	CS	1	19.60	0.00	0.00	0.00	0.00
2610	1450	LE	1	41.20	9.80	0.00	0.12	0.01
2612	1454	CX	1	3,673.72	140.84	0.00	0.76	0.76

Multinumber station codes are City of San Diego, Metropolitan Wastewater Department stations sampled during the survey - age column indicates disparity in reported ages sent and analyzed.

Appendix F2. Concentrations of tDDT and tChlordane isomers by whole fish composite of sanddab guild species at stations sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

			Age	Total DDT (µg/kg)						Total Chlordane	
Station	CompID	Species	Class	ppDDD	ppDDE	ppDDT	opDDD	opDDE	opDDT	Chlor-a	Chlor-g
2065	1001	LE	1	1.68	19.72	0.60	0.00	0.00	2.25	0.00	0.00
2067	1004	CS	1	5.38	17.08	0.00	0.00	0.00	8.48	0.00	0.00
2067	1005	CS	2	0.00	15.28	3.72	0.00	0.00	0.00	0.00	0.00
2067	1006	LE	2	0.00	26.40	0.00	0.00	0.00	0.00	0.00	0.00
2069	1007	CS	1	0.00	15.78	0.00	0.00	0.00	0.00	0.00	0.00
2070	1010	CS	1	0.00	3.82	0.00	0.00	0.00	0.00	0.00	0.00
2071	1012	CS	1	0.00	16.08	0.00	0.00	0.00	0.00	0.00	0.00
2072	1013	CSt	1	0.00	11.04	0.00	0.00	0.00	0.00	0.00	0.00
2073	1015	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2074	1018	CS	1	0.00	2.02	0.00	0.00	0.00	0.00	0.00	0.00
2075	1021	CX	1	0.00	9.12	0.00	0.00	0.00	0.00	0.00	0.00
2076	1024	CS	2	0.00	18.48	0.00	0.00	0.00	0.00	0.00	0.00
2076	1025	CS	1	0.00	35.00	5.22	0.00	0.00	0.00	0.00	0.00
2076	1026	LE	2	0.00	42.20	0.00	0.00	0.00	0.00	0.00	0.00
2077	1027	CX	1	0.00	6.96	0.00	0.00	0.00	0.00	0.00	0.00
2078	1029	CS	1	0.00	11.30	0.00	0.00	0.00	0.00	0.00	0.00
2079	1032	CX	1	0.00	28.80	0.00	0.00	1.87	0.00	0.00	0.00
2082	1035	CS	1	0.00	17.48	1.68	0.00	0.00	0.00	0.00	0.00
2084	1039	CS	1	0.00	29.20	0.00	0.00	0.00	0.00	0.00	0.00
2085	1041	CS	1	0.00	62.00	0.00	0.00	0.00	0.00	0.00	0.00
2085	1042	LE	0	0.00	5.20	0.00	0.00	0.00	0.00	0.00	0.00
2085	1043	CS		0.00	6.50	0.00	0.00	0.00	0.00	0.00	0.00
2085	1044	LE		0.00	8.60	0.00	0.00	0.00	0.00	0.00	0.00
2087	1045	CX	1	0.00	14.98	1.84	0.00	0.00	0.00	0.00	0.00
2088	1048	CSt	1	0.00	63.20	0.00	2.46	0.00	0.00	0.00	0.00
2089	1050	CS	1	0.00	35.60	6.82	0.00	0.00	0.00	0.00	0.00
2090	1053	CS	1	0.00	23.00	3.38	0.00	0.00	0.00	0.00	0.00
2091	1056	CX	1	0.00	29.50	0.00	0.00	0.00	0.00	0.00	0.00
2092	1060	CS	1	0.00	14.77	1.35	0.00	0.00	0.00	0.00	0.00
2093	1062	CS	1	0.00	1.21	0.00	0.00	1.29	0.00	0.00	0.00
2094	1064	CS	1	0.00	31.80	2.08	0.00	0.00	0.00	0.00	0.00
2094	1065	LE		0.00	16.34	0.00	0.00	0.00	0.00	0.00	0.00
2094	1066	CS	2	0.00	19.40	0.00	0.00	0.00	0.00	0.00	0.00
2095	1068	CS	1	0.00	21.40	0.00	0.00	0.00	0.00	1.00	0.00
2096	1071	CS	2	0.00	28.80	0.00	0.00	0.00	0.00	0.00	0.00
2097	1072	LE	1	1.42	36.00	2.38	0.00	0.00	0.00	0.00	0.00
2098	1073	CS	1	0.00	28.22	0.00	0.00	2.12	0.00	0.00	0.00
2099	1075	CS	2	0.00	14.80	0.00	0.00	0.00	0.00	0.00	0.00
2099	1076	LE		0.00	12.80	0.00	0.00	0.00	0.00	0.00	0.00
2099	1078	CS	1	0.00	6.20	0.00	0.00	0.00	0.00	0.00	0.00
2099	1079	LE	1	0.00	5.90	0.00	0.00	0.00	0.00	0.00	0.00
2100	1080	CS	2	0.00	19.60	0.00	0.00	0.00	0.00	0.00	0.00
2100	1081	LE	1	0.80	25.80	2.20	0.00	1.60	0.00	0.00	0.00
2100	1083	CS	1	0.00	6.80	0.00	0.00	0.00	0.00	0.00	0.00
2100	1084	LE	2	0.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00
2105	1085	LE	1	0.00	29.60	0.00	1.22	0.00	0.00	0.00	0.00

Appendix F2 (continued)

Station	CompID	Species	Age Class	Total DDT (ug/kg) ppDDD	ppDDE	ppDDT	opDDD	opDDE	opDDT	Total Chlordane Chlor-a	Chlor-g
2110	1088	CS	1	0.00	51.40	4.86	0.00	0.00	0.00	0.00	0.00
2111	1090	CS	1	0.00	7.60	0.00	0.00	0.00	0.00	0.00	0.00
2112	1092	CS	1	0.00	40.20	2.56	0.00	0.00	0.00	0.00	0.00
2113	1094	CS	1	4.39	179.60	14.11	0.00	4.83	0.00	1.52	0.00
2113	1095	LE	1	2.24	91.60	0.00	0.00	2.90	0.00	0.00	0.00
2113	1096	CS	2	0.00	107.60	8.28	0.00	0.00	0.00	0.00	0.00
2113	1097	LE	2	2.76	117.20	7.38	0.00	1.42	0.00	3.02	0.00
2114	1098	CS	1	4.28	134.00	0.00	0.00	7.10	0.00	0.00	0.00
2114	1099	LE	1	0.00	166.40	0.00	0.00	0.00	0.00	0.00	10.10
2114	1100	CS	2	0.00	19.04	1.20	0.00	0.00	0.00	0.00	0.00
2114	1101	LE	2	0.00	133.40	5.06	0.00	1.45	0.00	0.00	0.00
2115	1102	CS	1	0.00	132.20	0.00	0.00	1.79	0.00	1.67	0.00
2116	1103	LE	1	5.14	191.20	10.76	0.00	10.54	0.00	1.99	0.00
2117	1104	LE	1	0.00	27.20	2.94	0.00	1.26	0.00	0.00	0.00
2118	1168	CS	1	8.84	1,016.00	0.00	0.00	36.60	0.00	0.00	0.00
2119	1109	LE	1	0.00	13.60	0.00	0.00	0.00	0.00	0.00	0.00
2120	1111	LE	1	0.00	14.60	0.00	0.00	0.00	0.00	0.00	0.00
2122	1114	LE	1	0.00	6.20	0.00	0.00	0.00	0.00	0.00	0.00
2147	1116	PC	1	19.30	214.00	0.00	1.36	0.00	0.00	4.72	0.00
2189	1117	CX	1	5.94	824.00	30.40	0.00	27.20	0.00	10.44	0.00
2190	1118	CX	1	6.46	370.00	8.68	0.00	9.42	0.00	0.00	0.00
2191	1120	CX	1	9.20	936.00	36.60	0.00	32.80	0.00	5.06	0.00
2191	1121	CS	1	8.72	402.00	17.96	0.00	25.80	0.00	0.00	0.00
2192	1123	CX	1	6.22	298.00	15.72	0.00	28.40	0.00	6.26	0.00
2194	1125	CX	1	10.98	576.00	18.10	0.00	23.60	0.00	2.30	0.00
2195	1127	CX	1	16.05	858.00	51.90	0.00	51.60	0.00	7.72	0.00
2195	1128	CSt	1	11.34	684.00	30.20	0.00	43.20	0.00	10.08	0.00
2197	1129	CX	1	0.00	862.00	32.60	0.00	58.60	0.00	0.00	0.00
2198	1130	CSt	1	4.26	172.20	0.00	0.00	24.00	0.00	0.00	14.58
2200	1131	CX	1	27.00	4,640.00	8.54	6.92	256.00	0.00	0.00	0.00
2201	1133	CS	1	63.80	7,600.00	5.28	8.80	340.00	0.00	0.00	0.00
2202	1134	CX	1	56.40	7,200.00	3.72	10.26	336.00	0.00	0.00	0.00
2204	1136	CS	1	294.00	9,420.00	14.70	22.80	708.00	2.88	0.00	0.00
2205	1138	CX	1	32.00	2,640.00	2.70	8.08	160.80	0.00	0.00	0.00
2206	1139	CX	1	28.00	1,756.00	4.46	7.28	114.80	0.00	0.00	0.00
2206	1140	CSt	1	9.60	340.00	0.00	2.16	32.00	0.00	0.00	0.00
2207	1141	CSt	1	0.00	29.60	0.00	0.00	2.62	0.00	0.00	0.00
2208	1142	CX	1	0.00	70.40	0.00	0.00	0.00	0.00	0.00	0.00
2209	1144	CX	1	0.00	80.40	0.00	0.00	0.00	0.00	0.00	0.00
2210	1147	CX	1	0.00	59.00	0.00	0.00	0.00	0.00	0.00	0.00
2211	1149	CX	1	0.00	74.80	0.00	0.78	5.86	0.00	0.00	0.00
2212	1151	CX	1	0.00	70.60	0.00	0.00	4.38	0.00	0.00	0.00
2212	1152	CSt	1	0.00	25.00	0.00	0.00	1.14	0.00	0.00	0.00
2213	1154	CX	1	2.32	53.20	0.00	0.00	6.80	0.00	0.00	0.00
2213	1155	CS	1	0.00	39.10	0.00	0.00	0.00	0.00	0.00	0.00
2214	803981937	CX	1	0.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00
2215	803981938	CX	1	0.00	34.00	0.00	0.00	0.00	0.00	0.00	0.00
2216	804981939	CX	1	0.00	28.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix F2 (continued)

			Age	Total DDT (ug/kg)						Total Chlordane	
Station	CompID	Species	Class	ppDDD	ppDDE	ppDDT	opDDD	opDDE	opDDT	Chlor-a	Chlor-g
2216	804981940	CS	1	0.00	16.80	0.00	0.00	0.00	0.00	0.00	0.00
2217	731981941	CX	1	0.00	26.00	0.00	0.00	0.00	0.00	0.00	0.00
2218	731981942	CX	1	0.00	13.50	0.00	0.00	0.00	0.00	0.00	0.00
2219	730981944	CS	1	0.00	28.00	0.00	0.00	0.00	0.00	0.00	0.00
2220	731981943	CX	1	0.00	18.40	0.00	0.00	0.00	0.00	0.00	0.00
2233	814981945	PC	1	0.00	70.00	0.00	0.00	0.00	0.00	0.00	0.00
2242	813981946	PC	1	0.00	40.00	0.00	0.00	0.00	0.00	0.00	0.00
2244	818981947	PC	1	0.00	32.00	0.00	0.00	0.00	0.00	0.00	0.00
2254	813981992	PC	1	0.00	18.10	0.00	0.00	0.00	0.00	0.00	0.00
2256	817981949	PC	1	0.00	42.00	0.00	0.00	0.00	0.00	0.00	0.00
2262	818981948	PC	1	0.00	19.00	0.00	0.00	0.00	0.00	0.00	0.00
2267	1179	CSt	1	0.00	2.80	0.00	0.00	0.00	0.00	0.00	0.00
2268	1181	CSt	1	0.00	2.80	0.00	0.00	0.00	0.00	0.00	0.00
2274	1183	CSt	1	0.00	5.20	0.00	0.00	0.00	0.00	0.00	0.00
2276	1184	CSt	1	0.00	10.20	0.00	0.00	0.00	0.00	0.00	0.00
2277	1185	CX	1	0.00	4.40	0.00	0.00	0.00	0.00	0.00	0.00
2278	1187	CX	1	0.00	6.80	0.00	0.00	0.00	0.00	0.00	0.00
2280	1189	CX	1	0.00	3.20	0.00	0.00	0.00	0.00	0.00	0.00
2281	1190	CX	1	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00
2282	1192	CSt	0	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00
2283	1193	CX	1	0.00	25.00	0.00	0.00	2.40	3.20	0.00	0.00
2284	1194	CX	1	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00
2285	1195	CX	1	0.00	9.40	0.00	0.00	1.60	0.00	0.00	0.00
2286	1197	CX	1	0.00	3.60	0.00	0.00	0.00	0.00	0.00	0.00
2287	1198	CX	1	0.00	5.60	0.00	0.00	1.40	0.00	0.00	0.00
2288	1199	CX	1	0.00	3.80	0.00	0.00	0.00	0.00	0.00	0.00
2289	1200	CX	1	0.00	5.60	0.00	0.00	0.00	0.00	0.00	0.00
2290	1203	CX	1	0.00	9.40	0.00	0.00	0.00	0.00	0.00	0.00
2290	1204	CS	1	0.00	5.20	0.00	0.00	0.00	0.00	0.00	0.00
2291	1208	CX	1	0.00	4.20	0.00	0.00	0.00	0.00	0.00	0.00
2292	1210	CX	1	0.00	4.20	0.00	0.00	0.00	0.00	0.00	0.00
2292	1211	CS	1	0.00	5.20	0.00	0.00	0.00	0.00	0.00	0.00
2292	1212	LE		0.00	8.80	0.00	0.00	0.00	0.00	0.00	0.00
2293	1214	CSt	1	0.00	2.60	0.00	0.00	0.00	0.00	0.00	0.00
2294	1216	CX	1	0.00	6.40	0.00	0.00	0.00	0.00	0.00	0.00
2295	1217	CX	1	0.00	2.10	0.00	0.00	0.00	0.00	0.00	0.00
2296	1219	CX	1	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00
2298	1220	PC	0	0.00	15.80	0.00	0.00	3.40	0.00	0.00	0.00
2302	1221	CX	1	0.00	4.20	0.00	0.00	0.00	0.00	0.00	0.00
2303	1222	CX	1	0.00	4.60	0.00	0.00	0.00	0.00	0.00	0.00
2306	1224	CSt	1	0.00	39.60	2.74	0.00	0.00	0.00	0.00	0.00
2312	1225	CX	1	2.26	124.60	3.84	0.00	0.00	0.00	0.00	0.00
2314	1227	CSt	1	0.00	44.40	1.97	0.00	1.80	0.00	0.00	0.00
2317	807981950	CSt	1	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00
2319	1230	PC	1	0.00	20.60	0.00	0.00	2.20	0.00	0.00	0.00
2320	1231	PC	1	0.00	9.20	0.00	0.00	0.00	0.00	0.00	0.00
2322	1232	CSt	0	0.00	9.20	0.00	0.00	0.00	0.00	0.00	0.00
2324	1233	PC	1	0.90	23.90	0.00	0.00	0.00	0.00	0.00	0.00

Appendix F2 (continued)

			Age	Total DDT (ug/kg)						Total Chlordane	
Station	CompID	Species	Class	ppDDD	ppDDE	ppDDT	opDDD	opDDE	opDDT	Chlor-a	Chlor-g
2333	1234	PC	1	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00
2341	1235	CSt	1	0.00	8.40	0.00	0.00	0.00	0.00	0.00	0.00
2343	1236	CSt	1	0.00	3.80	0.00	0.00	0.00	0.00	0.00	0.00
2344	1238	CX	1	0.00	34.60	0.00	0.00	2.20	0.00	0.00	0.00
2345	1239	CX	1	0.00	9.20	0.00	0.00	0.00	0.00	0.00	0.00
2346	1240	CX	1	0.00	6.20	0.00	0.00	0.00	0.00	0.00	0.00
2347	1243	CX	1	0.00	10.80	0.00	0.00	0.00	0.00	0.00	0.00
2348	1244	CX	1	0.00	4.80	0.00	0.00	0.00	0.00	0.00	0.00
2349	806981951	CX	1	0.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00
2350	806981952	CX	1	0.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00
2351	806981953	CX	1	0.00	22.00	0.00	0.00	0.00	0.00	0.00	0.00
2352	715981954	CX	1	0.00	18.20	0.00	0.00	0.00	0.00	0.00	0.00
2352	715981955	CSt	1	0.00	6.20	0.00	0.00	0.00	0.00	0.00	0.00
2353	115991956	CS	1	0.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00
2354	1261	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2355	1263	CSt	1	0.00	3.60	0.00	0.00	0.00	0.00	0.00	0.00
2356	1265	CS	1	0.00	25.80	0.00	0.00	0.00	0.00	0.00	0.00
2357	1267	CS	1	0.00	21.80	0.00	0.00	0.00	0.00	0.00	0.00
2358	1269	CS	1	1.20	25.40	0.00	0.00	0.00	0.00	0.00	0.00
2359	1271	CS	1	0.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00
2359	1272	CSt	1	0.00	4.80	0.00	0.00	0.00	0.00	0.00	0.00
2360	1275	CS	1	0.00	7.20	0.00	0.00	0.00	0.00	0.00	0.00
2361	1277	CSt	0	0.00	2.60	0.00	0.00	0.00	0.00	0.00	0.00
2362	1278	CX	1	0.00	5.20	0.00	0.00	0.00	0.00	0.00	0.00
2364	1280	CX	1	0.00	9.80	0.00	0.00	1.20	0.00	0.00	0.00
2364	1281	CS	1	0.60	21.60	0.00	0.00	0.00	0.00	0.00	0.00
2364	1282	CSt	1	0.00	24.60	0.00	0.00	1.20	0.00	0.00	0.00
2365	1284	CSt	1	0.00	4.80	0.00	0.00	0.00	0.00	0.00	0.00
2368	1285	CX	1	0.00	8.40	0.00	0.00	0.00	0.00	0.00	0.00
2372	1286	CS	1	1.40	23.80	0.00	0.00	1.80	0.00	0.00	0.00
2373	1289	CSt	1	0.00	4.20	0.00	0.00	0.00	0.00	0.00	0.00
2374	1290	CS	1	1.00	23.20	0.00	0.00	1.40	0.00	0.00	0.00
2375	1292	CSt	1	0.00	11.20	0.00	0.00	2.80	0.00	0.00	0.00
2377	1293	CSt	1	0.00	8.80	0.00	0.00	0.00	0.00	0.00	0.00
2378	1294	CSt	1	0.00	9.20	0.00	0.00	1.00	0.00	0.00	0.00
2379	1296	CSt	0	0.00	9.80	0.00	0.00	0.00	0.00	0.00	0.00
2380	1297	CSt	1	0.00	28.80	1.41	0.00	0.00	0.00	0.00	0.00
2381	1298	CX	1	3.34	162.00	5.24	0.00	14.72	0.00	1.78	0.00
2382	1299	CX	1	3.88	152.80	0.00	0.00	15.54	12.04	0.00	0.00
2382	1300	CSt	1	0.00	26.80	3.68	0.00	4.74	0.00	0.00	0.00
2383	1301	CSt	1	0.00	41.40	2.42	0.00	0.00	0.00	0.00	0.00
2384	1302	CX	1	7.26	448.00	16.72	0.00	0.00	0.00	3.28	0.00
2385	1303	CSt	0	0.00	79.00	3.46	0.00	5.12	0.00	0.00	0.00
2386	1304	CSt	1	0.00	20.50	0.00	0.00	0.00	0.00	0.00	0.00
2387	1307	CX	0	4.02	812.00	2.82	0.00	26.40	0.00	0.00	0.00
2393	1309	CSt	0	0.00	34.40	0.00	0.00	0.00	0.00	0.00	0.00
2394	1310	CX	1	2.40	238.00	0.00	0.00	12.54	0.00	0.00	0.00
2396	1311	CSt	1	0.00	20.40	0.00	0.00	0.00	0.00	0.00	0.00

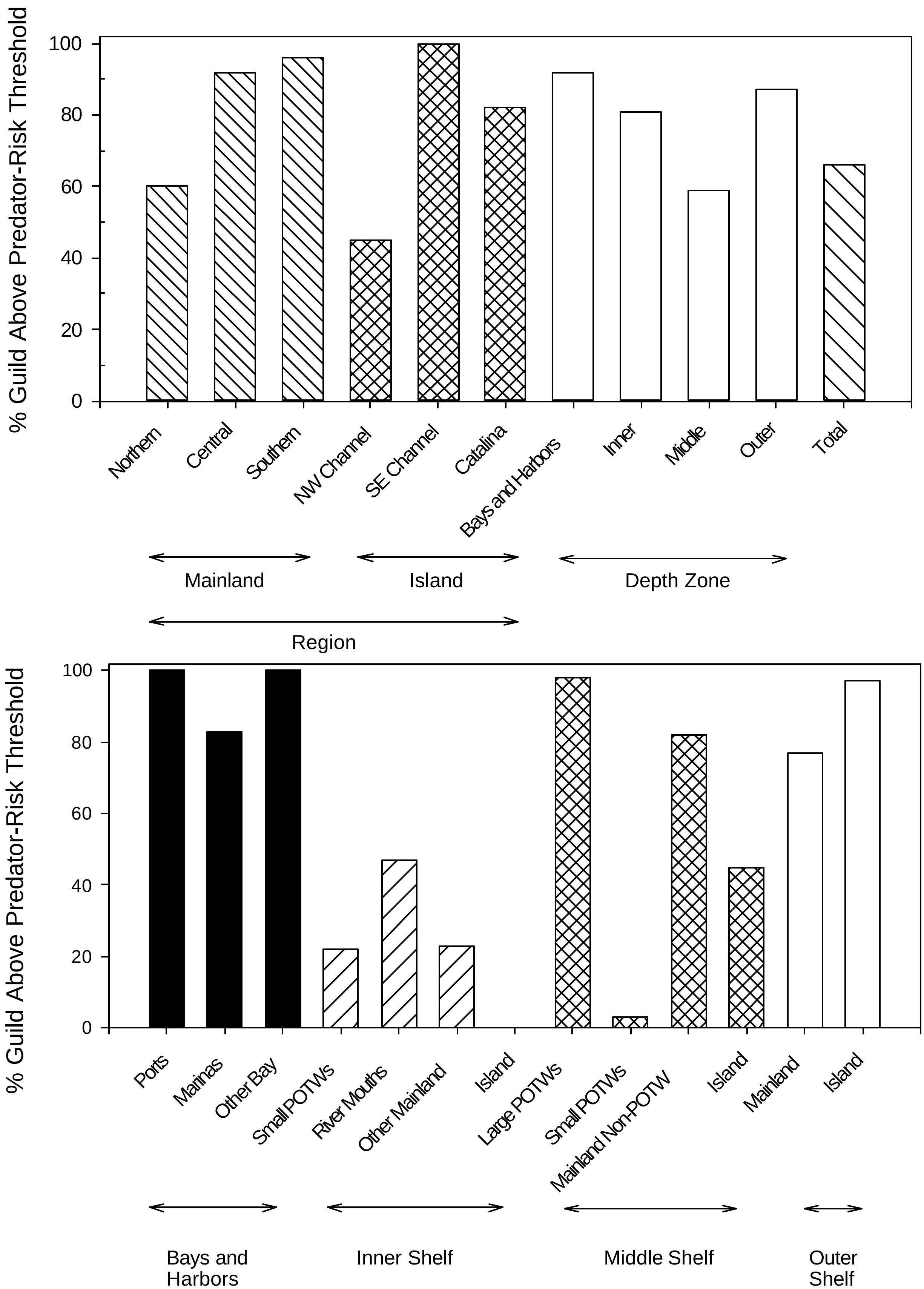
Appendix F2 (continued)

Station	CompID	Species	Age Class	Total DDT (ug/kg)						Total Chlordane	
				ppDDD	ppDDE	ppDDT	opDDD	opDDE	opDDT	Chlor-a	Chlor-g
2397	1313	CSt	1	0.00	26.40	0.00	0.00	0.00	0.00	0.00	0.00
2398	1314	CSt	1	0.00	21.40	0.00	0.00	0.00	0.00	0.00	0.00
2400	1315	CX	1	0.00	17.60	0.00	0.00	0.00	0.00	0.00	0.00
2401	1316	CX	1	0.00	14.20	0.00	0.00	0.00	0.00	0.00	0.00
2402	1318	CX	1	0.00	2.80	0.00	0.00	0.00	0.00	0.00	0.00
2403	1320	CX	1	0.00	23.20	0.00	0.00	0.00	0.00	0.00	0.00
2404	1322	CX		0.00	8.60	0.00	0.00	0.00	0.00	0.00	0.00
2405	1323	CX	1	0.00	14.80	0.00	0.00	0.00	0.00	0.00	0.00
2406	1325	PC	1	0.00	4.20	0.00	0.00	0.00	0.00	0.00	0.00
2407	1326	CX	1	0.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00
2408	1328	CX	1	0.00	15.00	0.00	0.00	1.20	0.00	0.00	0.00
2411	115991957	CX	1	0.00	26.00	0.00	0.00	0.00	0.00	0.00	0.00
2412	115991958	CX	1	0.00	16.20	0.00	0.00	0.00	0.00	0.00	0.00
2413	115991959	CX	1	0.00	14.80	0.00	0.00	0.00	0.00	0.00	0.00
2416	115991960	PC	1	0.00	22.00	0.00	0.00	0.00	0.00	0.00	0.00
2417	115991961	CSt	0	0.00	8.20	0.00	0.00	0.00	0.00	0.00	0.00
2418	115991962	CS	1	0.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00
2419	115991963	CX	1	0.00	28.00	0.00	0.00	0.00	0.00	0.00	0.00
2419	115991964	CS	1	0.00	17.20	0.00	0.00	0.00	0.00	0.00	0.00
2426	1345	PC	0	0.00	22.80	0.00	0.00	3.20	0.00	0.00	0.00
2436	115991965	PC	1	0.00	36.00	0.00	0.00	0.00	0.00	0.00	0.00
2444	1347	PC	1	0.00	7.40	0.00	0.00	0.00	0.00	0.00	0.00
2446	1348	PC	1	0.00	8.80	0.00	0.00	0.00	0.00	0.00	0.00
2447	1349	PC	1	0.80	17.80	0.00	0.00	0.00	0.00	0.00	0.00
2448	1350	PC	1	1.80	30.20	0.00	0.00	1.60	1.60	0.00	2.40
2461	115991966	LE	2	0.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00
2462	115991967	CS	1	0.00	12.20	0.00	0.00	0.00	0.00	0.00	0.00
2467	1354	CSt	1	1.73	5.04	0.00	0.00	0.00	0.00	0.00	0.00
2472	1356	CSt	1	0.00	11.60	0.00	0.00	0.00	0.00	0.00	11.36
2475	1357	CSt	1	0.00	7.08	0.00	0.00	0.00	0.00	0.00	0.00
2480	1358	CS	1	0.00	31.60	0.00	0.00	0.00	0.00	0.00	0.00
2483	1360	CS	0	0.00	5.16	0.00	0.00	0.00	0.00	0.00	0.00
2487	1361	CS	1	0.00	6.14	0.00	0.00	0.00	0.00	0.00	0.00
2487	1362	CSt	1	0.00	23.40	0.00	0.00	0.00	0.00	0.00	0.00
2490	1364	CS	1	0.00	16.98	0.00	0.00	0.00	0.00	0.00	0.00
2490	1365	CSt	1	0.00	12.22	0.00	0.00	0.00	0.00	0.00	0.00
2491	1368	CS	1	0.00	22.20	0.00	0.00	0.00	0.00	0.00	0.00
2492	1370	CS	1	0.00	23.00	2.76	0.00	0.00	0.00	0.00	0.00
2493	1373	CS	1	0.00	9.36	0.00	0.00	0.00	0.00	0.00	0.00
2493	1374	CSt	1	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.00
2494	1378	CS	2	0.00	29.20	3.00	0.00	0.00	0.00	0.00	0.00
2497	1380	CS	1	0.00	24.40	1.33	0.00	1.61	0.00	0.00	0.00
2499	1382	LE	1	0.00	32.80	2.86	0.00	0.00	0.00	0.00	0.00
2502	1385	CS	1	0.00	21.60	0.00	0.00	0.00	0.00	0.00	0.00
2512	1387	CS	1	2.39	137.49	13.24	0.00	2.36	0.00	0.60	0.00
2515	1392	CS	1	0.00	37.00	2.66	0.00	0.00	0.00	0.00	0.00
2516	1394	CS	1	0.00	23.10	0.00	0.00	0.00	0.00	0.00	0.00
2518	1397	CS	1	0.00	26.60	1.36	0.00	0.00	0.00	0.00	0.00

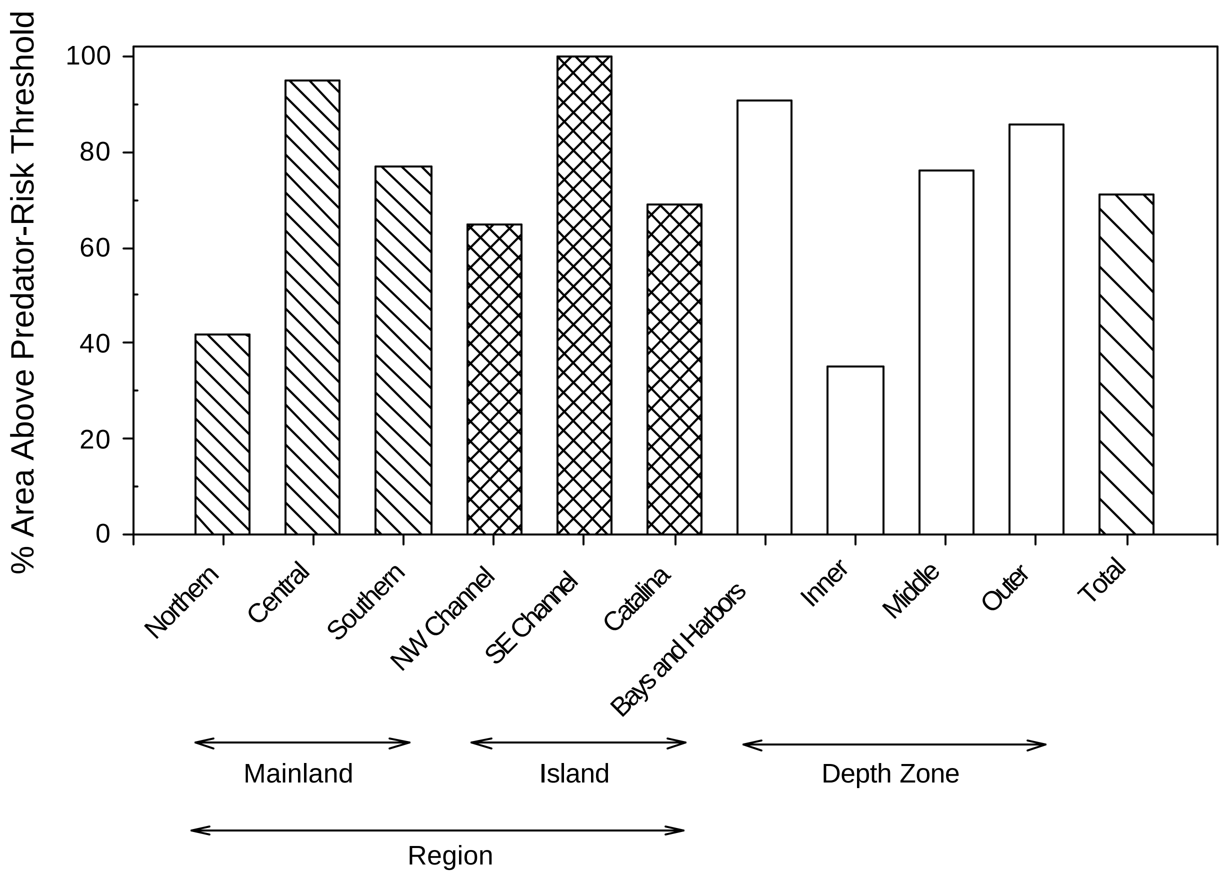
Appendix F2 (continued)

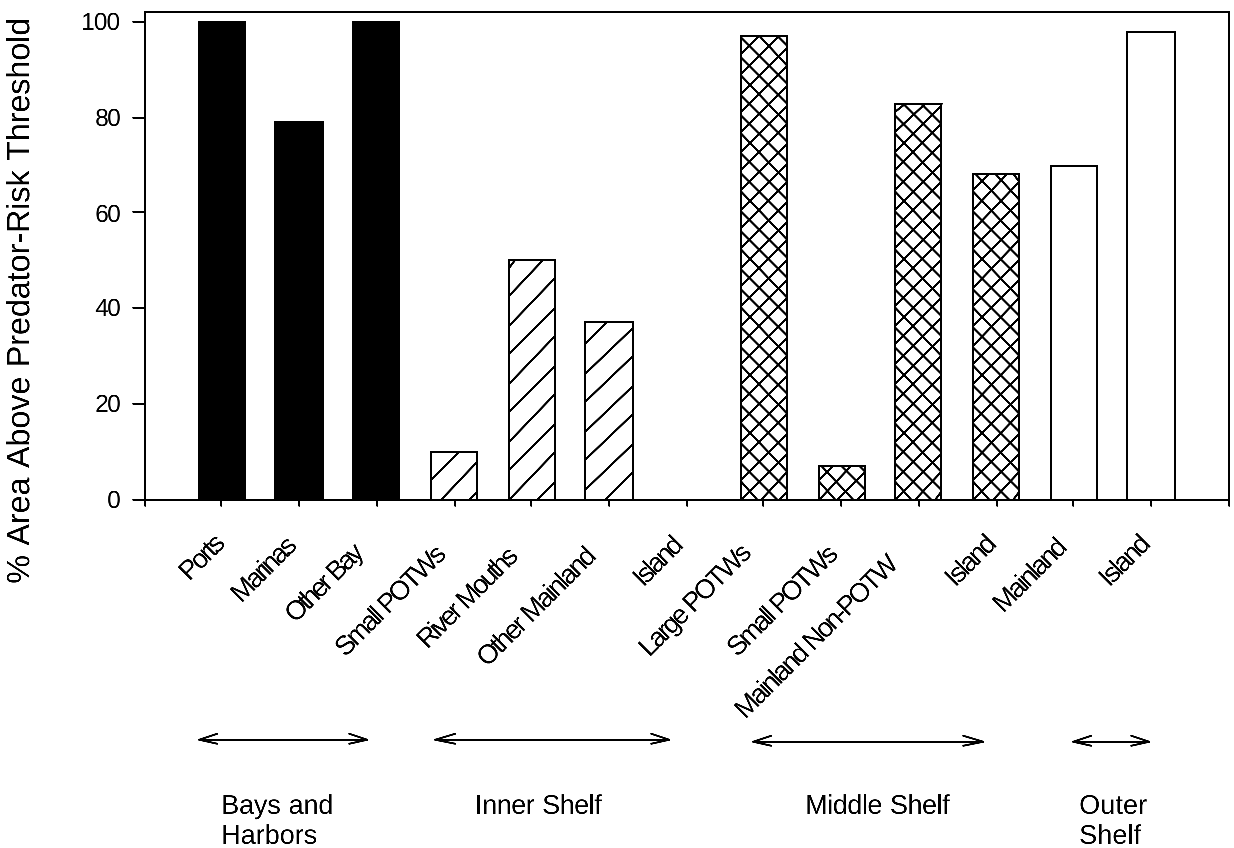
Station	CompID	Species	Age Class	Total DDT (ug/kg) ppDDD	ppDDE	ppDDT	opDDD	opDDE	opDDT	Total Chlordane Chlor-a	Chlor-g
2519	1400	CSt	1	0.00	17.57	0.00	0.00	0.00	0.00	0.00	0.00
2520	1401	CS	1	0.00	41.20	0.00	0.00	0.00	0.00	0.00	0.00
2522	1403	CS	1	0.00	37.80	0.00	0.00	0.00	7.92	0.00	0.00
2523	1406	CS	1	0.00	12.00	3.12	0.00	0.00	0.00	0.00	0.00
2525	1408	CS	1	0.00	58.80	4.16	0.00	0.00	0.00	0.00	0.00
2526	1410	CS	1	0.00	24.80	1.19	0.00	0.00	0.00	0.00	0.00
2528	1413	CS	1	0.00	28.40	3.28	0.00	0.00	0.00	0.00	0.00
2528	1414	LE	1	0.00	12.78	1.82	0.00	0.00	0.00	0.00	0.00
2528	1416	CS	2	2.70	21.00	0.00	0.00	0.00	0.00	0.00	0.00
2528	1417	LE	2	0.00	46.40	1.37	0.00	0.00	0.00	0.00	0.00
2531	1418	LE	1	0.00	33.40	1.59	0.00	0.00	0.00	0.00	0.00
2534	1421	LE	1	0.00	16.62	0.00	0.00	0.00	0.00	0.00	0.00
2537	1422	CS	1	0.00	38.00	3.82	0.00	0.00	0.00	0.00	0.00
2537	1423	LE	1	0.00	36.80	1.59	0.00	0.00	0.00	0.00	0.00
2537	1424	CS	2	0.00	42.80	3.84	0.00	2.84	0.00	0.00	0.00
2537	1425	LE	2	1.32	51.60	2.64	0.00	0.00	0.00	0.00	0.00
2538	1426	CS	1	0.00	37.60	0.00	0.00	0.00	0.00	0.00	0.00
2554	826981982	CX	1	0.00	160.00	0.00	0.00	8.40	0.00	0.00	0.00
2555	826981983	CX	1	0.00	152.00	0.00	0.00	8.20	0.00	0.00	0.00
2556	115991968	CX	1	0.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00
2558	827981985	PC	1	0.00	62.00	0.00	0.00	0.00	0.00	0.00	0.00
2559	827981986	PC	0	0.00	22.00	0.00	0.00	6.00	0.00	0.00	0.00
2580	821981987	PC	1	8.60	104.00	0.00	0.00	0.00	0.00	0.00	0.00
2591	826981984	PC	1	0.00	54.00	0.00	0.00	0.00	0.00	0.00	0.00
2593	1439	PC	1	6.78	164.80	15.66	0.00	0.00	0.00	5.20	0.00
2605	1440	CSt	1	0.00	10.64	1.19	0.00	0.00	0.00	0.00	0.00
2606	820981988	CSt	1	0.00	15.20	0.00	0.00	0.00	0.00	0.00	0.00
2607	820981989	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2608	819981990	CS	1	0.00	32.00	0.00	0.00	0.00	0.00	0.00	0.00
2609	819981991	CS	1	0.00	19.60	0.00	0.00	0.00	0.00	0.00	0.00
2610	1450	LE	1	1.20	37.20	0.00	0.00	1.20	1.60	0.00	0.00
2612	1454	CX	1	10.58	3,520.00	4.02	3.52	135.60	0.00	0.00	0.00

Multinumber station codes are City of San Diego, Metropolitan Wastewater Department stations sampled during the survey - age column indicates disparity in reported ages sent and analyzed.



Appendix F3. Percent of sanddab-guild fish with tDDT concentrations above predator-risk threshold by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.





Appendix F4. Percent of area with sanddab-guild fish above predator-risk threshold for tDDT by sub-population sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Appendix F5. Summary of tDDT (µg/kg) concentrations in longfin sanddab (*Citharichthys xanthostigma)* composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	76	100	2.1	7,606.4	18.0	197.6	115.4
Northern	4	100	5.2	36.8	6.8	8.4	2.7
Central	37	100	2.8	7,606.4	1,984.6	412.7	234.9
Southern	35	100	2.1	34.0	16.2	18.2	3.4
Island	5	100	7.0	30.7	13.0	18.6	8.7
Cool (NW Channel Islands)	0	---	---	---	---	---	---
Warm	5	100	7.0	30.7	13.0	18.6	8.7
SE Channel Islands	0	---	---	---	---	---	---
Santa Catalina Island	5	100	7.0	30.7	13.0	18.6	8.7
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	5	100	2.8	184.3	6.0	62.8	91.6
Small POTWs	2	100	3.6	4.0	37.0	3.9	0.3
River Mouths	0	---	---	---	---	---	---
Other Mainland	3	100	2.8	184.3	5.7	65.2	95.3
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	74	100	2.1	7,606.4	18.0	202.8	120.9
Small POTWs	14	100	2.1	30.6	5.5	7.3	3.4
Large POTWs	27	100	13.5	7,606.4	120.8	1,003.6	668.2
Mainland non-LPOTW	28	100	4.2	845.2	16.9	114.8	102.6
Island	5	100	7.0	30.6	13.0	18.6	8.7
Outer Shelf (121-202 m)	2	100	4.2	9.4	4.2	6.8	3.6
Mainland	2	100	4.2	9.4	4.2	3.0	6.0
Island	0	---	---	---	---	---	---
Total (all stations)	81	100	2.1	7,606.4	17.6	191.9	111.3

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

Appendix F6. Summary of tDDT (µg/kg) concentrations in Pacific sanddab (*Citharichthys sordidus*) composites by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	32	100	5.2	10,462.0	24.8	197.9	182.7
Northern	18	100	6.2	202.9	24.4	31.5	13.8
Central	6	100	39.1	10,462.0	454.5	1,166.4	1,174.9
Southern	8	100	5.2	28.0	17.1	19.3	4.4
Island	40	98	0.0	160.2	22.1	25.5	8.9
Cool (NW Channel Islands)	10	100	5.2	32.2	19.0	18.5	6.2
Warm	30	97	0.0	160.2	29.0	40.7	20.2
SE Channel Islands	12	100	15.2	160.2	37.6	46.9	26.5
Santa Catalina Island	18	94	0.0	62.0	19.2	22.3	7.3
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	1	100	8.0	8.0	8.0	8.0	---
Small POTWs	0	---	---	---	---	---	---
River Mouths	0	---	---	---	---	---	---
Other Mainland	1	100	8.0	8.0	8.0	8.0	---
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	42	98	0.0	10,462.0	22.6	95.7	82.0
Small POTWs	0	---	---	---	---	---	---
Large POTWs	6	100	16.8	10,462.0	39.1	3,169.8	3,482.8
Mainland non-LPOTW	12	100	7.2	1,061.4	24.8	126.5	175.5
Island	24	96.0	0.0	160.2	19.8	24.5	11.0
Outer Shelf (121-202 m)	29	100	2.0	202.9	27.6	37.1	14.1
Mainland	13	100	5.2	202.9	24.1	50.5	35.7
Island	16	100	2.0	63.0	27.5	29.6	4.6
Total (all stations)	72	99	0.0	10,462.0	23.3	82.3	62.9

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

Appendix F7. Summary of tDDT (µg/kg) concentrations in speckled sanddab (*Citharichthys stigmaeus*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	42	95	0.0	768.7	14.1	25.2	11.1
North	20	90	0.0	25.8	4.8	9.0	4.6
Central	16	100	20.4	768.7	26.4	49.3	26.2
South	6	100	2.6	9.2	7.2	7.9	0.7
Island	9	100	2.6	65.7	12.1	15.6	6.8
Cool (NW Channel Islands)	6	100	2.6	2.4	12.0	14.4	7.9
Warm	3	100	11.0	65.7	14.3	22.9	13.6
SE Channel Islands	1	100	17.6	17.6	17.6	17.6	---
Santa Catalina Island	2	100	11.0	65.7	38.4	38.4	37.8
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	35	94	0.0	87.6	10.1	17.8	8.1
Small POTWs	6	100	2.6	10.2	2.8	4.8	2.1
River Mouths	4	100	9.0	48.2	9.2	27.2	17.8
Other Mainland	21	90	0.0	87.6	10.2	18.5	8.8
Island	4	100	6.8	11.6	7.0	9.0	2.2
Middle Shelf (31-120 m)	15	100	4.8	768.7	20.0	28.5	15.7
Small POTWs	0	---	---	---	---	---	---
Large POTWs	5	100	26.1	768.7	116.3	282.3	242.2
Mainland non-LPOTW	6	100	4.8	25.8	20.2	180.0	7.7
Island	4	100.0	12.2	65.7	15.4	18.9	7.0
Outer Shelf (121-202 m)	1	100	2.6	2.6	2.6	2.6	---
Mainland	0	---	---	---	---	---	---
Island	1	100	2.6	2.6	2.6	2.6	---
Total (all stations)	51	96	0.0	768.7	12.5	21.8	7.7

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

Appendix F8. Summary of tDDT (µg/kg) concentrations in slender sole (*Lyopsetta exilis*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	14	100	5.9	217.6	30.6	54.3	34.3
Northern	6	100	5.9	166.4	30.8	61.7	43.5
Central	5	100	13.6	217.6	23.0	63.7	68.1
Southern	3	100	6.2	15.0	7.5	10.5	5.9
Island	10	100	5.2	42.2	35.1	29.5	6.9
Cool (NW Channel Islands)	1	100	35.7	35.7	---	---	---
Warm	9	100	5.2	42.2	21.5	25.1	7.6
SE Channel Islands	4	100	14.6	38.4	16.6	26.2	10.4
Santa Catalina Island	5	100	5.2	42.2	21.4	23.8	10.9
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
River Mouths	0	---	---	---	---	---	---
Other Mainland	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
Large POTWs	0	---	---	---	---	---	---
Mainland Non-LPOTW	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Outer Shelf (121-202 m)	24	100	5.2	217.6	31.2	44.3	21.2
Mainland	14	100	5.9	217.6	30.6	54.3	34.3
Island	10	100	5.2	42.2	35.1	29.5	6.9
Total (all stations)	24	100	5.2	217.6	31.2	44.3	21.2

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

Appendix F9. Summary of tDDT (µg/kg) concentrations in California halibut (*Paralichthys californicus*) composites by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	25	100	3.0	234.7	19.7	24.7	15.7
Northern	1	100	112.6	112.6	---	---	---
Central	13	100	7.4	234.7	25.6	52.0	34.1
Southern	11	100	3.0	70.0	19.1	15.8	11.2
Island	0	---	---	---	---	---	---
Cool (NW Channel Islands)	0	---	---	---	---	---	---
Warm	0	---	---	---	---	---	---
SE Channel Islands	0	---	---	---	---	---	---
Santa Catalina Island	0	---	---	---	---	---	---
Shelf Zone							
Bays and Harbors (2-30 m)	18	100	7.4	234.7	30.4	54.7	27.0
Ports	3	100	18.1	42.0	18.6	26.4	12.5
Marinas	9	100	7.4	234.7	48.5	83.0	51.8
Other Bay	6	100	26.0	70.0	27.5	34.4	9.6
Inner Shelf (2-30 m)	7	100	3.0	24.8	14.2	13.4	11.3
Small POTWs	1	100	19.2	19.2	---	---	---
River Mouths	4	100	3.0	24.8	9.2	15.0	9.0
Other Mainland	2	100	4.2	22.0	4.2	13.1	12.3
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
Large POTWs	0	---	---	---	---	---	---
Mainland non-LPOTW	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Outer Shelf (121-202 m)	0	---	---	---	---	---	---
Mainland	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Total (all stations)	25	100	3.0	234.7	19.7	24.7	15.7

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval;
POTW = Publicly owned treatment work monitoring areas.

Appendix F10. Summary of tChlordane (µg/kg) concentrations in longfin sanddab (*Citharichthys xanthostigma*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	76	9	0.0	10.4	0.0	0.4	0.3
Northern	4	0	0.0	0.0	0.0	0.0	0.0
Central	37	19	0.0	10.4	0.0	0.8	0.7
Southern	35	0	0.0	0.0	0.0	0.0	0.0
Island	5	0	0.0	0.0	0.0	0.0	0.0
Cool (NW Channel Islands)	0	---	---	---	---	---	---
Warm	5	0	0.0	0.0	0.0	0.0	0.0
SE Channel Islands	0	---	---	---	---	---	---
Santa Catalina Island	5	0	0.0	0.0	0.0	0.0	0.0
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	5	0	0.0	0.0	0.0	0.0	0.0
Small POTWs	2	0	0.0	0.0	0.0	0.0	0.0
River Mouths	0	---	---	---	---	---	---
Other Mainland	3	0	0.0	0.0	0.0	0.0	0.0
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	74	9	0.0	10.4	0.0	0.4	0.4
Small POTWs	14	0	0.0	0.0	0.0	0.0	0.0
Large POTWs	27	19	0.0	10.4	0.0	1.2	1.0
Mainland non-LPOTW	28	7	0.0	3.3	0.0	0.3	0.4
Island	5	0	0.0	0.0	0.0	0.0	0.0
Outer Shelf (121-202 m)	2	0	0.0	0.0	0.0	0.0	0.0
Mainland	2	0	0.0	0.0	0.0	0.0	0.0
Island	0	---	---	---	---	---	---
Total (all stations)	81	9	0.0	10.4	0.0	0.3	0.3

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

Appendix F11. Summary of tChlordane (µg/kg) concentrations in Pacific sanddab (*Citharichthys sordidus*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	32	6	0.0	1.7	0.0	0.1	0.2
Northern	18	6	0.0	1.5	0.0	0.1	0.1
Central	6	17	0.0	1.7	0.0	0.7	1.0
Southern	8	0	0.0	0.0	0.0	0.0	0.0
Island	40	5	0.0	1.0	0.0	0.0	0.0
Cool (NW Channel Islands)	10	0	0.0	0.0	0.0	0.0	0.0
Warm	30	7	0.0	1.0	0.0	0.1	0.1
SE Channel Islands	12	8	0.0	0.6	0.0	0.1	0.1
Catalina Island	18	6	0.0	0.0	0.0	0.1	0.1
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	1	0	0.0	0.0	0.0	0.0	0.0
Small POTWs	0	---	---	---	---	---	---
River Mouths	0	---	---	---	---	---	---
Other Mainland	1	0	0.0	0.0	0.0	0.0	0.0
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	42	5	0.0	1.7	0.0	0.1	0.1
Small POTWs	0	---	---	---	---	---	---
Large POTWs	6	0	0.0	0.0	0.0	0.0	0.0
Mainland non-LPOTW	12	8	0.0	1.7	0.0	0.2	0.3
Island	24	4.0	0.0	0.6	0.0	0.0	0.0
Outer Shelf (121-202 m)	29	7	0.0	1.5	0.0	0.1	0.1
Mainland	13	8	0.0	1.5	0.0	0.1	0.3
Island	16	6	0.0	1.0	0.0	0.0	0.1
Total (all stations)	72	6	0.0	1.7	0.0	0.1	0.1

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval;
POTW = Publicly owned treatment work monitoring areas.

Appendix F12. Summary of tChlordane (µg/kg) concentrations in speckled sanddab (*Citharichthys stigmaeus*) composites by subpopulation, on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	42	5	0.0	14.6	0.0	0.0	0.0
Northern	20	0	0.0	0.0	0.0	0.0	0.0
Central	16	33	0.0	14.6	0.0	0.3	0.5
Southern	6	0	0.0	0.0	0.0	0.0	0.0
Island	9	11	0.0	11.1	0.0	0.3	0.6
Cool (NW Channel Islands)	6	17	0.0	11.4	0.0	0.3	0.7
Warm	3	0	0.0	0.0	0.0	0.0	0.0
SE Channel Islands	1	0	0.0	0.0	0.0	0.0	0.0
Catalina Island	2	0	0.0	0.0	0.0	0.0	0.0
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	35	3	0.0	11.4	0.0	0.2	0.4
Small POTWs	6	0	0.0	0.0	0.0	0.0	0.0
River Mouths	4	0	0.0	0.0	0.0	0.0	0.0
Other Mainland	21	0	0.0	0.0	0.0	0.0	0.0
Island	4	25	0.0	11.4	0.0	3.0	5.0
Middle Shelf (31-120 m)	15	13	0.0	14.6	0.0	0.2	0.3
Small POTWs	0	---	---	---	---	---	---
Large POTWs	5	40	0.0	14.6	0.0	4.9	5.4
Mainland non-LPOTW	6	0	0.0	0.0	0.0	0.0	0.0
Island	4	0	0.0	0.0	0.0	0.0	0.0
Outer Shelf (121-202 m)	1	0	0.0	0.0	0.0	0.0	0.0
Mainland	0	---	---	---	---	---	---
Island	1	0	0.0	0.0	0.0	0.0	0.0
Total (all stations)	51	6	0.0	14.6	0.0	0.2	0.2

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval
POTW = Publicly owned treatment work monitoring areas.

Appendix F13. Summary of tChlordane (µg/kg) concentrations in slender sole (*Lyopsetta exilis*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	14	14	0.0	10.1	0.0	0.9	1.5
Northern	6	17	0.0	10.1	0.0	1.7	3.0
Central	5	20	0.0	2.0	0.0	0.4	0.7
Southern	3	0	0.0	0.0	0.0	0.0	0.0
Island	10	0	0.0	0.0	0.0	0.0	0.0
Cool (NW Channel Islands)	1	0	0.0	0.0	0.0	0.0	0.0
Warm	9	0	0.0	0.0	0.0	0.0	0.0
SE Channel Islands	4	0	0.0	0.0	0.0	0.0	0.0
Catalina Island	5	0	0.0	0.0	0.0	0.0	0.0
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
River Mouths	0	---	---	---	---	---	---
Other Mainland	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
Large POTWs	0	---	---	---	---	---	---
Mainland non-LPOTW	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Outer Shelf (121-202 m)	24	8	0.0	10.1	0.0	0.6	0.9
Mainland	14	14	0.0	10.1	0.0	0.9	1.5
Island	10	0	0.0	0.0	0.0	0.0	0.0
Total (all stations)	24	8	0.0	10.1	0.0	0.6	0.9

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interva
POTW = Publicly owned treatment work monitoring areas.

Appendix F14. Summary of tChlordane (µg/kg) concentrations in California halibut (*Paralichthys californicus*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	25	12	0.0	5.2	0.0	0.2	0.3
Northern	1	0	0.0	0.0	0.0	0.0	0.0
Central	13	23	0.0	5.2	0.0	0.8	0.9
Southern	11	0	0.0	0.0	0.0	0.0	0.0
Island	0	---	---	---	---	---	---
Cool (NW Channel Islands)	0	---	---	---	---	---	---
Warm	0	---	---	---	---	---	---
SE Channel Islands	0	---	---	---	---	---	---
Catalina Island	0	---	---	---	---	---	---
Shelf Zone							
Bays and Harbors (2-30 m)	18	17	0.0	5.2	0.0	0.6	0.7
Ports	3	0	0.0	0.0	0.0	0.0	0.0
Marinas	9	33	0.0	5.2	0.0	1.4	1.3
Other Bay	6	0	0.0	0.0	0.0	0.0	0.0
Inner Shelf (2-30 m)	7	0	0.0	0.0	0.0	0.0	0.0
Small POTWs	1	0	0.0	0.0	0.0	0.0	0.0
River Mouths	4	0	0.0	0.0	0.0	0.0	0.0
Other Mainland	2	0	0.0	0.0	0.0	0.0	0.0
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
Large POTWs	0	---	---	---	---	---	---
Mainland non-LPOTW	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Outer Shelf (121-202 m)	0	---	---	---	---	---	---
Mainland	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Total (all stations)	25	12	0.0	5.2	0.0	0.2	0.3

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

Appendix F15. Summary of tPCB (µg/kg) concentrations in longfin sanddab (*Citharichthys xanthostigma*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	76	42	0.0	390.9	1.2	21.3	12.2
Northern	4	25	0.0	4.6	0.0	0.0	0.0
Central	37	76	0.0	390.8	194.4	46.1	22.7
Southern	35	9	0.0	2.0	0.0	0.5	0.5
Island	5	40	0.0	4.6	0.0	1.6	1.7
Cool (NW Channel Islands)	0	---	---	---	---	---	---
Warm	5	40	0.0	4.6	0.0	1.6	1.7
SE Channel Islands	0	---	---	---	---	---	---
Catalina Island	5	40	0.0	4.6	0.0	1.6	1.7
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	5	20	0.0	36.0	0.0	11.5	18.5
Small POTWs	2	0	0.0	0	0.0	0	0.0
River Mouths	0	---	---	---	---	---	---
Other Mainland	3	33	0.0	36.0	0.0	12.0	19.2
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	74	45	0.0	390.9	1.2	21.5	12.7
Small POTWs	14	0	0.0	0	0.0	0	0.0
Large POTWs	27	70	0.0	390.9	26.8	89.7	44.5
Mainland non-LPOTW	28	43	0.0	101.2	1.2	14.3	13.3
Island	5	40	0.0	4.6	0.0	1.6	1.7
Outer Shelf (121-202 m)	2	0	0.0	0	0.0	0	0.0
Mainland	2	0	0.0	0	0.0	0	0.0
Island	0	---	---	---	---	---	---
Total (all stations)	81	42	0.0	390.9	1.2	20.7	11.8

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval
POTW = Publicly owned treatment work monitoring areas.

Appendix F16. Summary of tPCB (μg/kg) concentrations in Pacific sanddab (*Citharichthys sordidus*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	32	44	0.0	710.3	0.0	16.3	15.3
Northern	18	39	0.0	19.4	0.0	3.2	3.4
Central	6	100	9.1	710.3	17.7	94.9	88.0
Southern	8	13	0.0	2.0	0.0	0.0	0.0
Island	40	53	0.0	69.8	0.0	3.5	3.7
Cool (NW Channel Islands)	10	20	0.0	3.8	0.0	0.5	0.8
Warm	30	63	0.0	69.8	3.5	10.0	10.0
SE Channel Islands	12	83	0.0	69.8	4.7	12.0	13.3
Catalina Island	18	50	0.0	27.7	0.0	3.9	3.2
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	1	0	0.0	0.0	0.0	0.0	---
Small POTWs	0	---	---	---	---	---	---
River Mouths	0	---	---	---	---	---	---
Other Mainland	1	0	0.0	0.0	0.0	0.0	---
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	42	52	0.0	710.3	0.0	9.2	7.7
Small POTWs	0	---	---	---	---	---	---
Large POTWs	6	67	0.0	710.3	10.1	221.2	219.8
Mainland non-LPOTW	12	42	0.0	105.4	0.0	12.5	17.7
Island	24	54	0.0	69.8	0.0	3.7	4.6
Outer Shelf (121-202 m)	29	45	0.0	27.7	0.0	2.9	2.0
Mainland	13	38	0.0	16.6	0.0	3.3	3.1
Island	16	50	0.0	27.7	0.0	2.7	2.6
Total (all stations)	72	49	0.0	710.3	0.0	7.7	5.9

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval
POTW = Publicly owned treatment work monitoring areas.

Appendix F17. Summary of tPCB (µg/kg) concentrations in speckled sanddab (*Citharichthys stigmaeus*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	42	33	0.0	188.0	0.0	3.9	3.1
Northern	20	10	0.0	4.2	0.0	0.6	0.9
Central	16	75	0.0	188.0	0.0	8.8	8.3
Southern	6	0	0.0	0.0	0.0	0.0	0.0
Island	9	22	0.0	9.3	0.0	0.3	0.5
Cool (NW Channel Islands)	6	33	0.0	9.3	0.0	0.3	0.6
Warm	3	0	0.0	0.0	0.0	0.0	0.0
SE Channel Islands	1	0	0.0	0.0	0.0	0.0	0.0
Catalina Island	2	0	0.0	0.0	0.0	0.0	0.0
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	35	29	0.0	36.6	0.0	2.9	3.3
Small POTWs	6	0	0.0	0.0	0.0	0.0	0.0
River Mouths	4		0.0	18.4	0.0	7.4	7.7
Other Mainland	21	29	0.0	36.6	0.0	2.9	3.4
Island	4	50	0.0	9.3	0.2	2.9	3.9
Middle Shelf (31-120 m)	15	40	0.0	188.0	0.0	2.6	3.6
Small POTWs	0	---	---	---	---	---	---
Large POTWs	5	100	3.0	188.0	17.4	58.7	60.3
Mainland non-LPOTW	6	17	0.0	4.2	0.0	1.0	1.8
Island	4	0	0.0	0.0	0.0	0.0	0.0
Outer Shelf (121-202 m)	1	0	0.0	0.0	0.0	0.0	0.0
Mainland	0	---	---	---	---	---	---
Island	1	0	0.0	0.0	0.0	0.0	0.0
Total (all stations)	51	31	0.0	188.0	0.0	2.6	2.3

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval;
POTW = Publicly owned treatment work monitoring areas.

Appendix F18. Summary of tPCB (µg/kg) concentrations in slender sole (*Lyopsetta exilis*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	14	50	0.0	48.4	0.5	7.0	7.2
Northern	6	50	0.0	21.2	0.0	5.0	6.0
Central	5	80	0.0	48.4	1.4	12.2	16.2
Southern	3	0	0.0	0.0	0.0	0.0	0.0
Island	10	40	0.0	6.9	0.4	1.3	0.8
Cool (NW Channel Islands)	1	100	1.6	1.6	---	---	---
Warm	9	33	0.0	6.9	0.0	1.2	1.3
SE Channel Islands	4	25	0.0	1.7	0.0	0.4	0.7
Catalina Island	5	40	0.0	6.9	0.0	2.2	2.5
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
River Mouths	0	---	---	---	---	---	---
Other Mainland	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
Large POTWs	0	---	---	---	---	---	---
Mainland non-LPOTW	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Outer Shelf (121-202 m)	24	46	0.0	48.4	1.1	4.7	4.7
Mainland	14	50	0.0	48.4	0.5	7.0	7.2
Island	10	40	0.0	6.9	0.4	1.3	0.8
Total (all stations)	24	46	0.0	48.4	1.1	4.7	4.5

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

Appendix F19. Summary of tPCB (µg/kg) concentrations in California halibut (*Paralichthys californicus*) composites by subpopulation sampledon the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	25	68	0.0	323.0	0.0	24.1	26.6
Northern	1	0	0.0	0.0	---	---	---
Central	13	77	0.0	103.3	9.5	18.5	13.7
Southern	11	64	0.0	323.0	0.0	26.1	35.9
Island	0	---	---	---	---	---	---
Cool (NW Channel Islands)	0	---	---	---	---	---	---
Warm	0	---	---	---	---	---	---
SE Channel Islands	0	---	---	---	---	---	---
Catalina Island	0	---	---	---	---	---	---
Shelf Zone							
Bays and Harbors (2-30 m)	18	78	0.0	323.0	19.9	86.7	50.4
Ports	3	100	62.8	254.0	155.6	188.4	100.5
Marinas	9	67	0.0	103.3	8.8	25.4	21.2
Other Bay	6	83	0.0	323.0	12.1	114.2	107.3
Inner Shelf (2-30 m)	7	43	0.0	13.8	0.0	0.4	0.8
Small POTWs	1	100	13.8	13.8	---	---	---
River Mouths	4	50	0.0	4.0	0.0	1.4	1.6
Other Mainland	2	0	0.0	0.0	0.0	0.0	0.0
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
Large POTWs	0	---	---	---	---	---	---
Mainland non-LPOTW	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Outer Shelf (121-202 m)	0	---	---	---	---	---	---
Mainland	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Total (all stations)	25	68	0.0	323.0	0.0	24.1	26.6

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

Appendix F20. Concentrations of "dirty dozen" PCB congeners in whole fish composites of sanddab guild species at stations sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

			Age	Individual PCB Congeners used to Calculate PCB TEQs (µg/kg)											
Station	CompID	Species	Class	77	81	105	114	118	123	126	156	157	167	169	189
2065	1001	LE	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2067	1004	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2067	1005	CS	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2067	1006	LE	2	0.00	0.00	0.00	0.00	2.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2069	1007	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2070	1010	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2071	1012	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2072	1013	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2073	1015	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2074	1018	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2075	1021	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2076	1024	CS	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2076	1025	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2076	1026	LE	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2077	1027	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2078	1029	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2079	1032	CX	1	0.00	0.00	0.00	0.53	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2082	1035	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2084	1039	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2085	1041	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2085	1042	LE	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2085	1043	CS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2085	1044	LE		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2087	1045	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2088	1048	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2089	1050	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2090	1053	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2091	1056	CX	1	0.00	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2092	1060	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2093	1062	CS	1	1.48	0.00	0.00	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2094	1064	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2094	1065	LE		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2094	1066	CS	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2095	1068	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2096	1071	CS	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2097	1072	LE	1	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2098	1073	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2099	1075	CS	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2099	1076	LE		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2099	1078	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2099	1079	LE	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2100	1080	CS	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2100	1081	LE	1	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2100	1083	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2100	1084	LE	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2105	1085	LE	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2110	1088	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2111	1090	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2112	1092	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2113	1094	CS	1	0.00	0.00	0.00	0.00	2.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2113	1095	LE	1	1.84	0.00	0.00	0.00	1.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix F20 (continued)

Station	CompID	Species	Age Class	Individual PCB Congeners used to Calculate PCB TEQs (ug/kg) 77	81	105	114	118	123	126	156	157	167	169	189
2113	1096	CS	2	0.00	0.00	2.16	0.00	3.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2113	1097	LE	2	0.00	0.00	0.00	0.00	1.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2114	1098	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2114	1099	LE	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2114	1100	CS	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2114	1101	LE	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2115	1102	CS	1	0.00	0.00	0.00	3.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2116	1103	LE	1	0.00	0.00	0.00	0.00	5.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2117	1104	LE	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2118	1168	CS	1	0.00	0.00	4.44	0.00	11.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2119	1109	LE	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2120	1111	LE	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2122	1114	LE	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2147	1116	PC	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.82	0.00	0.00	0.00	0.00
2189	1117	CX	1	0.00	0.00	0.00	1.94	21.20	0.00	0.00	0.00	0.00	1.20	0.00	0.00
2190	1118	CX	1	0.00	2.80	0.00	9.14	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2191	1120	CX	1	0.00	0.00	13.28	0.00	32.60	2.92	0.00	3.78	0.00	1.68	0.00	0.00
2191	1121	CS	1	0.00	0.00	6.96	0.00	15.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2192	1123	CX	1	0.00	4.66	5.34	0.00	12.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2194	1125	CX	1	0.00	0.00	4.66	0.00	15.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2195	1127	CX	1	0.00	0.00	20.66	0.00	45.30	4.14	0.00	0.00	0.00	1.85	0.00	0.00
2195	1128	CSt	1	0.00	0.00	7.22	0.00	19.84	2.36	0.00	0.00	0.00	0.00	0.00	0.00
2197	1129	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2198	1130	CSt	1	0.00	0.00	3.08	0.00	7.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2200	1131	CX	1	0.00	0.00	12.16	0.00	33.60	0.00	0.00	2.44	0.00	0.00	0.00	0.00
2201	1133	CS	1	0.00	0.00	20.80	0.00	52.00	0.00	0.00	2.86	0.00	0.00	0.00	0.00
2202	1134	CX	1	0.00	0.00	17.48	0.00	47.20	0.00	0.00	3.70	0.00	0.00	0.00	0.00
2204	1136	CS	1	0.00	0.00	28.00	2.64	67.20	0.00	0.00	3.72	0.00	0.00	0.00	0.00
2205	1138	CX	1	0.00	0.00	7.20	0.00	18.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2206	1139	CX	1	0.00	0.00	6.14	2.32	15.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2206	1140	CSt	1	0.00	0.00	0.00	0.00	3.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2207	1141	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.82	0.00	0.00	0.00	0.00
2208	1142	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2209	1144	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2210	1147	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2211	1149	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2212	1151	CX	1	0.00	0.00	0.00	0.00	4.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2212	1152	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2213	1154	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2213	1155	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2214	803981937	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2215	803981938	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2216	804981939	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2216	804981940	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2217	731981941	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2218	731981942	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2219	730981944	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2220	731981943	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2233	814981945	PC	1	0.00	0.00	0.00	0.00	28.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2242	813981946	PC	1	0.00	0.00	0.00	0.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2244	818981947	PC	1	0.00	0.00	0.00	0.00	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2254	813981992	PC	1	0.00	0.00	0.00	0.00	28.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2256	817981949	PC	1	0.00	0.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix F20 (continued)

Station	CompID	Species	Age Class	Individual PCB Congeners used to Calculate PCB TEQs (ug/kg) 77	81	105	114	118	123	126	156	157	167	169	189
2262	818981948	PC	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2267	1179	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2268	1181	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2274	1183	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2276	1184	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2277	1185	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2278	1187	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2280	1189	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2281	1190	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2282	1192	CSt	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2283	1193	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2284	1194	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2285	1195	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2286	1197	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2287	1198	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2288	1199	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2289	1200	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2290	1203	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2290	1204	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2291	1208	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2292	1210	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2292	1211	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2292	1212	LE		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2293	1214	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2294	1216	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2295	1217	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2296	1219	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2298	1220	PC	0	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2302	1221	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2303	1222	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2306	1224	CSt	1	2.22	0.00	0.00	0.00	5.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2312	1225	CX	1	0.00	0.00	0.00	0.00	2.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2314	1227	CSt	1	0.00	0.00	0.00	0.00	1.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2317	807981950	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2319	1230	PC	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2320	1231	PC	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2322	1232	CSt	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2324	1233	PC	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2333	1234	PC	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2341	1235	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2343	1236	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2344	1238	CX	1	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2345	1239	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2346	1240	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2347	1243	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2348	1244	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2349	806981951	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2350	806981952	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2351	806981953	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2352	715981954	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2352	715981955	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2353	115991956	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2354	1261	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix F20 (continued)

Station	CompID	Species	Age Class	Individual PCB Congeners used to Calculate PCB TEQs (ug/kg) 77	81	105	114	118	123	126	156	157	167	169	189
2355	1263	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2356	1265	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2357	1267	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2358	1269	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2359	1271	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2359	1272	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2360	1275	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2361	1277	CSt	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2362	1278	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2364	1280	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2364	1281	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2364	1282	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2365	1284	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2368	1285	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2372	1286	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2373	1289	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2374	1290	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2375	1292	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2377	1293	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2378	1294	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2379	1296	CSt	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2380	1297	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2381	1298	CX	1	0.00	0.00	0.00	0.00	3.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2382	1299	CX	1	0.00	0.00	0.00	0.00	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2382	1300	CSt	1	0.00	0.00	0.00	0.00	1.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2383	1301	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2384	1302	CX	1	0.00	0.00	3.12	0.00	11.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2385	1303	CSt	0	0.00	0.00	0.00	0.00	2.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2386	1304	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2387	1307	CX	0	0.00	0.00	4.08	0.00	12.86	0.00	0.00	0.00	0.00	0.00	2.92	0.00
2393	1309	CSt	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2394	1310	CX	1	0.00	0.00	0.00	0.00	3.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2396	1311	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2397	1313	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2398	1314	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2400	1315	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2401	1316	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2402	1318	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2403	1320	CX	1	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2404	1322	CX		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2405	1323	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2406	1325	PC	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2407	1326	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2408	1328	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2411	115991957	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2412	115991958	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2413	115991959	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2416	115991960	PC	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2417	115991961	CSt	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2418	115991962	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2419	115991963	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2419	115991964	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2426	1345	PC	0	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

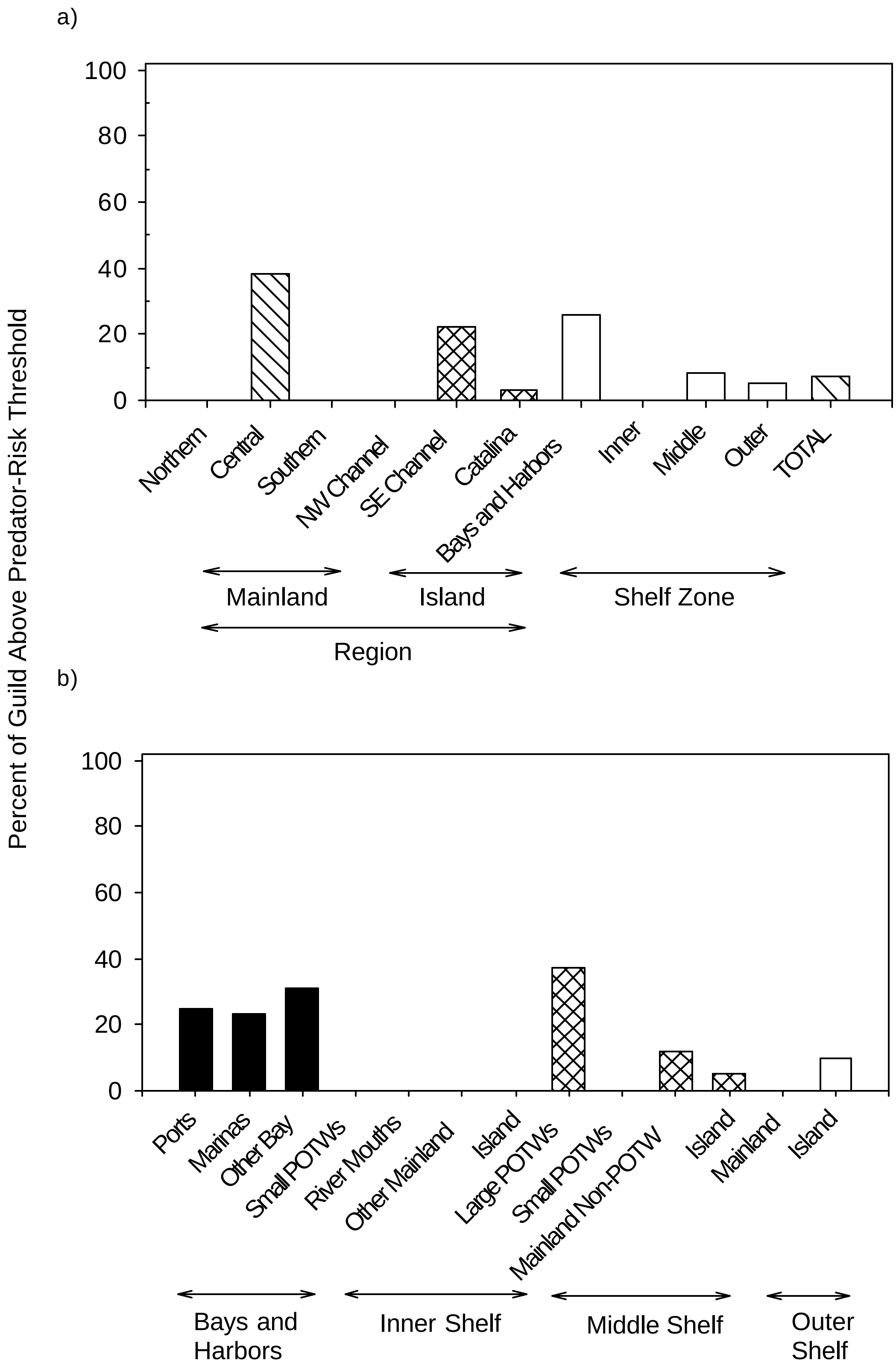
Appendix F20 (continued)

Station	CompID	Species	Age Class	Individual PCB Congeners used to Calculate PCB TEQs (ug/kg) 77	81	105	114	118	123	126	156	157	167	169	189
2436	115991965	PC	1	0.00	0.00	0.00	0.00	17.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2444	1347	PC	1	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2446	1348	PC	1	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2447	1349	PC	1	0.00	0.00	1.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2448	1350	PC	1	0.00	0.00	1.80	0.00	4.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2461	115991966	LE	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2462	115991967	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2467	1354	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2472	1356	CSt	1	0.00	0.00	0.00	0.00	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2475	1357	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2480	1358	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2483	1360	CS	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2487	1361	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2487	1362	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2490	1364	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2490	1365	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2491	1368	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2492	1370	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2493	1373	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2493	1374	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2494	1378	CS	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2497	1380	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2499	1382	LE	1	0.00	0.00	0.00	0.00	1.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2502	1385	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2512	1387	CS	1	0.00	4.37	2.20	0.00	7.38	0.00	0.00	0.82	0.00	0.00	0.00	0.00
2515	1392	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2516	1394	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2518	1397	CS	1	4.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2519	1400	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2520	1401	CS	1	0.00	0.00	0.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2522	1403	CS	1	0.00	0.00	0.00	0.00	1.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2523	1406	CS	1	1.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2525	1408	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2526	1410	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2528	1413	CS	1	0.00	0.00	0.00	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2528	1414	LE	1	0.00	0.00	0.00	1.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2528	1416	CS	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2528	1417	LE	2	5.38	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2531	1418	LE	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2534	1421	LE	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2537	1422	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2537	1423	LE	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2537	1424	CS	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2537	1425	LE	2	0.00	0.00	3.14	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2538	1426	CS	1	0.00	0.00	2.46	0.00	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2554	826981982	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2555	826981983	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2556	115991968	CX	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2558	827981985	PC	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2559	827981986	PC	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2580	821981987	PC	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2591	826981984	PC	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2593	1439	PC	1	0.00	0.00	2.32	0.00	11.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix F20 (continued)

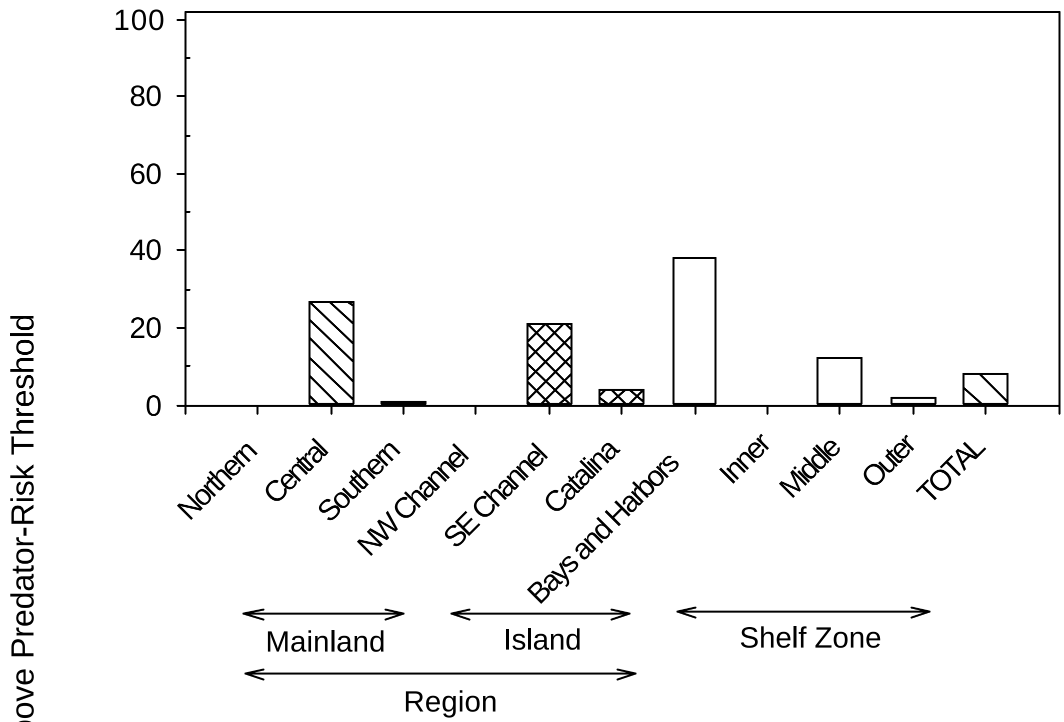
Station	CompID	Species	Age Class	Individual PCB Congeners used to Calculate PCB TEQs (ug/kg) 77	81	105	114	118	123	126	156	157	167	169	189
2605	1440	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2606	820981988	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2607	820981989	CSt	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2608	819981990	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2609	819981991	CS	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2610	1450	LE	1	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2612	1454	CX	1	0.00	0.00	7.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Multinumber station codes are City of San Diego, Metropolitan Wastewater Department stations sampled during the survey - age column indicates disparity in reported ages sent and analyzed.

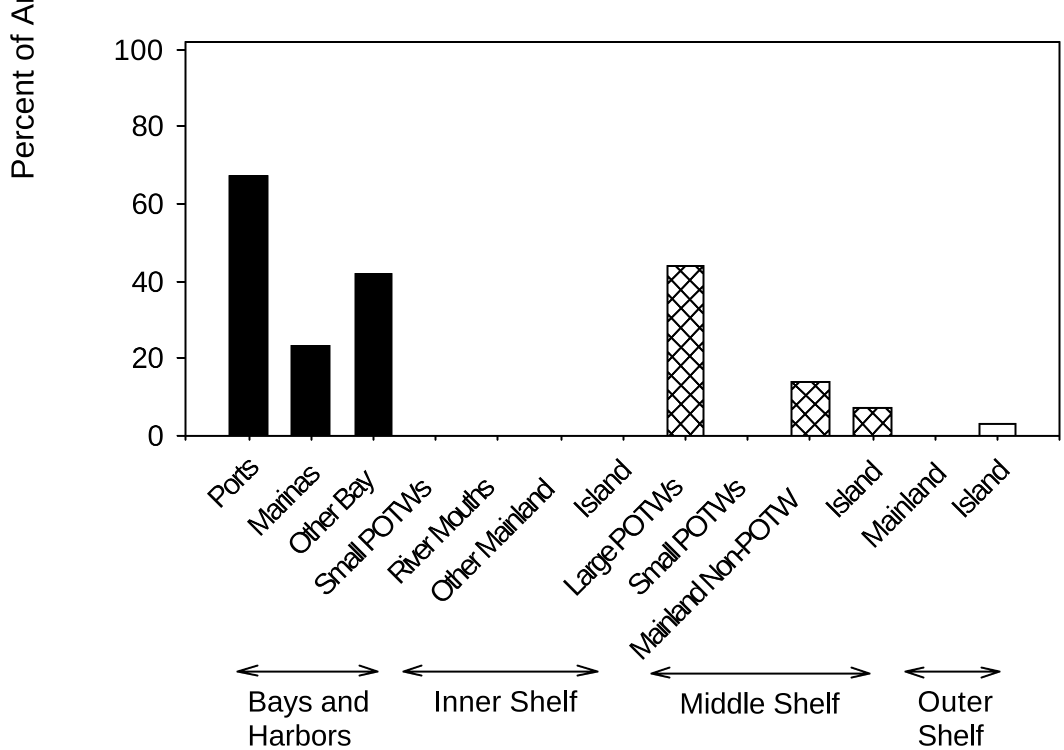


Appendix F21. Percent of sanddab guild fish with tPCB concentrations above predator-risk threshold for mammals by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

a)



b)



Appendix F22. Percent of area with sanddab guild composites above predator-risk threshold for PCB TEQs (ng/kg) for mammals by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

Appendix F23. Summary of tPCB TEQ (ng/kg) concentrations for mammals in longfin sanddab (*Citharichthys xanthostigma*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range		Area-Weighted Values		
			Min.	Max.	Median	Mean	95% CI
Region							
Mainland	76	26	0.00	30.89	0.00	1.74	2.73
Northern	4	25	0.00	0.14	0.00	0.00	0.00
Central	37	51	0.00	30.89	0.37	3.79	5.69
Southern	35	0	0.00	0.00	0.00	0.00	0.00
Island	5	40	0.00	0.38	0.00	0.09	0.13
Cool (NW Channel Islands)	0	---	---	---	---	---	---
Warm	5	40	0.00	0.38	0.00	0.09	0.13
SE Channel Islands	0	---	---	---	---	---	---
Catalina Island	5	40	0.00	0.38	0.00	0.09	0.13
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	5	20	0.00	0.37	0.00	0.12	0.19
Small POTWs	2	0	0.00	0.00	0.00	0.00	0.00
River Mouths	0	---	---	---	---	---	---
Other Mainland	3	33	0.00	0.37	0.00	0.12	0.19
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	74	28	0.00	30.89	0.00	1.82	2.87
Small POTWs	14	0	0.00	0.00	0.00	0.00	0.00
Large POTWs	27	44	0.00	8.31	0.00	1.78	0.98
Mainland non-LPOTW	28	25	0.00	30.89	0.00	1.93	3.40
Island	5	40	0.00	0.38	0.00	0.09	0.13
Outer Shelf (121-202 m)	2	0	0.00	0.00	0.00	0.00	0.00
Mainland	2	0	0.00	0.00	0.00	0.00	0.00
Island	0	---	---	---	---	---	---
Total (all stations)	81	27	0.00	30.89	0.00	1.68	2.65

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

Appendix F24. Summary of tPCB TEQ (ng/kg) concentrations for mammals in Pacific sanddab (*Citharichthys sordidus*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	32	19	0.00	12.70	0.00	0.34	0.31
Northern	18	6	0.00	0.22	0.00	0.01	0.01
Central	6	83	0.00	12.70	1.64	2.27	1.09
Southern	8	0	0.00	0.00	0.00	0.00	0.00
Island	40	20	0.00	1.80	0.00	0.10	0.11
Cool (NW Channel Islands)	10	0	0.00	0.00	0.00	0.00	0.00
Warm	30	27	0.00	1.80	0.00	0.32	0.27
SE Channel Islands	12	58	0.00	1.80	0.18	0.41	0.36
Catalina Island	18	6	0.00	1.08	0.00	0.06	0.11
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	1	0	0.00	0.00	0.00	0.00	0.00
Small POTWs	0	---	---	---	---	---	---
River Mouths	0	---	---	---	---	---	---
Other Mainland	1	0	0.00	0.00	0.00	0.00	0.00
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	42	26	0.00	12.70	0.00	0.22	0.17
Small POTWs	0	---	---	---	---	---	---
Large POTWs	6	50	0.00	12.70	0.00	3.94	3.99
Mainland non-LPOTW	12	17	0.00	1.76	0.00	0.31	0.39
Island	24	25.0	0.00	1.80	0.00	0.11	0.13
Outer Shelf (121-202 m)	29	10	0.00	0.82	0.00	0.06	0.07
Mainland	13	8	0.00	0.22	0.00	0.02	0.04
Island	16	8	0.00	0.82	0.00	0.08	0.11
Total (all stations)	72	19	0.00	12.70	0.00	0.18	0.13

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

Appendix F25. Summary of tPCB TEQ (ng/kg) concentrations for mammals in speckled sanddab (*Citharichthys stigmaeus*) composites by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	42	19	0.00	2.94	0.00	0.04	0.04
Northern	20	0	0.00	0.00	0.00	0.00	0.00
Central	16	50	0.00	2.94	0.00	0.11	0.11
Southern	6	0	0.00	0.00	0.00	0.00	0.00
Island	9	11	0.00	0.16	0.00	0.00	0.01
Cool (NW Channel Islands)	6	17	0.00	0.16	0.00	0.00	0.01
Warm	3	0	0.00	0.00	0.00	0.00	0.00
SE Channel Islands	1	0	0.00	0.00	0.00	0.00	0.00
Catalina Island	2	0	0.00	0.00	0.00	0.00	0.00
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	35	14	0.00	0.74	0.00	0.02	0.03
Small POTWs	6	0	0.00	0.00	0.00	0.00	0.00
River Mouths	4	50	0.00	0.74	0.00	0.23	0.30
Other Mainland	21	10	0.00	0.29	0.00	0.02	0.03
Island	4	25	0.00	0.16	0.00	0.04	0.07
Middle Shelf (31-120 m)	15	27	0.00	2.94	0.00	0.04	0.06
Small POTWs	0	---	---	---	---	---	---
Large POTWs	5	80	0.00	2.94	0.64	1.05	0.89
Mainland non-LPOTW	6	0	0.00	0.00	0.00	0.00	0.00
Island	4	0	0.00	0.00	0.00	0.00	0.00
Outer Shelf (121-202 m)	1	0	0.00	0.00	0.00	0.00	0.00
Mainland	0	---	---	---	---	---	---
Island	1	0	0.00	0.00	0.00	0.00	0.00
Total (all stations)	51	18	0.00	2.94	0.00	0.03	0.03

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

Appendix F26. Summary of tPCB TEQ (ng/kg) concentrations for mammals in slender sole (*Lyopsetta exilis)* composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

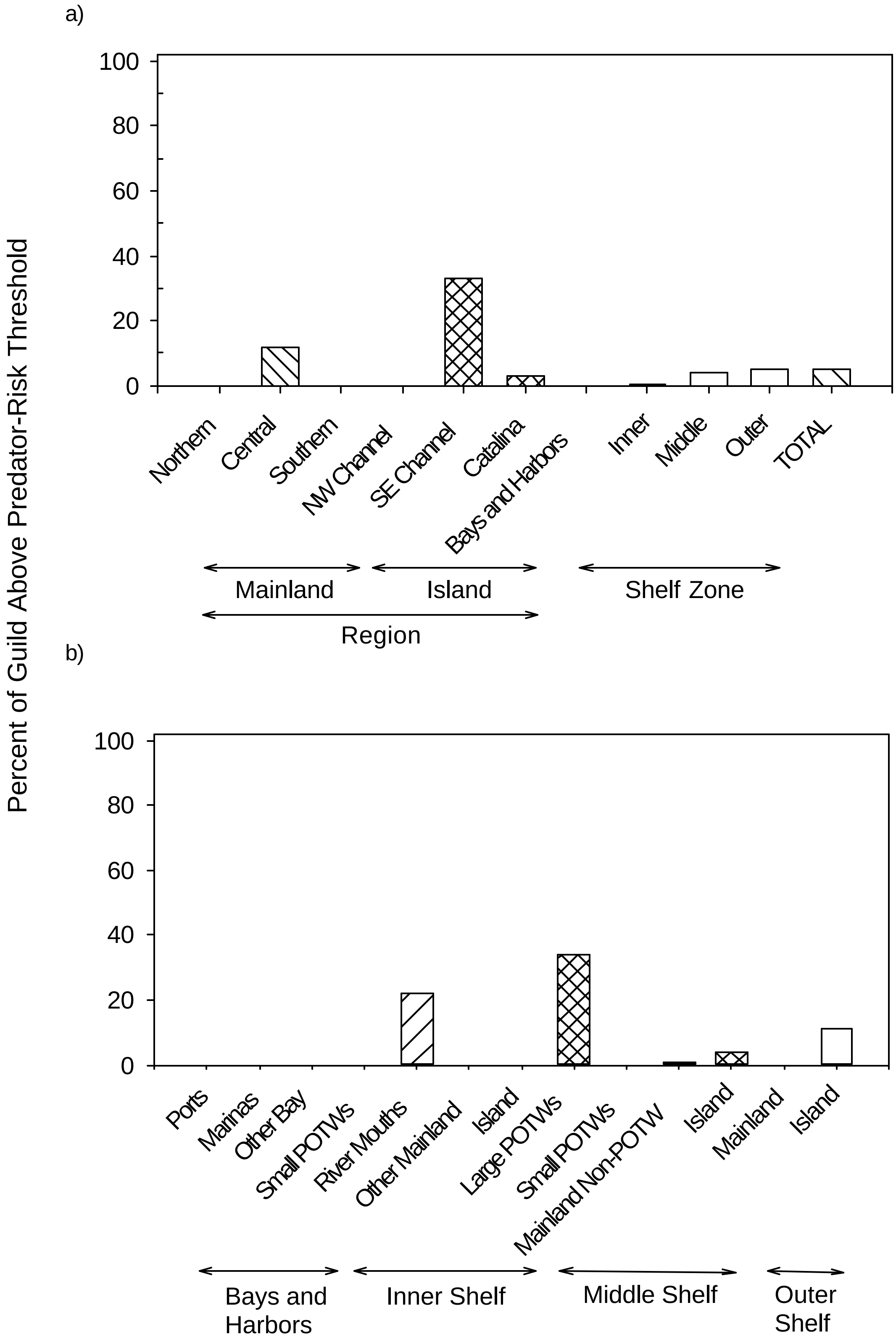
Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	14	36	0.00	0.51	0.00	0.09	0.09
Northern	6	50	0.00	0.37	0.00	0.08	0.10
Central	5	40	0.00	0.51	0.00	0.13	0.17
Southern	3	0	0.00	0.00	0.00	0.00	0.00
Island	10	30	0.00	0.84	0.02	0.15	0.13
Cool (NW Channel Islands)	1	100	0.16	0.16	---	---	---
Warm	9	22	0.00	0.84	0.00	0.14	0.22
SE Channel Islands	4	25	0.00	0.84	0.00	0.21	0.36
Catalina Island	5	20	0.00	0.27	0.00	0.05	0.10
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
River Mouths	0	---	---	---	---	---	---
Other Mainland	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
Large POTWs	0	---	---	---	---	---	---
Mainland non-LPOTW	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Outer Shelf (121-202 m)	24	33	0.00	0.84	0.00	0.11	0.07
Mainland	14	36	0.00	0.51	0.00	0.09	0.08
Island	10	30	0.00	0.84	0.02	0.15	0.13
Total (all stations)	24	33	0.00	0.84	0.00	0.11	0.07

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

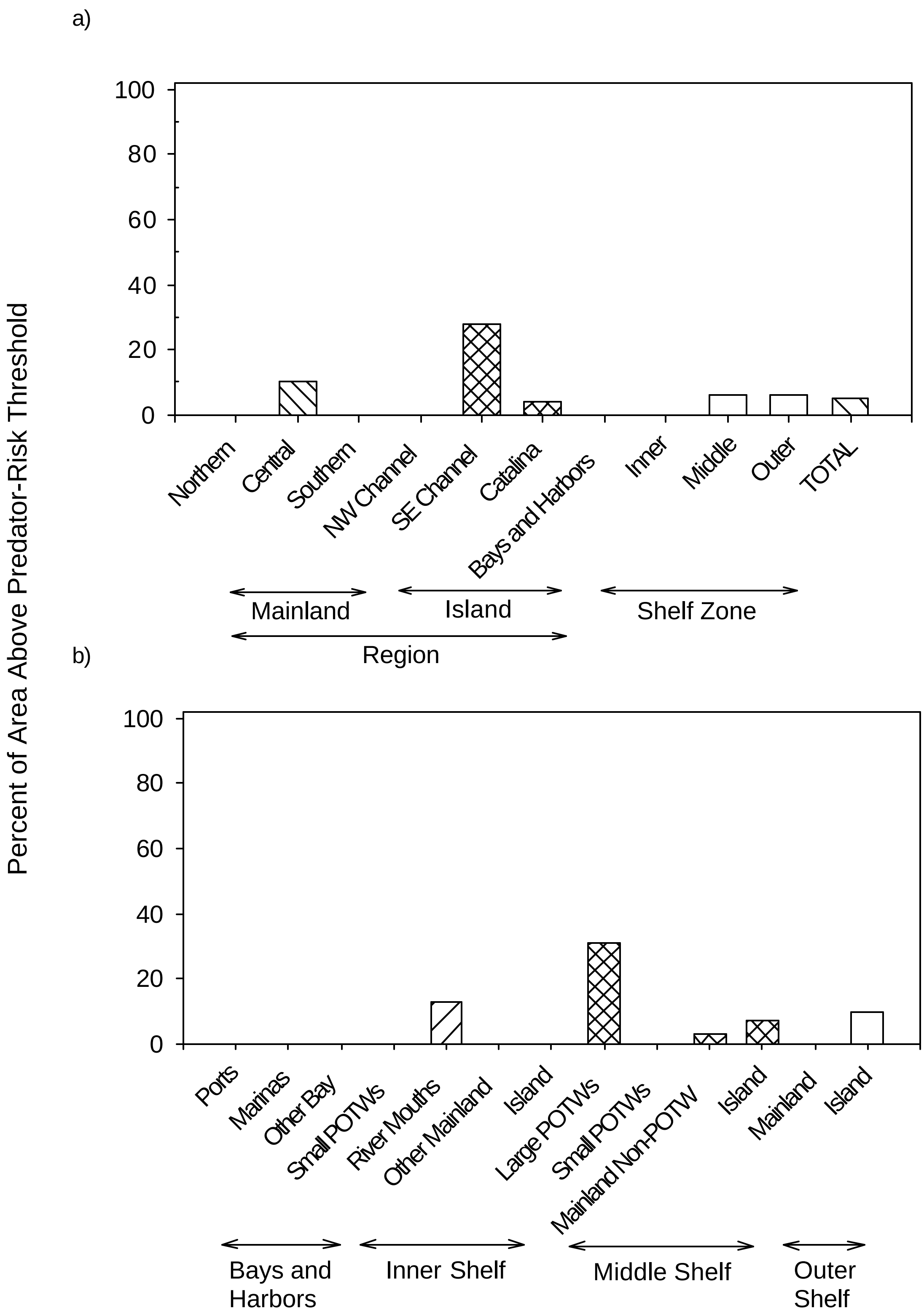
Appendix F27. Summary of tPCB TEQs (ng/kg) concentrations for mammals in California halibut (*Paralichthys californicus*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	25	56	0.00	3.00	0.00	0.28	0.30
Northern	1	0	0.00	0.00	0.00	0.00	0.00
Central	13	62	0.00	2.91	0.14	0.41	0.41
Southern	11	55	0.00	3.00	0.00	0.24	0.34
Island	0	---	---	---	---	---	---
Cool (NW Channel Islands)	0	---	---	---	---	---	---
Warm	0	---	---	---	---	---	---
SE Channel Islands	0	---	---	---	---	---	---
Catalina Island	0	---	---	---	---	---	---
Shelf Zone							
Bays and Harbors (2-30 m)	18	72	0.00	3.00	0.19	1.00	0.55
Ports	3	67	0.00	2.80	1.20	1.73	1.40
Marinas	9	67	0.00	2.90	0.14	0.64	0.63
Other Bay	6	83	0.00	3.00	0.15	1.09	1.00
Inner Shelf (2-30 m)	7	14	0.00	0.16	0.00	0.00	0.00
Small POTWs	1	100	0.16	0.16	---	---	---
River Mouths	4	0	0.00	0.00	0.00	0.00	0.00
Other Mainland	2	0	0.00	0.00	0.00	0.00	0.00
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
Large POTWs	0	---	---	---	---	---	---
Mainland non-LPOTW	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Outer Shelf (121-202 m)	0	---	---	---	---	---	---
Mainland	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Total (all stations)	25	56	0.00	3.00	0.00	0.28	0.30

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.



Appendix F28. Percent of sanddab guild fish above predator-risk threshold for PCB TEQs (ng/kg) for birds by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.



Appendix F29. Percent of area with sanddab-guild fish above predator-risk threshold for PCB TEQs (ng/kg) for birds by subpopulation on the southern California shelf at depths of 2-202 m, July-September 1998.

Appendix F30. Summary of tPCB TEQ (ng/kg) concentrations for birds in longfin sanddab (*Citharichthys xanthostigma)* composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	76	26	0.00	466.70	0.00	3.01	4.09
Northern	4	25	0.00	0.01	0.00	0.00	0.00
Central	37	51	0.00	466.70	0.04	6.57	9.15
Southern	35	0	0.00	0.00	0.00	0.00	0.00
Island	5	40	0.00	0.06	0.00	0.01	0.02
Cool (NW Channel Islands)	0	---	---	---	---	---	---
Warm	5	40	0.00	0.06	0.00	0.01	0.02
SE Channel Islands	0	---	---	---	---	---	---
Catalina Island	5	40	0.00	0.06	0.00	0.01	0.02
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	5	20	0.00	0.04	0.00	0.01	0.02
Small POTWs	2	0	0.00	0.00	0.00	0.00	0.00
River Mouths	0	---	---	---	0.00	---	---
Other Mainland	3	33	0.00	0.04	0.00	0.01	0.02
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	74	28	0.00	466.70	0.00	3.15	4.29
Small POTWs	14	0	0.00	0.00	0.00	0.00	0.00
Large POTWs	27	44	0.00	466.70	0.00	28.19	38.09
Mainland non-LPOTW	28	25	0.00	3.46	0.00	0.23	0.38
Island	5	10	0.00	0.06	0.00	0.01	0.02
Outer Shelf (121-202 m)	2	0	0.00	0.00	0.00	0.00	0.00
Mainland	2	0	0.00	0.00	0.00	0.00	0.00
Island	0	---	---	---	---	---	---
Total (all stations)	81	27	0.00	466.70		2.91	3.95

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interva
POTW = Publicly owned treatment work monitoring areas.

Appendix F31. Summary of tPCB TEQ (ng/kg) concentrations for birds in Pacific sanddab (*Citharichthys sordidus*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	32	19	0.00	4.11	0.00	0.10	0.09
Northern	18	6	0.00	0.02	0.00	0.00	0.00
Central	6	83	0.00	4.11	0.37	0.66	0.39
Southern	8	0	0.00	0.00	0.00	0.00	0.00
Island	40	20	0.00	437.38	0.00	19.30	25.04
Cool (NW Channel Islands)	10	0	0.00	0.00	0.00	0.00	0.00
Warm	30	27	0.00	437.38	0.00	60.78	68.52
SE Channel Islands	12	58	0.00	437.38	0.02	80.07	89.94
Catalina Island	18	6	0.00	74.09	0.00	4.12	7.84
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	1	0	0.00	0.00	0.00	0.00	0.00
Small POTWs	0	---	---	---	---	---	---
River Mouths	0	---	---	---	---	---	---
Other Mainland	1	0	0.00	0.00	0.00	0.00	0.00
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	42	26	0.00	437.38	0.00	12.18	19.60
Small POTWs	0	---	---	---	---	---	---
Large POTWs	6	50	0.00	4.11	0.00	1.31	1.29
Mainland non-LPOTW	12	17	0.00	0.56	0.00	0.08	0.11
Island	24	25	0.00	437.38	0.00	17.64	28.78
Outer Shelf (121-202 m)	29	10	0.00	203.00	0.00	16.62	30.91
Mainland	13	8	0.00	0.02	0.00	0.00	0.00
Island	16	8	0.00	203.00	0.00	25.89	47.46
Total (all stations)	72	19	0.00	437.38	0.00	12.98	16.63

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

Appendix F32. Summary of tPCB TEQ (ng/kg) concentrations for birds in speckled sanddab (*Citharichthys stigmaeus*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	42	19	0.00	111.10	0.00	0.15	0.28
Northern	20	0	0.00	0.00	0.00	0.00	0.00
Central	16	50	0.00	111.10	0.00	0.38	0.73
Southern	6	0	0.00	0.00	0.00	0.00	0.00
Island	9	11	0.00	0.02	0.00	0.00	0.00
Cool (NW Channel Islands)	6	17	0.00	0.02	0.00	0.00	0.00
Warm	3	0	0.00	0.00	0.00	0.00	0.00
SE Channel Islands	1	0	0.00	0.00	0.00	0.00	0.00
Catalina Island	2	0	0.00	0.00	0.00	0.00	0.00
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	35	14	0.00	111.10	0.00	0.19	0.38
Small POTWs	6	0	0.00	0.00	0.00	0.00	0.00
River Mouths	4	50	0.00	111.10	0.00	27.77	47.12
Other Mainland	21	10	0.00	0.03	0.00	0.00	0.00
Island	4	25	0.00	0.02	0.00	0.00	0.01
Middle Shelf (31-120 m)	15	27	0.00	1.16	0.00	0.01	0.02
Small POTWs	0	---	---	---	---	---	---
Large POTWs	5	80	0.00	1.16	0.11	0.35	0.37
Mainland non-LPOTW	6	0	0.00	0.00	0.00	0.00	0.00
Island	4	0	0.00	0.00	0.00	0.00	0.00
Outer Shelf (121-202 m)	1	0	0.00	0.00	0.00	0.00	0.00
Mainland	0	---	---	---	---	---	---
Island	1	0	0.00	0.00	0.00	0.00	0.00
Total (all stations)	51	18	0.00	111.10	0.00	0.10	0.19

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval
POTW = Publicly owned treatment work monitoring areas.

Appendix F33. Summary of tPCB TEQ (ng/kg) concentrations for birds in slender sole (*Lyopsetta exilis*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

	No. of	%	Range		Area-Weighted Values		
Subpopulation	Stations	Det.	Min.	Max.	Median	Mean	95% CI
Region							
Mainland	14	36	0.00	92.00	0.00	7.00	13.20
Northern	6	50	0.00	92.00	0.00	15.30	27.40
Central	5	40	0.00	0.05	0.00	0.01	0.02
Southern	3	0	0.00	0.00	0.00	0.00	0.00
Island	10	30	0.00	0.17	0.00	0.02	0.03
Cool (NW Channel Islands)	1	100	0.02	0.02	---	---	---
Warm	9	22	0.00	0.17	0.00	0.03	0.04
SE Channel Islands	4	25	0.00	0.17	0.00	0.04	0.07
Catalina Island	5	20	0.00	0.03	0.00	0.01	0.01
Shelf Zone							
Bays and Harbors (2-30 m)	0	---	---	---	---	---	---
Ports	0	---	---	---	---	---	---
Marinas	0	---	---	---	---	---	---
Other Bay	0	---	---	---	---	---	---
Inner Shelf (2-30 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
River Mouths	0	---	---	---	---	---	---
Other Mainland	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
Large POTWs	0	---	---	---	---	---	---
Mainland non-LPOTW	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Outer Shelf (121-202 m)	24	33	0.00	92.00	0.00	4.19	8.07
Mainland	14	36	0.00	92.00	0.00	7.00	13.20
Island	10	30	0.00	0.17	0.00	0.02	0.03
Total (all stations)	24	33	0.00	92.00	0.00	4.19	8.07

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interva
POTW = Publicly owned treatment work monitoring areas.

Appendix F34. Summary of tPCB TEQs (ng/kg) concentrations for birds in California halibut (*Paralichthys californicus*) composites by subpopulation sampled on the southern California shelf at depths of 2-202 m, July-September 1998.

Subpopulation	No. of Stations	% Det.	Range Min.	Range Max.	Area-Weighted Values Median	Area-Weighted Values Mean	Area-Weighted Values 95% CI
Region							
Mainland	25	56	0.00	0.58	0.00	0.04	0.04
Northern	1	0	0.00	0.00	0.00	0.00	0.00
Central	13	62	0.00	0.58	0.01	0.09	0.09
Southern	11	55	0.00	0.30	0.00	0.02	0.03
Island	0	---	---	---	---	---	---
Cool (NW Channel Islands)	0	---	---	---	---	---	---
Warm	0	---	---	---	---	---	---
SE Channel Islands	0	---	---	---	---	---	---
Catalina Island	0	---	---	---	---	---	---
Shelf Zone							
Bays and Harbors (2-30 m)	18	72	0.00	0.58	0.02	0.14	0.08
Ports	3	67	0.00	0.28	0.12	0.00	0.24
Marinas	9	67	0.00	0.58	0.01	0.15	0.13
Other Bay	6	83	0.00	0.30	0.01	0.11	0.10
Inner Shelf (2-30 m)	7	14	0.00	0.02	0.00	0.00	0.00
Small POTWs	1	100	0.02	0.02	---	---	---
River Mouths	4	0	0.00	0.00	0.00	0.00	0.00
Other Mainland	2	0	0.00	0.00	0.00	0.00	0.00
Island	0	---	---	---	---	---	---
Middle Shelf (31-120 m)	0	---	---	---	---	---	---
Small POTWs	0	---	---	---	---	---	---
Large POTWs	0	---	---	---	---	---	---
Mainland non-LPOTW	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Outer Shelf (121-202 m)	0	---	---	---	---	---	---
Mainland	0	---	---	---	---	---	---
Island	0	---	---	---	---	---	---
Total (all stations)	25	56	0.00	0.58	0.00	0.04	0.04

No. = Number; Det = detected; Min. = Minimum; Max. = Maximum; CI = Confidence interval; POTW = Publicly owned treatment work monitoring areas.

GLOSSARY

GLOSSARY

NUMBER **PAGE**

Glossary G1. Glossary of abbreviations, acronyms, and technical terms used in the Southern California Bight 1998 Regional Survey, July-September 1998.

Term	Definition
ANOVA	Analysis of Variance statistical test
ASE	Accelerated Solvent Extraction
B98, FSLC	Bight '98 Field Sampling & Logistics Committee
B98, SC	Bight '98 Steering Committee
BaP	Benzo [a]Pyrene
Bays/Harbors	Subpopulation comprising bays, harbors, marinas, ports, and other bay-like areas of southern California at depths of 2-30 m.
BUNA	A type of rubber that is an elastomeric copolymer of butadiene and acrylonitrile.
CARP-1	A ground whole-fish sample of common carp (*Cyprinus carpio*). Certified values for 14 PCB congeners exist for common carp.
CCD Camera	Charge coupled device (CCD) camera. A light-sensitive silicon, solid-state device composed of many small pixels. The light falling on a pixel is converted into a charge pulse which is then measured by the CCD electronics and represented by a number. A di
CDF	Cumulative distribution function. Represents the proportion of a population that has an attribute value equal to or less than the observed attribute value (Stevens 1995).
CINMS	Channel Islands National Marine Sanctuary
CLAEMD	City of Los Angeles, Environmental Monitoring Division
Comet TM values	Equivalent to TM values. See TM values.
Congener (PCB)	One of a possible 209 structural isomers for polychlorinated biphenyls (PCBs) that differ in the number and position of chlorine atoms on the two aromatic rings.
Connex	The proportion of possible positive affinities in a recurrent group analysis.
Co-planer	PCB congeners with one or no chlorine atoms in the *ortho* position on the phenyl groups. These congeners have a low resistance to free rotation around the bond connecting the rings and can readily attain a conformation under ambient conditions in which th
CRMs	Certified reference materials
CSC Biomarker Lab	Computer Sciences Corporation Biomarker Laboratory
CSDLAC	County Sanitation Districts of Los Angeles County
CSDMWWD	City of San Diego, Metropolitan Wastewater Department
CSDOC	County Sanitation Districts of Orange County
DDE	Dichlorodiphenyldichloroethylene. An organic derivitive of DDT.
DDT	Dichlorodiphenyltrichloroethane
DGPS	Differential Global Positioning System
DMSO	Dimethyl sulfoxide
DNA	Deoxyribonucleic acid. Nucleic acids made up of nucleotide units having a 2-deoxy-- D-ribosyl component.
DQOs	Data quality objectives
EDTA	Ethylenediametetraacetic acid
EtBr	Ethidium Bromide
FACS	Fluorescent Aromatic Compounds
FFG	Fish Foraging Guild Index. A biointegrity index.
FRI	Fish Response Index. A biointegrity index.

Glossary G1 (continued)

Term	Definition
GIS	Geographical Information System
GPS	Global Positioning System
HPLC	High Performance Liquid Chromatography
IA	Index of Affinity used in recurrent group analysis.
ID	Inner diameter
Inner Shelf	Subpopulation occurring along the southern California shelf at depths of 5-30 m.
IRI	Invertebrate Response Index. A biointegrity index.
LA/LB Harbor	Los Angeles/Long Beach Harbor
Large POTW	Subpopulation occurring on the middle shelf at large publicly owned treatment work (POTW) outfall areas: CLAEMD, CSDLAC, CSDOC, and CSDMWWD.
LMA	Low melting temperature agarose
LS	Lysing solution
MASE	Microwave-Assisted Solvent Extraction
Middle Shelf	Subpopulation occurring on the southern California shelf at depths of 31-120 m.
NAS	National Academy of Sciences
NEXUS	A modular file format designed to house systematic (classificatory) data in use by several computer programs.
NOAA	National Oceanographic and Atmospheric Administration
NW	Northwest
NWFSC	Northwest Fisheries Science Center (of National Marine Fisheries Service)
OC	Organic carbon
OCSD	Orange County Sanitation District
OEHHA	California Office of Environmental Health Hazard Assessment
Outer Shelf	Subpopulation occurring on the southern California shelf at depths of 121-202 m.
PAA	Parsimony analysis for an “R-mode” approach
PAHs	Polycyclic Aromatic Hydrocarbons
PAUP*	Phylogenetic Analysis Using Parsimony (* and other methods)
PBS	Phosphate-buffered saline
PCBs	Polychlorinated biphenyls
POTW	Publicly owned treatment works
QA	Quality assurance
QA/QC	Quality assurance/quality control
QC	Quality control
Q-mode	Cladograms of site groups, showing the association of sites with one another.
RBC	Red blood cells
R-mode	Cladograms of species groups, showing the association of species with one another.
RPD	Relative percent of difference
SCB	Southern California Bight
SCBPP	Southern California Bight Pilot Project
SCCWRP	Southern California Coastal Water Research Project

Glossary G1 (continued)

Term	Definition
SE	Southeast
SERRA	South East Regional Reclamation Authority
SL	Standard length. The length of a fish measured from the most posterior vertebrae to the tip of the snout.
Small POTW	Subpopulation occurring on the middle shelf at small publicly owned treatment work (POTW) outfall areas: Goleta, Santa Barbara, Oxnard, Terminal Island, Aliso, South East Regional Reclamation Authority (SERRA), Oceanside, Encina, and San Elijo wastewater
TCDD	Tetrachlorodibenzo-p-dioxin
TEF	Toxicity equivalency factor. The relative toxicity of PCBs based on their similarity to TCDD dioxin.
TEQ	Toxicity equivalent quotient. The sum of the products of the PCB congeners and their toxicity equivalency factors (TEFs).
TL	Total length. The length of a fish measured from the furthest extension of the tail to the tip of the snout.
TM	Tail Moment (% DNA in the nucleus * tail length/100)
TOC	Total organic carbon
TRI	Trawl Response Index. A biointegrity index.
USEPA	United States Environmental Protection Agency
WBC	White blood cells

Glossary G2. Alphabetic list by scientific name of demersal fish species collected at depths of 2-202 m on the southern California shelf, July-September 1998.

Scientific Name	Common Name
Acanthogobius flavimanus	yellowfin goby
Agonopsis sterletus	southern spearnose poacher
Albula vulpes	bonefish
Amphistichus argenteus	barred surfperch
Anchoa compressa	deepbody anchovy
Anchoa delicatissima	slough anchovy
Anisotremus davidsonii	sargo
Anoplopoma fimbria	sablefish
Argentina sialis	Pacific argentine
Atherinops affinis	topsmelt
Atherinopsis californiensis	jacksmelt
Atractoscion nobilis	white seabass
Caulolatilus princeps	ocean whitefish
Cephaloscyllium ventriosum	swell shark
Cheilotrema saturnum	black croaker
Chilara taylori	spotted cusk-eel
Chitonotus pugetensis	roughback sculpin
Citharichthys fragilis	gulf sanddab
Citharichthys sordidus	Pacific sanddab
Citharichthys stigmaeus	speckled sanddab
Citharichthys xanthostigma	longfin sanddab
Clupea pallasii	Pacific herring
Coryphopterus nicholsii	blackeye goby
Cryptotrema corallinum	deepwater blenny
Cymatogaster aggregata	shiner perch
Dasyatis dipterura	diamond stingray
Embiotoca jacksoni	black perch
Engraulis mordax	northern anchovy
Engyophrys sanctilaurentii	speckletail flounder
Enophrys taurina	bull sculpin
Eopsetta exilis (see *Lyopsetta exilis*)	
Eopsetta jordani	petrale sole
Eptatretus stoutii	Pacific hagfish
Errex zachirus (see *Glyptocephalus zachirus*)	
Genyonemus lineatus	white croaker
Glyptocephalus zachirus (=*Errex zachirus*)	rex sole
Gymnura marmorata	California butterfly ray
Heterostichus rostratus	giant kelpfish
Hippocampus ingens	Pacific seahorse
Hippoglossina stomata	bigmouth sole
Hydrolagus colliei	spotted ratfish
Hyperprosopon argenteum	walleye surfperch
Hypsopsetta guttulata (see *Pleuronichthys guttulatus*)	

Glossary G2 (continued)

Scientific Name	Common Name
Icelinus tenuis	spotfin sculpin
Ilypnus gilberti	cheekspot goby
Kathetostoma averruncus	smooth stargazer
Lepidogobius lepidus	bay goby
Lepidopsetta bilineata (=*Pleuronectes bilineatus*)	rock sole
Lycodes cortezianus	bigfin eelpout
Lycodes pacificus (=*Lycodopsis pacificus*)	blackbelly eelpout
Lycodopsis pacifica (see *Lycodes pacificus*)	
Lyconema barbatum	bearded eelpout
Lyopsetta exilis (=*Eopsetta exilis*)	slender sole
Lythrypnus dalli	bluebanded goby
Lythrypnus zebra	zebra goby
Macroramphosus gracilis	slender snipefish
Menticirrhus undulatus	California corbina
Merluccius productus	Pacific hake
Microstomus pacificus	Dover sole
Mustelus californicus	gray smoothhound
Mustelus henlei	brown smoothhound
Myliobatis californica	bat ray
Neoclinus blanchardi	sarcastic fringehead
Odontopyxis trispinosa	pygmy poacher
Ophidion scrippsae	basketweave cusk-eel
Ophiodon elongatus	lingcod
Paralabrax clathratus	kelp bass
Paralabrax maculatofasciatus	spotted sand bass
Paralabrax nebulifer	barred sand bass
Paralichthys californicus	California halibut
Parophrys vetula (see *Parophrys vetulus*)	
Parophrys vetulus (=vetula; *Pleuronectes vetulus*)	English sole
Peprilus simillimus	Pacific pompano
Phanerodon furcatus	white seaperch
Physiculus rastrelliger	hundred-fathom codling
Platyrhinoidis triseriata	thornback
Plectobranchus evides	bluebarred prickleback
Pleuronectes bilineatus (see *Lepidopsetta bilineata*)	
Pleuronectes vetulus (see *Parophrys vetulus*)	
Pleuronichthys coenosus	C-O sole
Pleuronichthys decurrens	curlfin sole
Pleuronichthys guttulatus (=*Hypsopsetta guttulata*)	diamond turbot
Pleuronichthys ritteri	spotted turbot
Pleuronichthys verticalis	hornyhead turbot
Porichthys myriaster	specklefin midshipman
Porichthys notatus	plainfin midshipman

Glossary G2 (continued)

Scientific Name	Common Name
Raja rhina	longnose skate
Raja stellulata	starry skate
Rathbunella alleni	stripedfin ronquil (=rough ronquil)
Rathbunella hypoplecta	bluebanded ronquil (=stripedfin[1] ronquil)
Rhacochilus vacca	pile perch
Rhinobatos productus	shovelnose guitarfish
Roncador stearnsii	spotfin croaker
Sardinops sagax	Pacific sardine
Scorpaena guttata	California scorpionfish
Sebastes atrovirens	kelp rockfish
Sebastes auriculatus	brown rockfish
Sebastes caurinus	copper rockfish
Sebastes chlorostictus	greenspotted rockfish
Sebastes constellatus	starry rockfish
Sebastes dallii	calico rockfish
Sebastes diploproa	splitnose rockfish
Sebastes elongatus	greenstriped rockfish
Sebastes ensifer	swordspine rockfish
Sebastes eos	pink rockfish
Sebastes goodei	chilipepper
Sebastes jordani	shortbelly rockfish
Sebastes lentiginosus	freckled rockfish
Sebastes levis	cowcod
Sebastes macdonaldi	Mexican rockfish
Sebastes miniatus	vermilion rockfish
Sebastes rosaceus	rosy rockfish
Sebastes rosenblatti	greenblotched rockfish
Sebastes rubrivinctus	flag rockfish
Sebastes saxicola	stripetail rockfish
Sebastes semicinctus	halfbanded rockfish
Sebastes simulator	pinkrose rockfish
Sebastes umbrosus	honeycomb rockfish
Sebastolobus alascanus	shortspine thornyhead
Semicossyphus pulcher	California sheephead
Seriphus politus	queenfish
Squalus acanthias	spiny dogfish
Squatina californica	Pacific angel shark
Stereolepis gigas	giant sea bass
Symphurus atricauda (see *Symphurus atricaudus*)	
Symphurus atricaudus (=*Symphurus atricauda*)	California tonguefish
Synchiropus atrilabiatus	blacklip dragonet
Syngnathus californiensis	kelp pipefish
Syngnathus exilis	barcheek pipefish
Synodus lucioceps	California lizardfish

Glossary G2 (continued)

Scientific Name	Common Name
Trichiurus lepturus (=*Trichiurus nitens*)	cutlassfish (=Pacific cutlassfish)
Trichiurus nitens (see *Trichiurus lepturus)*	
Umbrina roncador	yellowfin croaker
Urolophus halleri	round stingray
Xeneretmus latifrons	blacktip poacher
Xeneretmus triacanthus	bluespotted poacher
Xystreurys liolepis	fantail sole
Zalembius rosaceus	pink seaperch
Zaniolepis frenata	shortspine combfish
Zaniolepis latipinnis	longspine combfish

"See..." indicates name in report is different from that of database or Allen *et al*. (1998) and directs reader to name used in this study. Reasons for changes are given in Appendix C13.

[1] *Rathbunella alleni* was formerly called 'rough ronquil' and *Rathbunella hypoplecta* was formerly called 'stripedfin ronquil' in Allen *et al.* (1998). The names shown in this list follow those of Matarese (1991).

Glossary G3. Alphabetic list by common name of demersal fish species collected at depths of 2-202 m on the southern California shelf, July-September 1998.

Common Name	Scientific Name
barcheek pipefish	*Syngnathus exilis*
barred sand bass	*Paralabrax nebulifer*
barred surfperch	*Amphistichus argenteus*
basketweave cusk-eel	*Ophidion scrippsae*
bat ray	*Myliobatis californica*
bay goby	*Lepidogobius lepidus*
bearded eelpout	*Lyconema barbatum*
big skate	*Raja binoculata*
bigfin eelpout	*Lycodes cortezianus*
bigmouth sole	*Hippoglossina stomata*
black croaker	*Cheilotrema saturnum*
black perch	*Embiotoca jacksoni*
blackbelly eelpout	*Lycodes pacificus* (=*Lycodopsis pacifica*)
blackeye goby	*Coryphopterus nicholsii*
blacklip dragonet	*Synchiropus atrilabiatus*
blacktip poacher	*Xeneretmus latifrons*
bluebanded goby	*Lythrypnus dalli*
bluebanded ronquil (=stripedfin ronquil[1])	*Rathbunella hypoplecta*
bluebarred prickleback	*Plectobranchus evides*
bluespotted poacher	*Xeneretmus triacanthus*
bonefish	*Albula vulpes*
brown rockfish	*Sebastes auriculatus*
brown smoothhound	*Mustelus henlei*
bull sculpin	*Enophrys taurina*
calico rockfish	*Sebastes dallii*
California butterfly ray	*Gymnura marmorata*
California corbina	*Menticirrhus undulatus*
California halibut	*Paralichthys californicus*
California lizardfish	*Synodus lucioceps*
California scorpionfish	*Scorpaena guttata*
California sheephead	*Semicossyphus pulcher*
California skate	*Raja inornata*
California tonguefish	*Symphurus atricaudus* (=*Symphurus atricauda*)
cheekspot goby	*Ilypnus gilberti*
chilipepper	*Sebastes goodei*
C-O sole	*Pleuronichthys coenosus*
copper rockfish	*Sebastes caurinus*
cowcod	*Sebastes levis*
curlfin sole	*Pleuronichthys decurrens*
cutlassfish (=Pacific cutlassfish)	*Trichiurus lepturus* (=*Trichiurus nitens*)
deepbody anchovy	*Anchoa compressa*
deepwater blenny	*Cryptotrema corallinum*

Glossary G3 (continued)

Common Name	Scientific Name
English sole	*Parophrys vetulus* (=*vetula; Pleuronectes vetulus*)
fantail sole	*Xystreurys liolepis*
flag rockfish	*Sebastes rubrivinctus*
freckled rockfish	*Sebastes lentiginosus*
giant kelpfish	*Heterostichus rostratus*
giant sea bass	*Stereolepis gigas*
gray smoothhound	*Mustelus californicus*
greenblotched rockfish	*Sebastes rosenblatti*
greenspotted rockfish	*Sebastes chlorostictus*
greenstriped rockfish	*Sebastes elongatus*
gulf sanddab	*Citharichthys fragilis*
halfbanded rockfish	*Sebastes semicinctus*
honeycomb rockfish	*Sebastes umbrosus*
hornyhead turbot	*Pleuronichthys verticalis*
hundred-fathom codling	*Physiculus rastrelliger*
jack mackerel	*Trachurus symmetricus*
jacksmelt	*Atherinopsis californiensis*
kelp bass	*Paralabrax clathratus*
kelp pipefish	*Syngnathus californiensis*
kelp rockfish	*Sebastes atrovirens*
leopard shark	*Triakis semifasciata*
lingcod	*Ophiodon elongatus*
longfin sanddab	*Citharichthys xanthostigma*
longnose skate	*Raja rhina*
longspine combfish	*Zaniolepis latipinnis*
lumptail searobin	*Prionotus stephanophrys*
Mexican rockfish	*Sebastes macdonaldi*
mussel blenny	*Hypsoblennius jenkinsi*
northern anchovy	*Engraulis mordax*
ocean whitefish	*Caulolatilus princeps*
Pacific angel shark	*Squatina californica*
Pacific argentine	*Argentina sialis*
Pacific cutlass fish (*see* cutlassfish)	
Pacific electric ray	*Torpedo californica*
Pacific hagfish	*Eptatretus stoutii*
Pacific hake	*Merluccius productus*
Pacific herring	*Clupea pallasii*
Pacific pompano	*Peprilus simillimus*
Pacific sanddab	*Citharichthys sordidus*
Pacific sardine	*Sardinops sagax*
Pacific seahorse	*Hippocampus ingens*
petrale sole	*Eopsetta jordani*
pile perch	*Rhacochilus vacca*
pink rockfish	*Sebastes eos*

Glossary G3 (continued)

Common Name	Scientific Name
pygmy poacher	*Odontopyxis trispinosa*
queenfish	*Seriphus politus*
rex sole	*Glyptocephalus zachirus* (=*Errex zachirus*)
rock sole	*Lepidopsetta bilineata* (=*Pleuronectes bilineatus*)
rosy rockfish	*Sebastes rosaceus*
rough ronquil[1] (*see* stripedfin ronquil)	
roughback sculpin	*Chitonotus pugetensis*
round stingray	*Urolophus halleri*
sablefish	*Anoplopoma fimbria*
sarcastic fringehead	*Neoclinus blanchardi*
sargo	*Anisotremus davidsonii*
shiner perch	*Cymatogaster aggregata*
shortbelly rockfish	*Sebastes jordani*
shortspine combfish	*Zaniolepis frenata*
shortspine thornyhead	*Sebastolobus alascanus*
shovelnose guitarfish	*Rhinobatos productus*
slender snipefish	*Macroramphosus gracilis*
slender sole	*Lyopsetta exilis* (=*Eopsetta exilis*)
slim sculpin	*Radulinus asprellus*
slough anchovy	*Anchoa delicatissima*
smooth stargazer	*Kathetostoma averruncus*
southern spearnose poacher	*Agonopsis sterletus*
speckled sanddab	*Citharichthys stigmaeus*
specklefin midshipman	*Porichthys myriaster*
speckletail flounder	*Engyophrys sanctilaurentii*
spiny dogfish	*Squalus acanthias*
splitnose rockfish	*Sebastes diploproa*
spotfin croaker	*Roncador stearnsii*
spotfin sculpin	*Icelinus tenuis*
spotted cusk-eel	*Chilara taylori*
spotted ratfish	*Hydrolagus colliei*
spotted sand bass	*Paralabrax maculatofasciatus*
spotted turbot	*Pleuronichthys ritteri*
starry rockfish	*Sebastes constellatus*
starry skate	*Raja stellulata*
stripedfin ronquil[1] (=rough ronquil)	*Rathbunella alleni*
stripetail rockfish	*Sebastes saxicola*
swell shark	*Cephaloscyllium ventriosum*
swordspine rockfish	*Sebastes ensifer*
thornback	*Platyrhinoidis triseriata*
threadfin sculpin	*Icelinus filamentosus*
topsmelt	*Atherinops affinis*
vermilion rockfish	*Sebastes miniatus*

Glossary G3 (continued)

Common Name	Scientific Name
yellowchin sculpin	*Icelinus quadriseriatus*
yellowfin croaker	*Umbrina roncador*
yellowfin goby	*Acanthogobius flavimanus*
zebra goby	*Lythrypnus zebra*

"See..." indicates name in report is different from that of database or Allen *et al*. (1998) and directs reader to name used in this study. Reasons for changes are given in Appendix C13.

[1] *Rathbunella alleni* was formerly called 'rough ronquil' and *Rathbunella hypoplecta* was formerly called 'stripedfin ronquil' in Allen *et al.* (1998). The names shown in this list follow those of Matarese (1991).

Glossary G4. Alphabetic list by scientific name of megabenthic invertebrates collected at depths of 2-202 m on the southern California shelf, July-September 1998.

Scientific Name	Common Name
Acanthodoris brunnea	brown spiny doris
Acanthodoris hudsoni	Hudson spiny doris
Acanthodoris rhodoceras	black-tipped spiny doris
Acanthoptilum sp	trailtip sea pen, unid.
Actiniaria sp SD 1	"anemone"
Addisonia brophyi	eggcase limpet
Adelogorgia phyllosclera	orange gorgonian
Aglaophenia struthionides	ostrichplume hydroid
Alcyonacea (=*Alcyonaria*) sp SD 1	"gorgonian"
Alcyonaria (see *Alcyonacea*) sp SD 1	
Allocentrotus fragilis	fragile sea urchin
Alpheus californiensis	mudflat snapping shrimp
Amphichondrius granulatus	roughdisk brittlestar
Amphiodia digitata	"brittlestar"
Amphiodia psara	"brittlestar"
Amphiodia urtica	red brittlestar
Amphioplus sp	"brittlestar"
Amphiura arcystata	"brittlestar"
Amygdalum politum	pallid papermussel
Anoplodactylus erectus	"sea spider"
Anoplodactylus virdintestinalis	"sea spider"
Antiplanes catalinae (=*Antiplanes perversus*)	Catalina turrid
Antiplanes perversus (see *Antiplanes catalinae*)	
Aphrocallistes vastus	cloud sponge
Aphrodita armifera	copperwire sea mouse
Aphrodita negligens	shaggy sea mouse
Aphrodita refulgida	green sea mouse
Aplydium sp	"colonial tunicate"
Aplysia californica	purple sea hare
Aplysia vaccaria	black sea hare
Archidoris montereyensis	Monterey sea-lemon
Argopecten ventricosus	Pacific calico scallop
Armina californica	California armina
Ascidia zara	"tunicate"
Ascidiidae sp SD 1	"tunicate"
Asterina miniata	bat star
Astropecten armatus	spiny sand star
Astropecten ornatissimus	orange sand star
Astropecten verrilli	California sand star
Austrotrophon catalinensis	Catalina forreria
Balanus pacificus	Pacific acorn barnacle
Berthella californica	California sidegill slug

Glossary G4 (continued)

Scientific Name	Common Name
Bulla gouldiana	California bubble
Calinaticina oldroydii	delicate moonsnail
Calliostoma gloriosum	glorious topsnail
Calliostoma turbinum	spindle topsnail
Cancellaria cooperi (see *Cancellaria cooperii*)	
Cancellaria cooperii (=*Cancellaria cooperi*)	Cooper nutmeg
Cancellaria crawfordiana	Crawford nutmeg
Cancer anthonyi	yellow rock crab
Cancer branneri	furrowed rock crab
Cancer gracilis	graceful rock crab
Cancer jordani	hairy rock crab
Cancer productus	red rock crab
Caryophyllia alaskensis	"cup coral"
Ceramaster sp	"cookie star"
Chaetopterus variopedatus Cmplx	parchment tube worm
Chama arcana	secret jewelbox
Chlamys hastata	spiny scallop
Chorilia longipes	longhorn decorator crab
Cidarina cidaris	spiny margarite
Ciona intestinalis	yellow-green sea squirt
Coenocyathus bowersi	colonial cup coral
Conus californicus	California cone
Crangon alaskensis	Alaska bay shrimp
Crangon nigromaculata	blackspotted bay shrimp
Crassadoma gigantea	giant rock scallop
Crassispira semiinflata	California drillia
Crepidula onyx	onyx slippersnail
Crepidula perforans	white slippersnail
Crepipatella dorsata	Pacific half-slippersnail
Crossata californica	California frogsnail
Crucibulum spinosum	spiny cup-and-saucer
Cryptodromiopsis larraburei	Pacific sponge crab
Cucumaria sp	"nestling sea cucumber"
Dendraster excentricus	Pacific sand dollar
Dendraster terminalis	offshore sand dollar
Dendronotus iris	giant frond-aeolis
Diaulula sandiegensis	ringed doris
Dirona sp	"dirona"
Doriopsilla albopunctata	salted yellow doris
Dromalia alexandri	sea dandelion
Enallopaguropsis guatemoci	"right-handed hermit"
Epiactis prolifera	brooding anemone
Epialtoides hiltoni	winged kelp crab
Erato vitellina	appleseed erato

Glossary G4 (continued)

Scientific Name	Common Name
Euspira lewisii (=*Polinices lewisii*)	Lewis moonsnail
Euvola diegensis	San Diego scallop
Excorallana truncata	cuttail sea louse
Farfantepenaeus (=*Penaeus*) *californiensis*	yellowleg shrimp
Fissurella volcano	volcano keyhole limpet
Flabellina iodinea	Spanish shawl
Flabellina pricei	smooth-tooth aeolis
Florometra serratissima	feather star
Fusinus barbarensis	Santa Barbara spindle
Galathea californiensis	California squat lobster
Gorgonocephalus eucnemis	basket star
Hamatoscalpellum californicum	California blade barnacle
Haminaea vesicula (see *Haminoea vesicula*)	
Haminoea (=*Haminaea*) *vesicula*	blister glassy-bubble
Hemisquilla ensigera californiensis	blueleg mantis shrimp
Henricia leviuscula	blood star
Heptacarpus stimpsoni	Stimpson coastal shrimp
Heptacarpus tenuissimus	slender coastal shrimp
Heterocrypta occidentalis	sandflat elbow crab
Heterogorgia tortuosa	"gorgonian"
Hippasteria spinosa	spiny red star
Isocheles pilosus	moon snail hermit
Kelletia kelletii (=*Kelletia kelletti*)	Kellet whelk
Kelletia kelletti (see *Kelletia kelletii*)	
Laqueus californianus	California lamp shell
Leptasterias hexactis	six-arm sea star
Leptopecten latiauratus	kelp scallop
Leucilla nuttingi	urn sponge
Limaria hemphilli	Hemphill fileclam
Loligo opalescens	California market squid
Lophogorgia chilensis	pink sea whip
Lopholithodes foraminatus	brown box crab
Lophopanopeus bellus	blackclaw crestleg crab
Lophopanopeus frontalis	molarless crestleg crab
Lovenia cordiformis	sea porcupine
Loxorhynchus crispatus	moss crab
Loxorhynchus grandis	sheep crab
Luidia armata	mosaic sand star
Luidia asthenosoma	fringed sand star
Luidia foliolata	gray sand star
Lysmata californica	red rock shrimp
Lytechinus pictus	white sea urchin
Mediaster aequalis	red sea star
Megasurcula carpenteriana	tower snail

Glossary G4 (continued)

Scientific Name	Common Name
Microcosmos (see *Microcosmus*) *squamiger*	
Microcosmus (=Microcosmos) squamiger	scaly tunicate
Mitra idae	half-pitted miter
Molgula verrucifera	warty tunicate
Munida hispida	bristle squat lobster
Munida quadrispina	northern squat lobster
Muricea californica	golden gorgonian
Musculista senhousia	mat mussel
Mytilus galloprovincialis	Mediterranean mussel
Nassarius fossatus	channeled nassa
Nassarius insculptus	smooth western nassa
Nassarius perpinguis	fat western nassa
Nassarius tegula (see *Nassarius tiarula*)	
Nassarius tiarula (=Nassarius tegula)	western mud nassa
Navanax inermis	California aglaja
Neocrangon communis	gray shrimp
Neocrangon resima	flagnose bay shrimp
Neocrangon zacae	moustache bay shrimp
Neosimnia aequalis	Vidler spindlesnail
Neosimnia barbarensis	seapen spindlesnail
Neosimnia loebbeckeana	Loebbeck spindlesnail
Neotrypaea californiensis	bay ghost shrimp
Neptunea tabulata	tabled whelk
Neverita reclusiana	southern moonsnail
Ocinebrina sp	"rocksnail"
Octopus bimaculoides	California two-spot octopus
Octopus californicus	orange bigeye octopus
Octopus rubescens	red octopus
Octopus veligero	brownspot octopus
Ophiacantha phragma	fragile spinyarm brittlestar
Ophionereis eurybrachiplax	"brittlestar"
Ophiopholis bakeri	roughspine brittlestar
Ophiopteris papillosa	flatspine brittlestar
Ophiothrix spiculata	Pacific spiny brittlestar
Ophiura luetkenii	brokenspine brittlestar
Opisthopus transversus	mottled pea crab
Orthopagurus minimus	tubicolous hermit
Ostrea sp	"oyster"
Paguristes bakeri	digger hermit
Paguristes sp A	"left-handed hermit"
Paguristes turgidus	slenderclaw hermit
Paguristes ulreyi	furry hermit
Pagurus armatus	armed hermit
Pagurus redondoensis	bandclaw hermit

Glossary G4 (continued)

Scientific Name	Common Name
Pantomus affinis	hinged shrimp
Panulirus interruptus	California spiny lobster
Paracyathus stearnsii	brown cup coral
Paralithodes californiensis	California king crab
Paralithodes rathbuni	forknose king crab
Parapagurodes makarovi	smoothpalm hermit
Parastenella doederleini	"gorgonian"
Parastichopus californicus	California sea cucumber
Parastichopus sp A	"sea cucumber"
Paraxanthias taylori	lumpy rubble crab
Paristichopus parvimensis	warty sea cucumber
Penaeus californiensis (see *Farfantepenaeus californiensis*)	
Pentamera pseudocalcigera	globose hooked cucumber
Pentamera pseudopopulifera	southern hooked cucumber
Philine alba	white paperbubble
Philine auriformis	New Zealand paperbubble
Phimochirus californiensis	porcelainclaw hermit
Pilumnus spinohirsutus	retiring hairy crab
Pisaster brevispinus	shortspined sea star
Pisaster giganteus capitatus	giant spined star
Pisaster ochraceus	ochre star
Platydoris macfarlandi	California flat doris
Platymera gaudichaudii	armed box crab
Plesionika trispinus	Colombian longbeak shrimp
Pleurobranchaea californica	California sea slug
Pleuroncodes planipes	pelagic red crab
Plocamia karykina	"sponge"
Plumularia sp	"seabristle"
Podochela hemphillii	Hemphill neck crab
Podochela lobifrons	thinbeak neck crab
Poecillastra tenuilaminaris	plate sponge
Polinices (see Euspira) draconis	
Polinices (see Euspira) lewisii	
Polyplacophora	"chiton"
Poraniopsis inflata	spiny sea star
Porifera sp SD 1	"sponge"
Porifera sp SD 10	"sponge"
Porifera sp SD 14	"sponge"
Porifera sp SD 2	"sponge"
Porifera sp SD 3	"sponge"
Porifera sp SD 4	"sponge"
Porifera sp SD 5	"sponge"
Porifera sp SD 6	"sponge"

Glossary G4 (continued)

Scientific Name	Common Name
Protula superba	chalktube worm
Psolus squamatus	scaly sea cucumber
Pteropurpura festiva	festive murex
Pteropurpura vokesae	wrinkle-wing murex
Ptilosarcus gurneyi	fleshy sea pen
Pugettia dalli	spined kelp crab
Pugettia producta	northern kelp crab
Pugettia richii	cryptic kelp crab
Puncturella galeata	helmet puncturella
Pycnopodia helianthoides	sunflower star
Pyromaia tuberculata	tuberculate pear crab
Randallia ornata	globose sand crab
Rathbunaster californicus	California sun star
Rhabdocalyptus dawsoni	"glass sponge"
Rocinela angustata	"fish louse"
Rossia pacifica	Eastern Pacific bobtail
Scabrotrophon grovesi	"trophon"
Schmittius politus	polished mantis shrimp
Sclerasterias heteropaes	banded sea star
Scyra acutifrons	sharpnose crab
Sicyonia ingentis	ridgeback rock shrimp
Sicyonia penicillata	peanut rock shrimp
Solenocera mutator	blossom shrimp
Spatangus californicus	California heart urchin
Sphincturella sp A	"sponge"
Spirontocaris holmesi	slender blade shrimp
Spirontocaris sica	offshore blade shrimp
Stachyptilum superbum	"sea pen"
Staurocalyptus solidus	"glass sponge"
Stenorhynchus debilis	Pacific arrow crab
Strongylocentrotus franciscanus	red sea urchin
Strongylocentrotus purpuratus	Pacific purple urchin
Styela montereyensis	longstalk sea squirt
Styela plicata	cobblestone sea squirt
Stylasterias forreri	fish-eating star
Stylatula elongata	slender sea pen
Suberites suberea	hermitcrab sponge
Synalpheus lockingtoni	littoral pistol shrimp
Terebra pedroana	San Pedro auger
Terebratalia occidentalis	ribbed lamp shell
Terebratalia transversa	red lamp shell
Terebratulina crossei	white lamp shell
Tethya aurantium	orange puffball sponge
Thalamoporella californica	chambered bryozoan

Glossary G4 (continued)

Scientific Name	Common Name
Triopha maculata	maculated triopha
Tritonia diomedea	rosy tritonia
Virgularia agassizi	"sea pen"
Virgularia californica	California sea pen
Zoobotryon verticillatum (=pellucida)	spaghetti moss-animal
Zoobotryon pellucida (see Z. *verticillatum)*	

"See..." indicates name in report is different from that of database or Allen *et al*. (1998) and directs reader to name used in this study. Reasons for changes are given in Appendix D13.

Glossary G5. Alphabetic list by common name of megabenthic invertebrates collected at depths of 2-202 m on the southern California shelf, July-September 1998.

Common Name	Scientific Name
Adam spiny margarite (*see* spiny margarite)	
Alaska bay shrimp	*Crangon alaskensis*
"alcyonacean" (*see* sea pen)	
"anemone"	*Actiniaria* sp SD 1
appleseed erato	*Erato vitellina*
armed box crab	*Platymera gaudichaudii*
armed hermit	*Pagurus armatus*
bandclaw hermit	*Pagurus redondoensis*
banded sea star	*Sclerasterias heteropaes*
basket star	*Gorgonocephalus eucnemis*
bat star	*Asterina miniata*
bay ghost shrimp	*Neotrypaea californiensis*
black sea hare	*Aplysia vaccaria*
blackclaw crestleg crab	*Lophopanopeus bellus*
blackspotted bay shrimp	*Crangon nigromaculata*
black-tipped spiny doris	*Acanthodoris rhodoceras*
blister glassy-bubble	*Haminoea* (=*Haminaea*) vesicula
blood star	*Henricia leviuscula*
blossom shrimp	*Solenocera mutator*
blueleg mantis shrimp	*Hemisquilla ensigera californiensis*
bristle squat lobster	*Munida hispida*
roughdisk brittlestar	*Amphichondrius granulatus*
"brittlestar"	*Amphiodia psara*
"brittlestar"	*Amphioplus* sp
"brittlestar"	*Amphiura arcystata*
"brittlestar"	*Ophionereis eurybrachiplax*
brokenspine brittlestar	*Ophiura luetkenii*
brooding anemone	*Epiactis prolifera*
brown box crab	*Lopholithodes foraminatus*
brown cup coral	*Paracyathus stearnsii*
brown spiny doris	*Acanthodoris brunnea*
brownspot octopus	*Octopus veligero*
California aglaja	*Navanax inermis*
California armina	*Armina californica*
California black sea hare (*see* black seaha..)	
California blade barnacle	*Hamatoscalpellum californicum*
California bubble	*Bulla gouldiana*
California cone	*Conus californicus*
California drillia	*Crassispira semiinflata*
California flat doris	*Platydoris macfarlandi*
California frogsnail	*Crossata californica*
California golden gorgonian (*see* golden go..)	

Glossary G5 (continued)

Common Name	Scientific Name
California king crab	*Paralithodes californiensis*
California lamp shell	*Laqueus californianus*
California market squid	*Loligo opalescens*
California sand star	*Astropecten verrilli*
California sea cucumber	*Parastichopus californicus*
California sea hare (*see* purple sea hare)	
California sea pen	*Virgularia californica*
California sea slug	*Pleurobranchaea californica*
California sidegill slug	*Berthella californica*
California spiny lobster	*Panulirus interruptus*
California squat lobster	*Galathea californiensis*
California sun star	*Rathbunaster californicus*
California two-spot octopus	*Octopus bimaculoides*
Catalina forreria	*Austrotrophon catalinensis*
Catalina turrid	*Antiplanes catalinae (=perversus)*
chalktube worm	*Protula superba*
chambered bryozoan	*Thalamoporella californica*
channeled nassa	*Nassarius fossatus*
"chiton"	Polyplacophora
cloud sponge	*Aphrocallistes vastus*
cobblestone sea squirt	*Styela plicata*
Colombian longbeak shrimp	*Plesionika trispinus*
colonial cup coral	*Coenocyathus bowersi*
"colonial tunicate"	*Aplydium* sp
"cookie star"	*Ceramaster* sp
Cooper nutmeg	*Cancellaria cooperii (=cooperi)*
copper sea mouse (*see* copperwire sea mo.)	
copperwire sea mouse	*Aphrodita armifera*
Crawford nutmeg	*Cancellaria crawfordiana*
cryptic kelp crab	*Pugettia richii*
"cup coral"	*Caryophyllia alaskensis*
cuttail fish louse (*see* cuttail sea louse)	
cuttail sea louse	*Excorallana truncata*
delicate moonsnail	*Calinaticina oldroydii*
digger hermit	*Paguristes bakeri*
"dirona"	*Dirona* sp
Drake moonsnail	*Euspira* (=*Polinices*) *draconis*
Eastern Pacific bobtail	*Rossia pacifica*
eggcase limpet	*Addisonia brophyi*
fat western nassa	*Nassarius perpinguis*
feather star	*Florometra serratissima*
festive murex	*Pteropurpura festiva*
"fish louse"	*Rocinela angustata*
fish-eating star	*Stylasterias forreri*

Glossary G5 (continued)

Common Name	Scientific Name
forknose king crab	*Paralithodes rathbuni*
fragile sea urchin	*Allocentrotus fragilis*
fragile spinyarm brittlestar	*Ophiacantha phragma*
fringed sand star	*Luidia asthenosoma*
furrowed rock crab	*Cancer branneri*
furry hermit	*Paguristes ulreyi*
giant frond-aeolis	*Dendronotus iris*
giant orange tochui	*Tochuina tetraquetra*
giant rock scallop	*Crassadoma gigantea*
giant spined star	*Pisaster giganteus capitatus*
gigantic anemone	*Metridium farcimen* (=*senile* Cmplx)
"glass sponge"	*Rhabdocalyptus dawsoni*
"glass sponge"	*Staurocalyptus solidus*
globose hooked cucumber	*Pentamera pseudocalcigera*
globose sand crab	*Randallia ornata*
glorious topsnail	*Calliostoma gloriosum*
golden gorgonian	*Muricea californica*
golden paperbubble (*see* New Zealand pap.)	
"gorgonian"	*Alcyonacea* (=*Alcyonaria*) sp SD 1
"gorgonian"	*Heterogorgia tortuosa*
"gorgonian"	*Parastenella doederleini*
graceful rock crab	*Cancer gracilis*
gray sand star	*Luidia foliolata*
gray shrimp	*Neocrangon communis*
green sea mouse	*Aphrodita refulgida*
hairy rock crab	*Cancer jordani*
half-pitted miter	*Mitra idae*
helmet puncturella	*Puncturella galeata*
Hemphill fileclam	*Limaria hemphilli*
Hemphill kelp crab (*see* Hemphill neck crab)	
Hemphill neck crab	*Podochela hemphillii*
hermitcrab sponge	*Suberites suberea*
hinged shrimp	*Pantomus affinis*
"horn coral" (*see* cup coral)	
Hudson doris (*see* Hudson spiny doris)	
Hudson spiny doris	*Acanthodoris hudsoni*
Kellet whelk	*Kelletia kelletii* (=*kelletti*)
kelp scallop	*Leptopecten latiauratus*
"left-handed hermit"	*Paguristes* sp A
Lewis moonsnail	*Euspira* (=*Polinices*) *lewisii*
littoral pistol shrimp	*Synalpheus lockingtoni*
Loebbeck spindlesnail	*Neosimnia loebbeckeana*
longhorn decorator crab	*Chorilia longipes*
longstalk sea squirt	*Styela montereyensis*

Glossary G5 (continued)

Common Name	Scientific Name
Mediterranean mussel	*Mytilus galloprovincialis*
microcosm tunicate (*see* scaly tunicate)	
molarless crestleg crab	*Lophopanopeus frontalis*
Monterey sea-lemon	*Archidoris montereyensis*
moon snail hermit	*Isocheles pilosus*
mosaic sand star	*Luidia armata*
moss crab	*Loxorhynchus crispatus*
mottled pea crab	*Opisthopus transversus*
moustache bay shrimp	*Neocrangon zacae*
mudflat snapping shrimp	*Alpheus californiensis*
"nestling sea cucumber"	*Cucumaria* sp
New Zealand paperbubble	*Philine auriformis*
northern heart urchin	*Brisaster latifrons*
northern kelp crab	*Pugettia producta*
northern squat lobster	*Munida quadrispina*
ocean shrimp	*Pandalus jordani*
ochre star	*Pisaster ochraceus*
offshore blade shrimp	*Spirontocaris sica*
offshore sand dollar	*Dendraster terminalis*
onyx slippersnail	*Crepidula onyx*
orange bigeye octopus	*Octopus californicus*
orange gorgonian	*Adelogorgia phyllosclera*
orange puffball sponge	*Tethya aurantium*
orange sand star	*Astropecten ornatissimus*
ostrichplume hydroid	*Aglaophenia struthionides*
"oyster"	*Ostrea* sp
Pacific acorn barnacle	*Balanus pacificus*
Pacific arrow crab	*Stenorhynchus debilis*
Pacific calico scallop	*Argopecten ventricosus*
Pacific half-slippersnail	*Crepipatella dorsata*
Pacific heart urchin	*Brissopsis pacifica*
Pacific purple urchin	*Strongylocentrotus purpuratus*
Pacific sand dollar	*Dendraster excentricus*
Pacific spiny brittlestar	*Ophiothrix spiculata*
Pacific sponge crab	*Cryptodromiopsis larraburei*
pallid papermussel	*Amygdalum politum*
parchment tube worm	*Chaetopterus variopedatus* Cmplx
peanut rock shrimp	*Sicyonia penicillata*
pelagic red crab	*Pleuroncodes planipes*
pink sea whip	*Lophogorgia chilensis*
plate sponge	*Poecillastra tenuilaminaris*
polished mantis shrimp	*Schmittius politus*
porcelainclaw hermit	*Phimochirus californiensis*
purple aeolis (*see* Spanish shawl)	

Glossary G5 (continued)

Common Name	Scientific Name
red lamp shell	*Terebratalia transversa*
red octopus	*Octopus rubescens*
red rock crab	*Cancer productus*
red rock shrimp	*Lysmata californica*
red sea star	*Mediaster aequalis*
red sea urchin	*Strongylocentrotus franciscanus*
retiring hairy crab	*Pilumnus spinohirsutus*
ribbed lamp shell	*Terebratalia occidentalis*
ridgeback rock shrimp	*Sicyonia ingentis*
"right-handed hermit"	*Enallopaguropsis guatemoci*
ringed doris	*Diaulula sandiegensis*
"rocksnail"	*Ocinebrina* sp
rosy tritonia	*Tritonia diomedea*
brittlestar	*Amphiodia digitata*
roughspine brittlestar	*Ophiopholis bakeri*
salted yellow doris	*Doriopsilla albopunctata*
San Diego scallop	*Euvola diegensis*
San Pedro auger	*Terebra pedroana*
sandflat elbow crab	*Heterocrypta occidentalis*
Santa Barbara simnia (*see* seapen spindle.)	
Santa Barbara spindle	*Fusinus barbarensis*
scaly sea cucumber	*Psolus squamatus*
scaly tunicate	*Microcosmus (=Microcosmos) squamiger*
"sea cucumber"	*Parastichopus* sp A
sea dandelion	*Dromalia alexandri*
"sea pen"	*Stachyptilum superbum*
"sea pen"	*Virgularia agassizi*
sea porcupine	*Lovenia cordiformis*
"sea spider"	*Anoplodactylus erectus*
"sea spider"	*Anoplodactylus virdintestinalis*
sea strawberry (*see* sea dandelion)	
"sea twig"	*Thesea* sp A
"seabristle"	*Plumularia* sp
seapen spindlesnail	*Neosimnia barbarensis*
secret jewelbox	*Chama arcana*
Senhouse mussel (*see* mat mussel)	
shaggy sea mouse	*Aphrodita negligens*
sharpnose crab	*Scyra acutifrons*
sheep crab	*Loxorhynchus grandis*
short arm octopus (*see* brownspot octopus)	
shortkeel bay shrimp (*see* moustache bay)	
shortneck pear crab	*Erileptus spinosus*
shortspined sea star	*Pisaster brevispinus*
six-arm sea star	*Leptasterias hexactis*

Glossary G5 (continued)

Common Name	Scientific Name
smooth western nassa	*Nassarius insculptus*
smoothpalm hermit	*Parapagurodes makarovi*
smooth-tooth aeolis	*Flabellina pricei*
southern hooked cucumber	*Pentamera pseudopopulifera*
southern moonsnail	*Neverita reclusiana*
southern spinyhead	*Metacrangon spinosissima*
spaghetti moss-animal	*Zoobotryon verticillatum (=pellucida)*
Spanish shawl	*Flabellina iodinea*
spindle topsnail	*Calliostoma turbinum*
spined kelp crab	*Pugettia dalli*
spiny cup-and-saucer	*Crucibulum spinosum*
spiny margarite	*Cidarina cidaris*
spiny red star	*Hippasteria spinosa*
spiny sand star	*Astropecten armatus*
spiny scallop	*Chlamys hastata*
spiny sea star	*Poraniopsis inflata*
"sponge"	*Plocamia karykina*
"sponge"	Porifera sp SD 1
"sponge"	Porifera sp SD 10
"sponge"	Porifera sp SD 14
"sponge"	Porifera sp SD 2
"sponge"	Porifera sp SD 3
"sponge"	Porifera sp SD 4
"sponge"	Porifera sp SD 5
"sponge"	Porifera sp SD 6
"sponge"	Porifera sp SD 7
"sponge"	Porifera sp SD 8
"sponge"	*Sphincturella* sp A
spot shrimp	*Pandalus platyceros*
spotwrist hermit	*Pagurus spilocarpus*
Stimpson coastal shrimp	*Heptacarpus stimpsoni*
sunflower star	*Pycnopodia helianthoides*
tabled whelk	*Neptunea tabulata*
thinbeak neck crab	*Podochela lobifrons*
tower snail	*Megasurcula carpenteriana*
"trailtip sea pen".	*Acanthoptilum* sp
"trophon"	*Boreotrophon* sp
"trophon"	*Scabrotrophon grovesi*
tuberculate pear crab	*Pyromaia tuberculata*
tubicolous hermit	*Orthopagurus minimus*
"tunicate"	*Ascidia zara*
"tunicate"	*Ascidiidae* sp SD 1
urn sponge	*Leucilla nuttingi*
Vidler simnia (*see* Vidler spindlesnail)	

Glossary G5 (continued)

Common Name	Scientific Name
warty tunicate	*Molgula verrucifera*
western mud nassa	*Nassarius tiarula* (=*tegula*)
white lamp shell	*Terebratulina crossei*
white paperbubble	*Philine alba*
white sea urchin	*Lytechinus pictus*
white slippersnail	*Crepidula perforans*
winged kelp crab	*Epialtoides hiltoni*
wrinkle-wing murex	*Pteropurpura vokesae*
Xantus swimming crab	*Portunus xantusii*
yellow rock crab	*Cancer anthonyi*
yellow sea twig	*Thesea* sp B
yellow-green sea squirt	*Ciona intestinalis*
yellowleg shrimp	*Farfantepenaeus* (=*Penaeus*) californiensis

"See..." indicates name in report is different from that of database or Allen *et al*. (1998) and directs reader to name used in this study. Reasons for changes are given in Appendix D13.