Demersal Fishes and Megabenthic Invertebrates

Hotels located along the north end of the Silver Strand, Coronado Island

Chapter 4
Demersal Fishes and Megabenthic Invertebrates

INTRODUCTION

Bays and estuaries are important nursery and refuge areas for many fish species (Cross and Allen 1993) and provide suitable habitats to large populations of megabenthic invertebrates (i.e., large epibenthic species) as well. However, human development has altered or degraded many embayments in southern California with few still serving all of their original functions. San Diego Bay is the largest naturally occurring marine embayment between San Francisco and Scammon's Lagoon in central Baja California, Mexico. As such, it forms an essential habitat for many ecologically and commercially important species. Consequently, the fishes of San Diego Bay have been studied extensively in order to better understand this important ecosystem (see review in USDoN, SWDIV and SDUPD 2000). Of the 86 species reported from the Bay, the most common are the California halibut, spotted sand bass, barred sand bass and round stingray. In contrast to fishes, invertebrate assemblages have been studied much less extensively. For example, little is known about many of the megebenthic species that inhabit the Bay, including populations of various sponges, gastropods, bivalves and decapods (see USDoN, SWDIV and SDUPD 2000).

The City of San Diego and SPAWAR surveyed the demersal fish and megabenthic invertebrate populations of San Diego Bay as part of the Bight'98 regional survey. The purposes of the study were to add to the existing body of knowledge on fish and invertebrate communities in the Bay, describe their structure, and provide insight into the effects associated with anthropogenic and natural influences on these communities. This chapter presents analyses and interpretation of data collected by otter trawl during the summer of 1998. The San Diego Bay assemblages are also compared to those from other bays and harbors sampled during Bight'98.

MATERIALS & METHODS

Sampling

Demersal fishes and megabenthic invertebrates were collected at 16 randomly selected stations in San Diego Bay during the summer of 1998 (Figure 4.1). The methodology for locating stations and trawling are described in the Field Manual for the Bight'98 project (FSLC 1998). A 7.6 m Marinovich otter trawl with a 1.3 cm cod-end mesh was towed at each station along a predetermined heading for five minutes at approximately 2.5 knots. Trawl catches were brought on board for sorting and inspection. Fishes and invertebrates were identified to the lowest taxon possible and enumerated aboard ship. However, sponges were recorded only as "present" because their tendency to fragment prevented accurate enumeration. Animals that could not be identified in the field were set aside and returned to the laboratory for further identification. Fish were inspected for the presence of external parasites and physical anomalies (e.g., tumors, fin erosion, discoloration) and measured (or size-classed) to the nearest centimeter according to protocols described in the field manual (FSLC 1998). The biomass (wet weight, kg) were recorded for each fish species, while

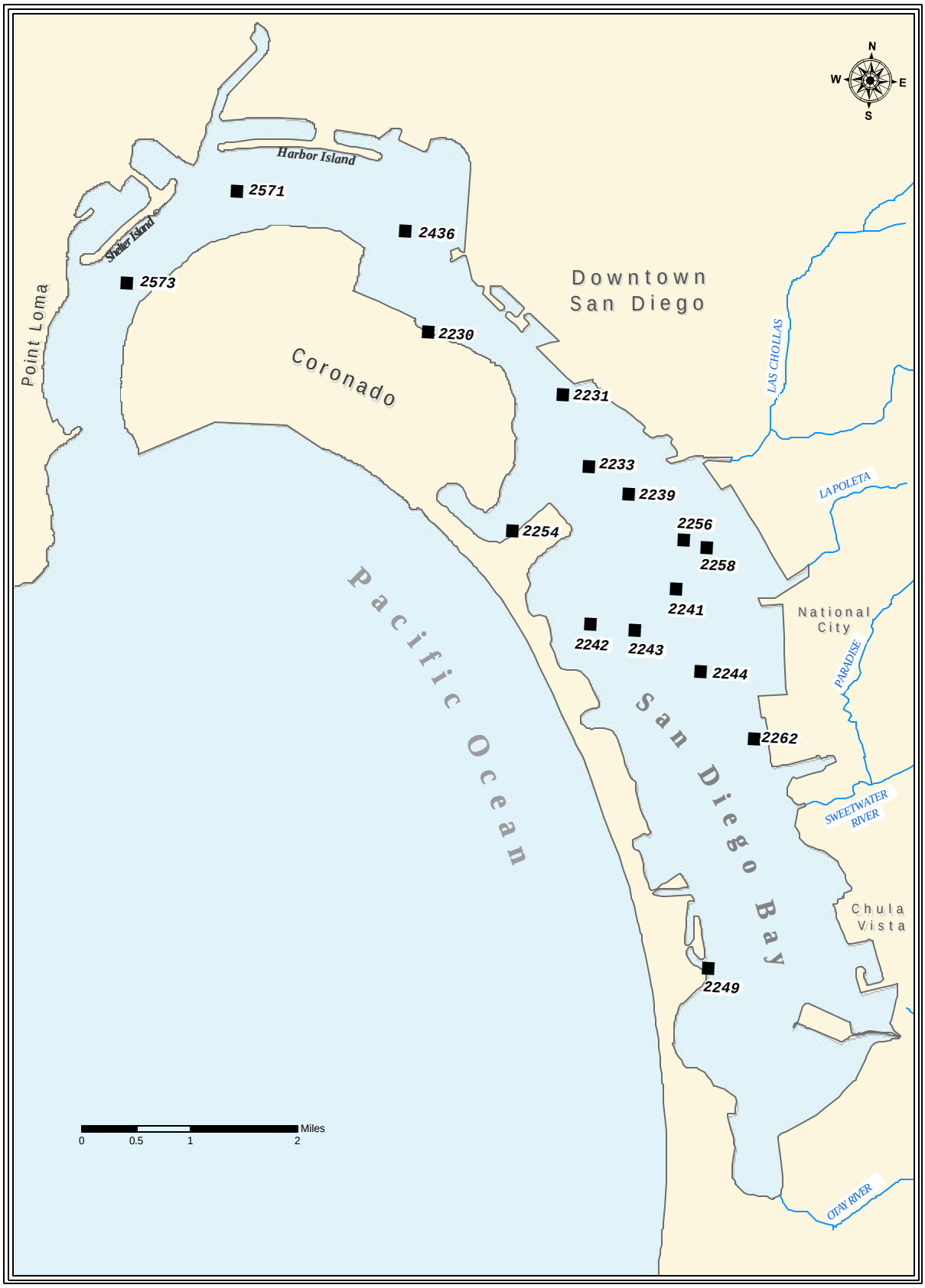

Figure 4.1
Otter trawl station locations sampled in San Diego Bay during 1998.

invertebrate biomass was measured as a composite weight of all species combined. The type and amount of any debris associated with each haul was also identified (see Appendix D.1).

Data Analyses

Fish and invertebrates communities were summarized by calculating (1) the mean abundance per occurrence (MO = number per species/total number of trawls), (2) percent abundance (PA = number per species/total number caught), and (3) frequency of occurrence (FO = number of occurrences for each species/total number of trawls). In addition, the following parameters were calculated by station for both fishes and invertebrates: (1) species richness (number of species); (2) abundance (number of individuals); (3) Shannon diversity index (H'); (4) biomass (wet weight, kg.).

Ordination (principal coordinates) and classification (hierarchical agglomerative clustering) analyses were performed separately for fishes and invertebrates to examine spatial patterns among assemblages occurring in San Diego Bay. All analyses were performed on total abundance per trawl for each species using Ecological Analysis Package (EAP) software (see Smith 1982, Smith et al. 1988). The abundance data were square-root transformed prior to analysis.

Comparison of San Diego Bay to Other Embayments

In addition to San Diego Bay, nine other southern California bays were sampled by trawl during Bight'98. From north to south these embayments are Ventura Harbor, Channel Islands Harbor, Marina Del Rey, King Harbor, Los Angeles/Long Beach Harbor, Alamitos Bay, Newport Bay, Oceanside Harbor, and Mission Bay. Including San Diego Bay stations, a total of 55 sites were surveyed by 11 participating agencies. Methodologies and protocols for the collection and processing of these samples were the same as for those outlined previously. Ordination and classification of total abundance data from all 55 stations was performed to evaluate spatial patterns among the ten embayments. The distribution of fish and megabenthic invertebrates were considered separately.

RESULTS

Fishes in San Diego Bay

Community Description

Trawl catches from San Diego Bay during the summer of 1998 were fairly small in terms of the abundance and diversity of fish. Three hundred forty-nine individuals, representing 16 species of fish were collected from 16 stations (Table 4.1, Appendeces D.2 and D.3). Generally, the small size of each haul was reflected in the low abundance, species richness, diversity and biomass values (Table 4.2). For example, the average trawl included only 22 individual fish with a diversity (H') of 1.4. Despite the small size of the hauls, fish populations in San Diego Bay appeared to be healthy, with no physical abnormalities (i.e., fin rot) detected on any fish. In addition, only one instance of parasitic infestation was observed on a barred sand bass collected from Glorietta Bay (i.e., station 2254).

The four most widely occurring species were the round stingray, spotted sand bass, barred sand bass and California halibut (Table 4.1). Each of these species was present in more than 75% of the trawls and represented

Table 4.1

Demersal fish species collected in 16 trawls from San Diego Bay during 1998. Data for each species are expressed as: frequency of occurrence (FO); percent abundance (PA); and mean abundance per occurrence (MAO).

Species	FO	PA	MAO
Round stingray	79	25	8
Spotted sand bass	100	18	5
Barred sand bass	100	15	4
California halibut	86	13	4
California tonguefish	21	5	6
Spotted turbot	50	5	3
Slough anchovy	14	4	8
Black croaker	43	4	2
Diamond turbot	57	4	2
Specklefin midshipman	14	3	5
White croaker	14	2	3
California lizardfish	21	1	1
Diamond stingray	14	1	1
Pacific seahorse	14	1	1
California butterfly ray	7	<1	1
Shovelnose guitarfish	7	<1	1

Table 4.2

Summary of demersal fish community parameters sampled in San Diego Bay during 1998. Number of species (SR) is expressed as total number of species. Abundance, diversity (H:) and biomass (kg, wet weight) are expressed for each station.

STATION	SR	ABUND	H'	BM
2230	3	7	1.0	0.6
2231	6	20	1.6	3.9
2233	7	24	1.7	5.5
2239	7	22	1.8	13.6
2241	5	47	1.1	12.8
2242	7	24	1.5	3.4
2243	6	32	1.4	5.3
2244	3	13	1.0	2.5
2249	3	5	1.1	0.3
2254	4	15	1.3	1.5
2256	8	24	1.7	9.1
2258	4	15	1.3	3.1
2262	4	17	0.8	0.9
2436	9	43	1.9	3.3
2571	9	31	1.9	7.2
2573	5	10	1.5	1.0
Survey Mean	**6**	**22**	**1.4**	**4.6**
Survey STD	**2**	**12**	**0.4**	**4.1**

between13 and 25% of the total fish abundance. Diamond and spotted turbots and black croaker also occurred quite frequently (i.e., 40 – 60% of the hauls), but in fairly low numbers (≤ 3 fish per haul). The round stringray and slough anchovy had the highest numbers per occurrence (i.e,. 8 fish per haul).

Ordination and classification of sites discriminated among three assemblages (SG1-SG3) within San Diego Bay (Table 4.3, Figure 4.2). SG1 comprised 56% of all samples analyzed (i.e., 9 stations) and represents the dominant assemblage in the central region of the Bay. This assemblage was characterized by relatively large numbers of round stingrays and spotted sand bass per trawl. Other species typical of southern California embayments, such as barred sand bass and California halibut, were also common in this assemblage. SG2 consisted of four stations located along the margins of central and southern San Diego Bay. This assemblage included many of these same species found in SG1, but with lower numbers of round stingrays and spotted sand bass. This group had the lowest average abundance and number of species of the three groups. In contrast, SG3, which included three relatively deep stations located close to the entrance of the Bay, had the highest average species richness and abundance. This assemblage was characterized by relatively high abundances of species frequently associated with shallow coastal communities, such as those located just outside of San Diego Bay. For example, three species unique to SG3 (specklefin midshipman, California tonguefish, and California lizardfish) are commonly collected on the coastal shelf off Point Loma and Imperial Beach (City of San Diego 2001a, 2001b).

Size Distribution

The fishes captured in San Diego Bay ranged in length from 4 to 79 cm (Appendix D.2). Only the four most abundant species (round sting ray, spotted sand bass, barred sand bass, California halibut) provided enough data to evaluate life history traits. Almost all of the barred sand bass and California halibut were juveniles, indicating that they use the Bay primarily as a nursery (Figure 4.3). For example, the average barred sand bass from San Diego Bay was 14 cm long with a maximum length of 21 cm, well below the size at which they are considered mature (i.e., 27 cm; Love 1996). California halibut also averaged 14 cm in length, far below the size at which they typically become mature (30 cm and 58 cm for males and females, respectively; Love 1996). On the other hand, round stingrays and spotted sand bass had multi-modal length distributions, representing both juvenile and adult life stages. Round stingrays ranged from 15 to 36 cm in lenght, with an average of 25 cm. According to Love (1996), round stingrays become sexually mature around 25 cm. Therefore, approximately 56% of the round stingrays collected in San Diego Bay would be classified as adults. Similarly, 30% of the spotted sand bass captured were considered sexually mature. These fish ranged in length from 11 to 29 cm, with an average length of 21 cm. Female spotted sand bass mature at one year old or at a length of about 25 cm, and males mature slightly later (and larger) at about three years old (Love 1996).

Megabenthic Invertebrates in San Diego Bay

A total of 1,172 megabenthic invertebrates, representing 43 taxa, were collected in San Diego Bay during 1998 (Table 4.4, Appendix D.4). The non-indigenous bivalve *Musculista senhousia* was present in over 70% of the samples and was the most widely distributed trawl-caught invertebrate. Other frequently occurring species that were present in at least 33% of the samples included two unidentified sponges, Porifiera sp SD4 and Porifera sp SD5, the ascidian *Microcosmus squamiger*, the bivalve *Argopecten ventricosus*, and the gastropod *Crepidula onyx*. *Musculista senhousia* and *Microcosmus squamiger,* both introduced species, together accounted for over 50% of the total catch.

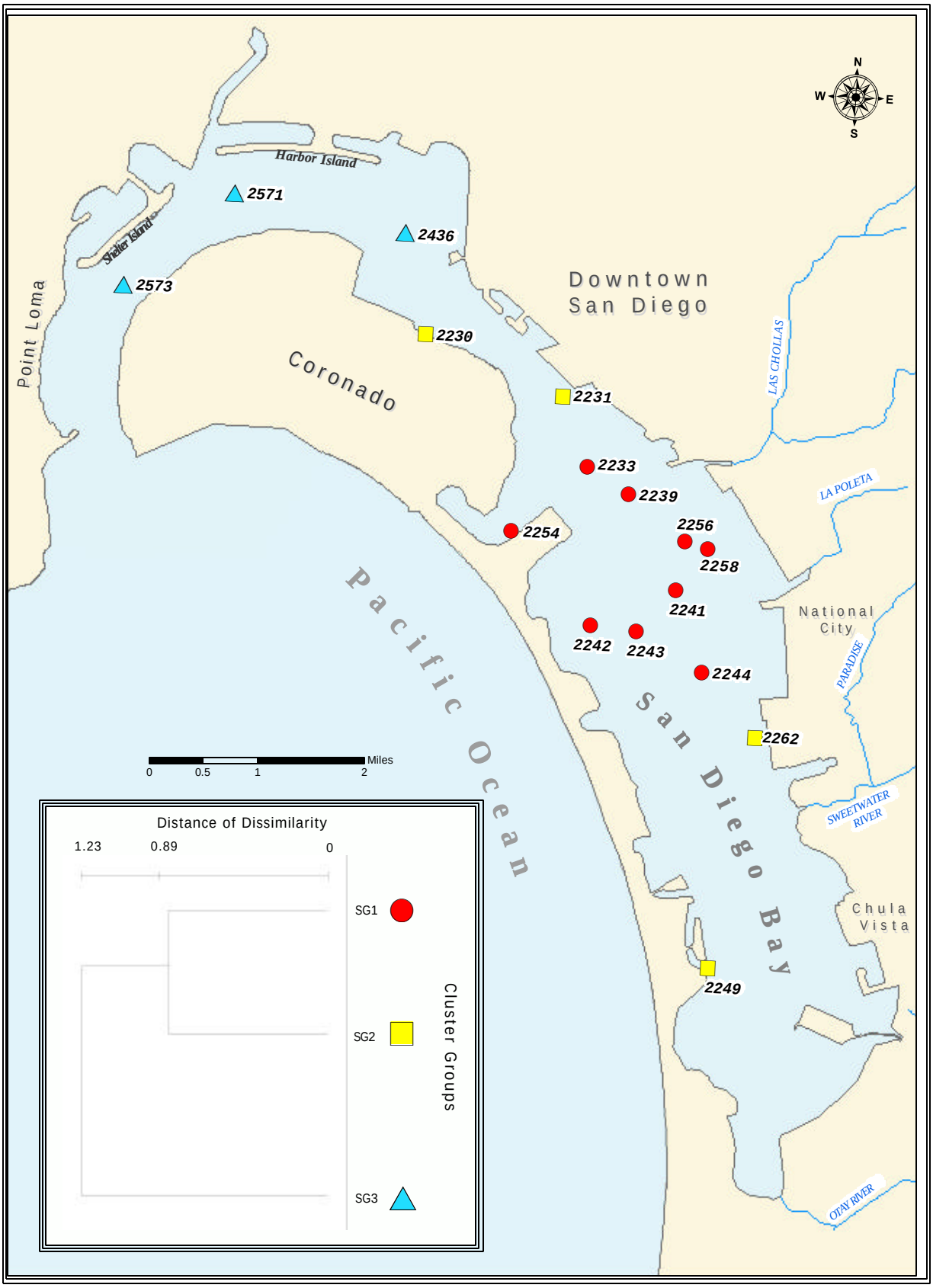

Figure 4.2

Summary of results of classification analysis of demersal fish collected in San Diego Bay during 1998.

Table 4.3

Distribution of the abundant and frequently occurring fish species among the main station cluster groups for San Diego Bay. '—'= not present. The three most abundant species per group are shown in bold type.

	SG1	SG2	SG3
Number of hauls	9	4	3
Mean depth per haul (m)	7	8	13
(Range)	(3-11)	(3-11)	(10-15)
Mean No. of Species	6	4	8
(Range)	(3-8)	(3-6)	(5-9)
Mean No. of Individuals	24	12	28
(Range)	(13-47)	(5-20)	(10-43)
Species	**Mean Abundance**		
Round stingray	**9.2**	0.3	0.7
Spotted sand bass	**5.8**	**2.3**	0.7
Barred sand bass	**3.9**	**2.5**	2.0
California halibut	2.9	**3.3**	**2.7**
Black croaker	0.6	1.3	1.0
Spotted turbot	0.3	1.8	**2.7**
Diamond turbot	0.3	1.0	2.0
Specklefin midshipman	0.1	—	**2.7**
California tonguefish	—	—	**6.0**
Slough anchovy	—	—	**5.0**
California lizardfish	—	—	1.3

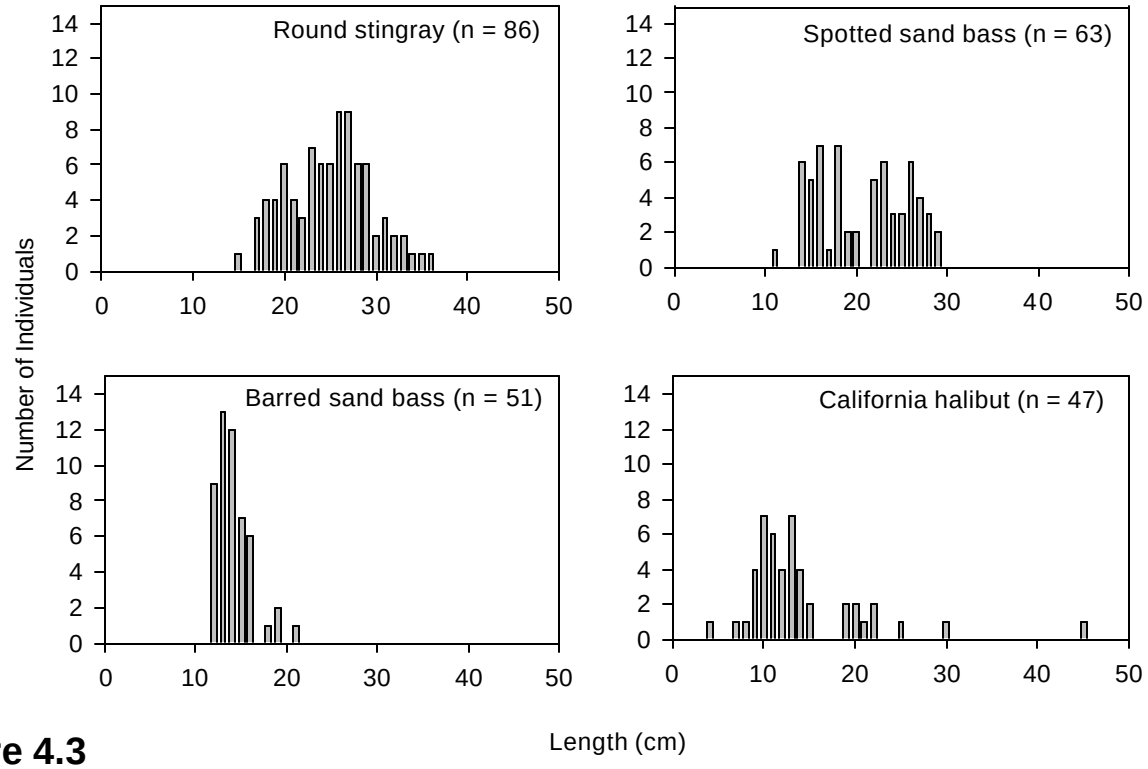

Figure 4.3

Length frequency plots for the top four most abundant fish captured in San Diego Bay during 1998.

Table 4.4

Megabenthic invertebrate species collected in 16 trawls from San Diego Bay during 1998. Data for each species are expressed as: mean abundance per occurrence (MAO); percent abundance (PA); and frequency of occurrence (FO).

Species	Taxa	FO	PA	MAO
Musculista senhousia	Mollusca	71	42	50
Porifera sp SD 4*	Porifera	50	1	1
Microcosmus squamiger	Ascidiacea	43	16	32
Argopecten ventricosus	Mollusca	43	1	1
Crepidula onyx	Mollusca	36	7	15
Porifera sp SD 5*	Porifera	36	<1	1
Ostrea sp	Mollusca	29	7	20
Nassarius tiarula	Mollusca	29	6	17
Bulla gouldiana	Mollusca	29	6	17
Styela plicata	Ascidiacea	29	2	5
Pteropurpura festiva	Mollusca	29	1	3
Ascidiacea	Ascidiacea	29	<1	1
Crucibulum spinosum	Mollusca	14	5	31
Penaeus californiensis	Crustacea	14	1	5
Lophopanopeus frontalis	Crustacea	14	<1	3
Porifera*	Porifera	14	<1	3
Pyromaia tuberculata	Crustacea	14	<1	3
Ciona sp	Ascidiacea	14	<1	2
Diaulula sandiegensis	Mollusca	14	<1	2
Styela montereyensis	Ascidiacea	14	<1	2
Synalpheus lockingtoni	Crustacea	14	<1	2
Porifera sp SD 2*	Porifera	14	<1	1
Actiniaria sp SD 1	Cnidaria	7	1	15
Limaria hemphilli	Mollusca	7	<1	2
Loligo opalescens	Mollusca	7	<1	2
Acanthoptilum sp	Cnidaria	7	<1	1
Asterina miniata	Echinodermata	7	<1	1
Crangon nigromaculata	Crustacea	7	<1	1
Doriopsilla albopunctata	Mollusca	7	<1	1
Haminoea vesicula	Mollusca	7	<1	1
Leptopecten latiauratus	Mollusca	7	<1	1
Leucilla nuttingi	Porifera	7	<1	1
Lophopanopeus bellus	Crustacea	7	<1	1
Loxorhynchus sp	Crustacea	7	<1	1
Navanax inermis	Mollusca	7	<1	1
Panulirus interruptus	Crustacea	7	<1	1
Porifera sp SD 1*	Porifera	7	<1	1
Porifera sp SD 10*	Porifera	7	<1	1
Porifera sp SD 6*	Porifera	7	<1	1
Porifera sp SD 7*	Porifera	7	<1	1
Porifera sp SD 8*	Porifera	7	<1	1
Pugettia producta	Crustacea	7	<1	1
Synidotea harfordi	Crustacea	7	<1	1

* Sponges identified as present/absent (abundance always =1)

Table 4.5

Megabenthic invertebrate community parameters sampled in San Diego Bay during 1998. Number of species (SR) is expressed as total number of species. Abundance (ABUND), diversity (H') and biomass (BM) (kg, wet weight) are expressed for each station. P-BM = average sponge biomass per station (subset of total).

STATION	SR	ABUND	H'	BM	P-BM
2230	3	11	0.6	0.1	-
2231	11	18	2.2	4.0	2.6
2233	13	20	2.4	0.3	0.2
2239	5	58	0.5	1.5	1.4
2241	5	167	0.7	5.8	5
2242	3	20	0.9	4.4	4.2
2243	7	32	1.4	24.9	24.8
2244	4	5	1.3	5.3	5.2
2249	4	7	1.2	14.1	14
2254	10	24	1.9	0.6	-
2256	9	294	0.8	0.3	-
2258	9	387	1.6	62.7	61
2262	6	70	1.0	1.1	1
2436	10	46	1.3	4.5	4.2
2571	2	10	0.3	1.1	-
2573	3	3	1.1	0.1	-
Survey Mean	**7**	**73**	**1.2**	**8.2**	**11.2**
Survey STD	**3**	**113**	**0.6**	**15.9**	**18.0**

Although the contribution of marine sponges to the total trawl catch was significant, abundance estimates were not possible since these animals tended to fragment upon collection. Consequently, the importance of sponges to the megabenthic invertebrate community can only be inferred from their biomass and frequency of occurrence, which is only represented in the raw data (Appendix D.5). For example, Porifera sp SD4 and Porifera sp SD5 were collected in what appeared to be large mats. The overwhelming contribution of these sponges to a station's total biomass (e.g., 97% at station 2258) was indicative of their dominance, as well as their contribution as a substrate for other organisms.

The structure of the trawl-caught invertebrate assemblages was highly variable (Table 4.5). For example, the number of species per trawl ranged from 2 at station 2571 near the entrance to the Bay to 13 at station 2333 located near the middle of the Bay. Abundance per trawl averaged from 3 near the mouth of the Bay (i.e., station 2573) to 387 individuals near the middle of the Bay (i.e., station 2258). The highest invertebrate abundances occurred at sites near the Naval Station San Diego (i.e., stations 2241, 2256, 2258) located towards the middle of the Bay. These sites included large numbers of the ascidian *Microcosmus squamiger* and the bivalve *Musculista senhousia*. Average biomass also ranged widely, ranging from 0.1 to 62.7 kg depending upon the amount of sponge material collected. For example, when present, sponges frequently accounted for 65-97% of the total invertebrate biomass. The three stations with the highest sponge biomass occurred in the central and southern sections of the Bay (i.e., stations 2243, 2249, 2258). Stations with the lowest species richness, abundance, and biomass values tended to occur towards the northern portion of the Bay (i.e., 2230, 2571, 2573).

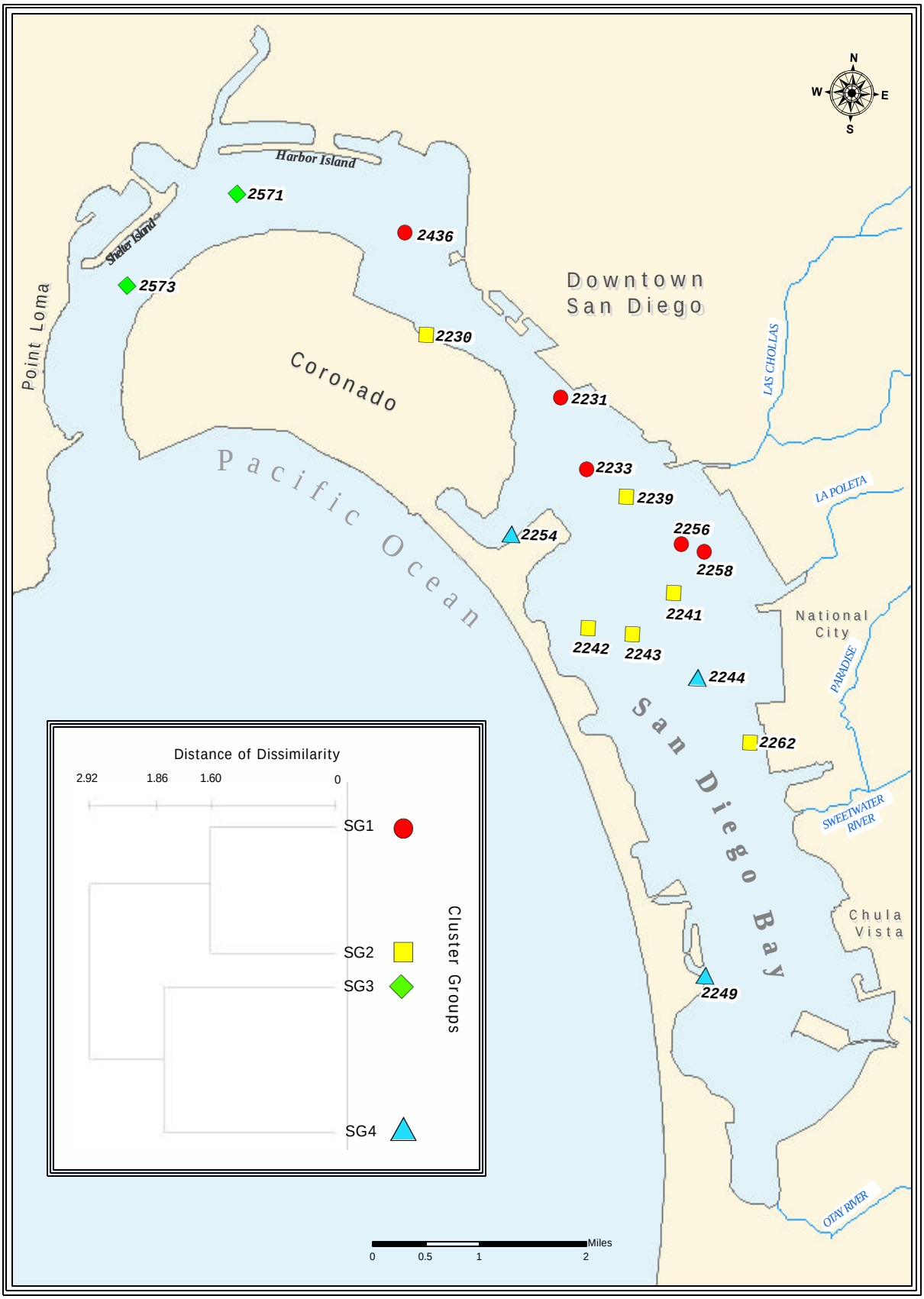

Figure 4.4

Summary of results of classification analysis of megabenthic invertebrates collected in San Diego Bay during 1998.

Table 4.6

Distribution of the abundant and frequently occurring megabenthic invertebrate species among the main station cluster groups for San Diego Bay; '—'= not present. The three most abundant species per group are shown in bold type.

	SG1	SG2	SG3	SG4
Number of hauls	5	6	2	3
Mean depth per haul (m)	10	7	15	4
(Range)	(8-11)	(3-11)	(15-15)	(3-4)
Mean No. of Species	10	5	3	6
(Range)	(9-13)	(3-7)	(2-3)	(4-10)
Mean No. of Individuals	153	60	7	12
(Range)	(18-387)	(11-167)	(3-10)	(5-24)
Species	**Mean Abundance**			
Musculista senhousia	**54.6**	**36.0**	—	**3.0**
Microcosmus squamiger	**37.6**	0.2	—	0.3
***Ostrea* sp**	**15.6**	—	—	0.3
Crepidula onyx	14.8	—	—	1.0
Crucibulum spinosum	12.4	—	—	—
Nassarius tiarula	6.4	**6.2**	—	—
Styela plicata	2.0	0.8	—	**1.3**
Porifera sp SD 4	1.0	0.5	—	—
Argopecten ventricosus	0.6	0.7	—	—
Penaeus californiensis	0.2	—	**4.5**	—
Bulla gouldiana	—	**11.2**	—	0.3
Actiniaria sp SD 1	—	2.5	—	—
Ascidiacea	—	0.3	—	0.7
Synidotea harfordi	—	—	**0.5**	—
Pugettia producta	—	—	**0.5**	—
Porifera	—	—	—	**1.7**
Panulirus interruptus	—	—	**0.5**	—
Crangon nigromaculata	—	—	**0.5**	—

Ordination and classification of sites discriminated among four main invertebrate assemblages (SG1-SG4) within San Diego Bay (Figure 4.4 and Table 4.6). Two assemblages (SG1 and SG2) occurred along the shipping channel in the north and central portions of the Bay. SG1 consisted of five relatively deep stations located along the east half of the Bay. This section of San Diego Bay included the most dense and diverse invertebrate populations. *Musculista senhousia*, *Microcosmus squamiger*, *Ostrea* sp, *Crepidula onyx*, and various sponges (Porifera species SD4 and SD5) were common members of this assemblage (see Appendix D.3). SG2 consisted of six stations that were slightly shallower and located more centrally within the Bay than SG1. These sites averaged fewer species and fewer numbers of individuals, and had lower abundances of *M. squamiger*, *Ostrea* sp, *Crepidula onyx*, *Crucibulum spinosum*. SG2 also differed from those stations along the east side of the bay (SG1) by the presence of *Bulla gouldina*, a gastropod that was one of the dominant taxa. The other two assemblages represented sites that were located in relatively deeper waters near the entrance to the mouth of the Bay (SG3), or shallow, muddy habitats located towards the back of the Bay (SG4). With the exception of station 2254 located in Glorietta Bay, species richness and overall abundances were low at the locations comprising these two station groups. SG3 was represented by species typically found in the shallow, off-shore coastal areas of San Diego, such

as the decapods *Penaeus californiensis*, *Pugettia producta*, *Crangon nigromaculata* and *Panulirus interruptus*, and the isopod *Synidotea harfodi*. In contrast, SG4 comprised sites containing many species common to the main assemblage in the northern and central portion of the Bay (i.e., SG1 and SG2), but in significantly lower abundances.

Comparison of San Diego Bay to Other Embayments

Fish Assemblages

Ordination and classification of all 55 Bight'98 embayment sites discriminated between five major clusters, each consisting of similar types of demersal fish assemblages (SG1 – SG5) (Figure 4.5 and 4.6). The stations generally clustered according to the size and structure of the bay. For example, most of the stations of San Diego Bay and Los Angeles/Long Beach Harbor separated into their own respective groups, while some of the smaller embayments (e.g., Marina Del Rey, Alamitos Bay, Channel Islands, Oceanside, and Ventura Harbors) tended to group together.

SG1 consisted of two shallow water sites, one each from Newport Harbor and Marina Del Ray. These stites were unique in that each was represented by a single species collected: one California halibut was collected in Newport Harbor, and three anchovies were collected in Marina Del Rey.

Stations from central San Diego Bay formed SG2. These thirteen stations averaged the second lowest species richness and abundance, and included relatively large numbers of round sting rays and spotted sand bass, as well as barred sand bass. These interior stations of San Diego Bay reflect the community described previously as SG1 (see Fishes in San Diego Bay, Community Description). One additional site from this group was located in Mission Bay, close to the Kendall Frost Marine Reserve, the only remaining estuarine area of Mission Bay.

The SG3 assemblage comprised most of the sites in Marina Del Ray, all of the sites in Alamitos Bay, and three sites in north and south San Diego Bay. This assemblage included barred sand bass, California halibut, and diamond turbot as the dominant fish. Overall abundances at SG3 were higher than SG1 and SG2, but lower than the other two assemblages (SG4 and SG5).

Assemblages from Los Angeles/Long Beach Harbor formed SG4 and averaged the highest mean abundance per haul, with the greatest range (i.e., 4 to 1,051 fish/haul). The assemblage was characterized by relatively large numbers of several schooling species, such as white croaker, northern anchovy, Pacific sardine, and queenfish (Table 4.7). California tonguefish were also prominent members of this assemblage. These fishes were also collected in large numbers close to the mouth of San Diego Bay (i.e., station 2573) and inside the breakwater at King Harbor (Figure 4.6). These species are common in shallow, open coastal communities (versus true estuary or bay habitats), and their large numbers may reflect the proximity of these sites to the open coast.

The SG5 assemblage comprised sites from several of the smaller harbors (Channel Island Harbor, Oceanside Harbor, Ventura Harbor), as well as one site each from Mission Bay and Los Angeles/Long Beach Harbor (Figure 4.6). These sites averaged the second highest abundance of fish (79 individuals/haul) and species richness (6 species/haul) of the five cluster groups (Table 4.7). This assemblage was also dominated by schooling species (i.e., white croaker and deepbody anchovy), but included higher numbers of fish that favor piers, pilings, and rocks as preferred habitats (e.g., spotfin croaker, shiner and black perch, and white

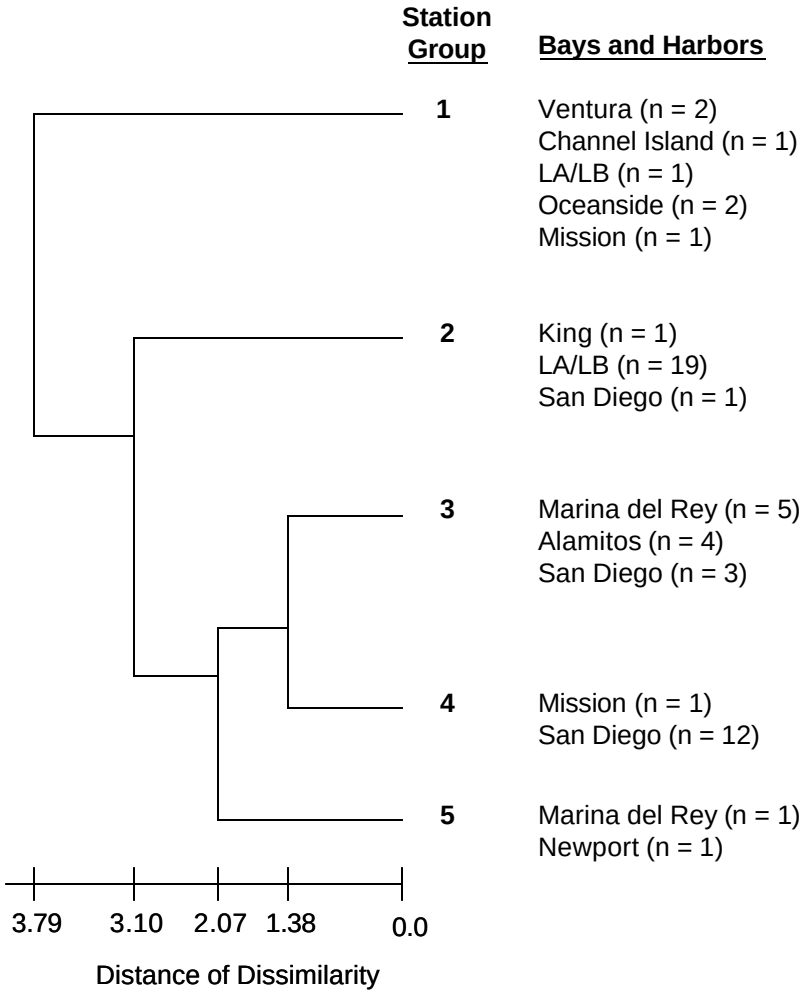

Figure 4.5

Results of classification analysis of demersal fishes collected from all bays and harbors sampled as part of Bight'98.

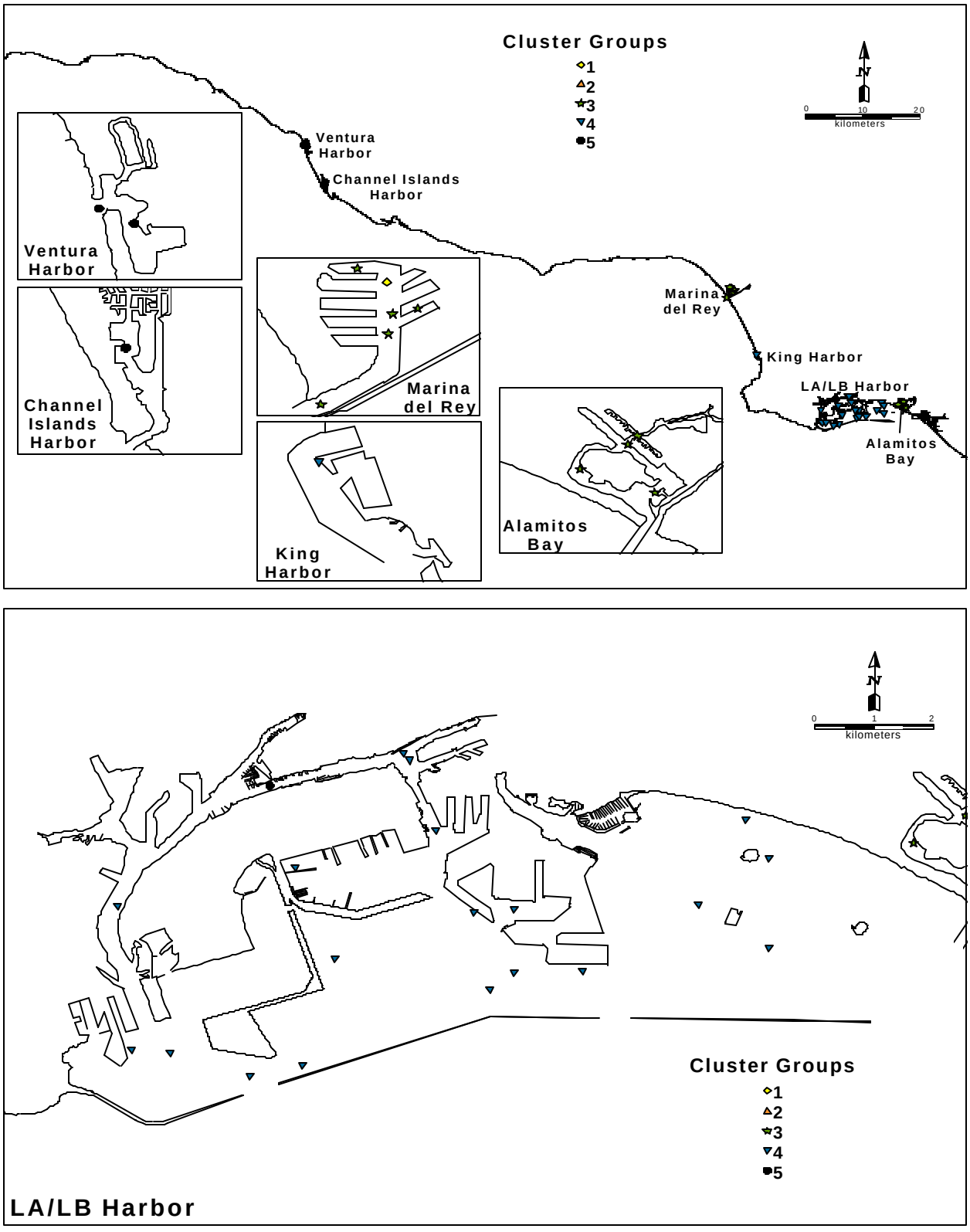

Figure 4.6

Distribution of station groups from classification analysis of fishes collected from all bays and harbors sampled as part of Bight'98.

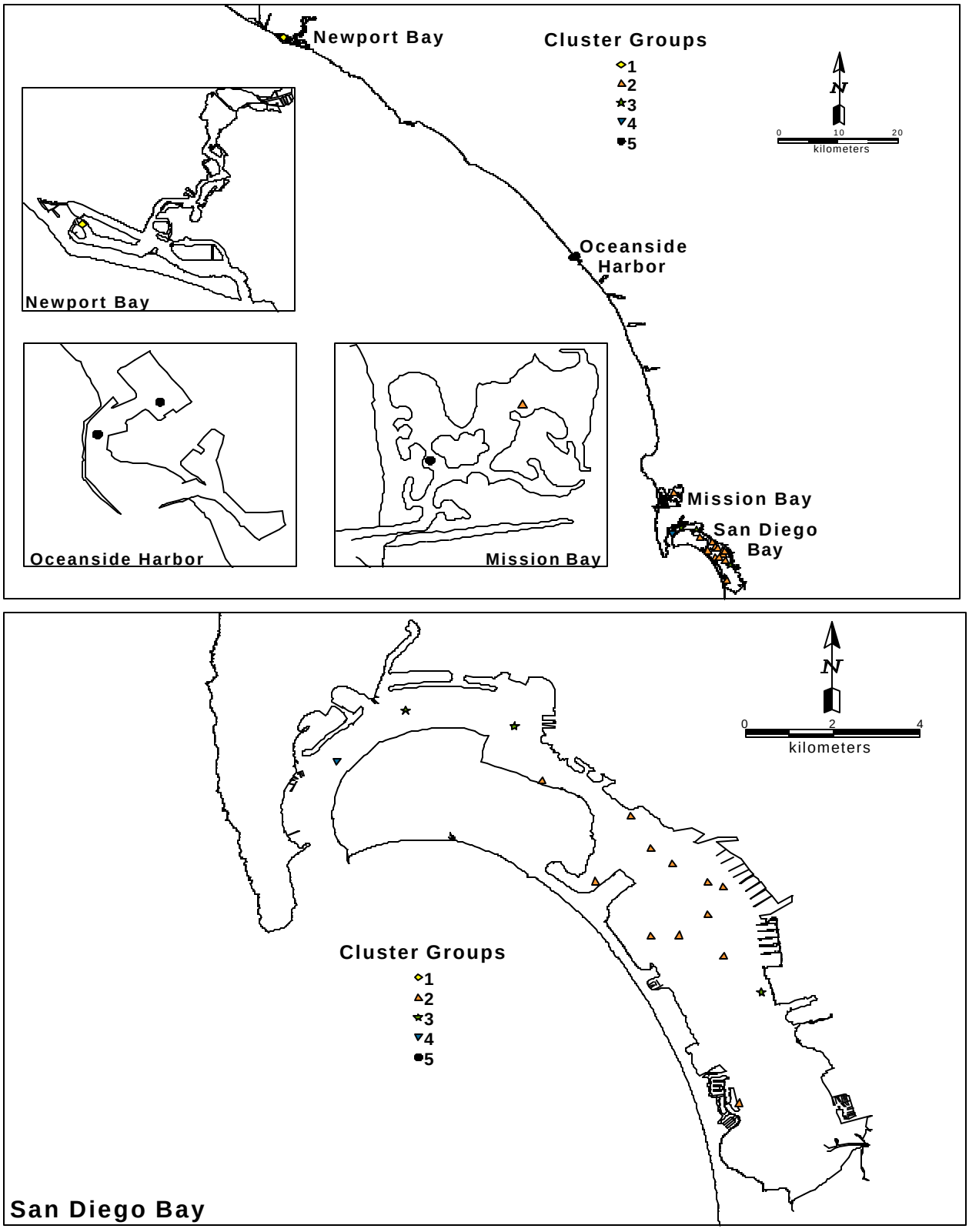

Figure 4.6 (continued)

Table 4.7

Distribution of the abundant and frequently occurring fish species among the main station cluster groups for all bays and harbors sampled as part of Bight'98. '—'= not present. The three most abundant species per group are shown in bold type.

	SG1	SG2	SG3	SG4	SG5
Number of hauls	7	21	12	13	2
Mean No. of species per haul	6	7	7	5	1
(Range)	(1-11)	(3-10)	(4-11)	(2-8)	(1-1)
Mean No. of individuals per haul	79	241	34	19	2
(Range)	(1-232)	(4-1051)	(13-55)	(3-47)	(1-3)
Mean depth per haul (m)	6	16	6	6	3
(Range)	(3-14)	(7-27)	(3-15)	(2-11)	(3-3)
Species	**Mean Abundance**				
Round stingray	—	—	0.3	**6.5**	—
Spotted sand bass	—	—	0.3	**4.6**	—
Black croaker	—	0.1	0.3	0.8	—
Diamond turbot	0.3	—	**2.8**	0.5	—
Slough anchovy	—	—	2.4	—	**1.5**
Barred sand bass	0.4	1.4	**8.9**	**3.5**	—
California halibut	0.7	1.2	**5.9**	2.0	**0.5**
Spotted turbot	—	0.9	1.0	0.8	—
Pacific sardine	—	6.0	—	—	—
Northern anchovy	—	**64.0**	0.2	—	—
California tonguefish	0.1	**8.0**	1.5	—	—
California lizardfish	0.1	2.2	0.2	—	—
Queenfish	2.6	7.5	0.9	—	—
White croaker	**24.9**	**143.7**	2.1	0.2	—
Deepbody anchovy	**31.0**	—	1.8	—	—
Spotfin croaker	3.3	—	0.3	—	—
Shiner perch	5.7	1.6	1.9	—	—
White seaperch	**6.6**	1.2	—	—	—
Black perch	0.9	—	—	—	—

seaperch).This assemblage may reflect the presence of various physical structures in the vicinity of the trawl locations.

Megabenthic Invertebrate Assemblages

Ordination and classification of the Bight'98 embayment sites discriminated between three major station groups (SG1 – SG3) (Figures 4.7 - 4.8, Table 4.8). The groups reflect differences between assemblages typical of bays versus coastal communities. SG1 represents a distinct southern bay community that was limited to the San Diego region (San Diego Bay, Mission Bay, and Oceanside Harbor). This assemblage was distinguished by relatively large populations of *Musculista senhousia* and *Microcosmus squamiger*, and a paucity of decapod crustaceans. Other widespread members of this station group included various sponges (e.g., *Porifera* sp SD4 and SD5) whose abundances were significantly under estimated, and several ascidians (e.g., *Styela* spp.). SG2 represented a mix of coastal and bay communities characterized by such widespread and abundant taxa as the crab *Pyromaia tuberculata*, the shrimp *Penaeus californicus*, the gastropod *Bulla gouldiana*, and the bivalve *Mytilus galloprovincialis*. SG3 consisted of relatively deep water sites that were located primarily in Los Angeles/Long Beach Harbor. This assemblage of megabenthic invertebrates was characterized by low numbers of a few coastal species such as the gastropod

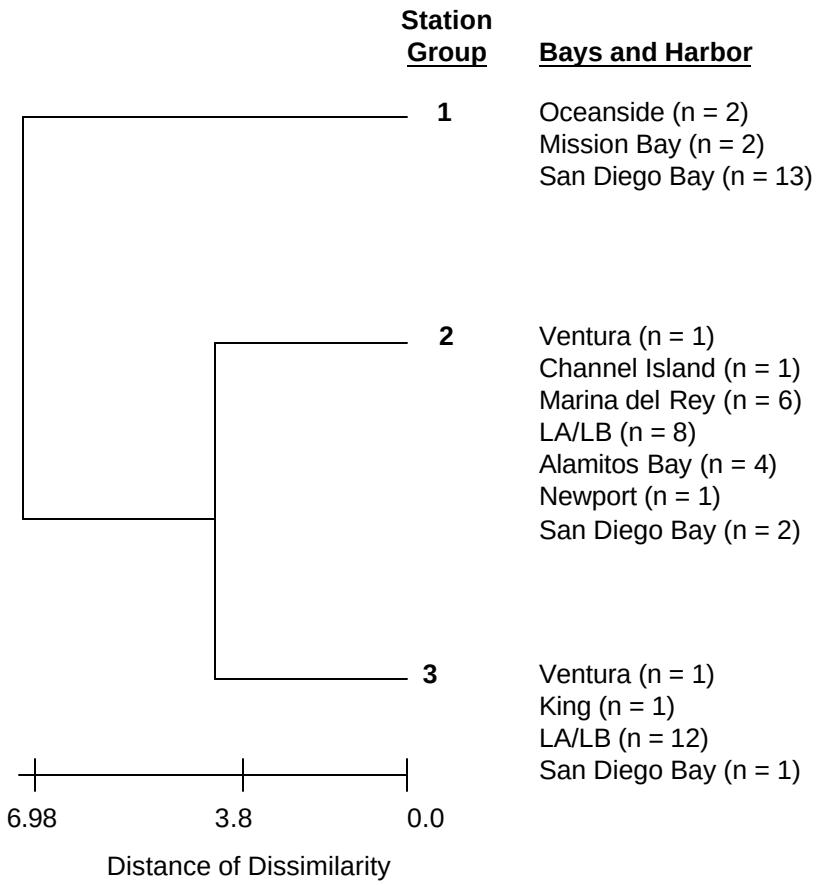

Figure 4.7

Results of classification analysis of megabenthic invertebrates collected from all bays and harbors sampled as part of Bight'98.

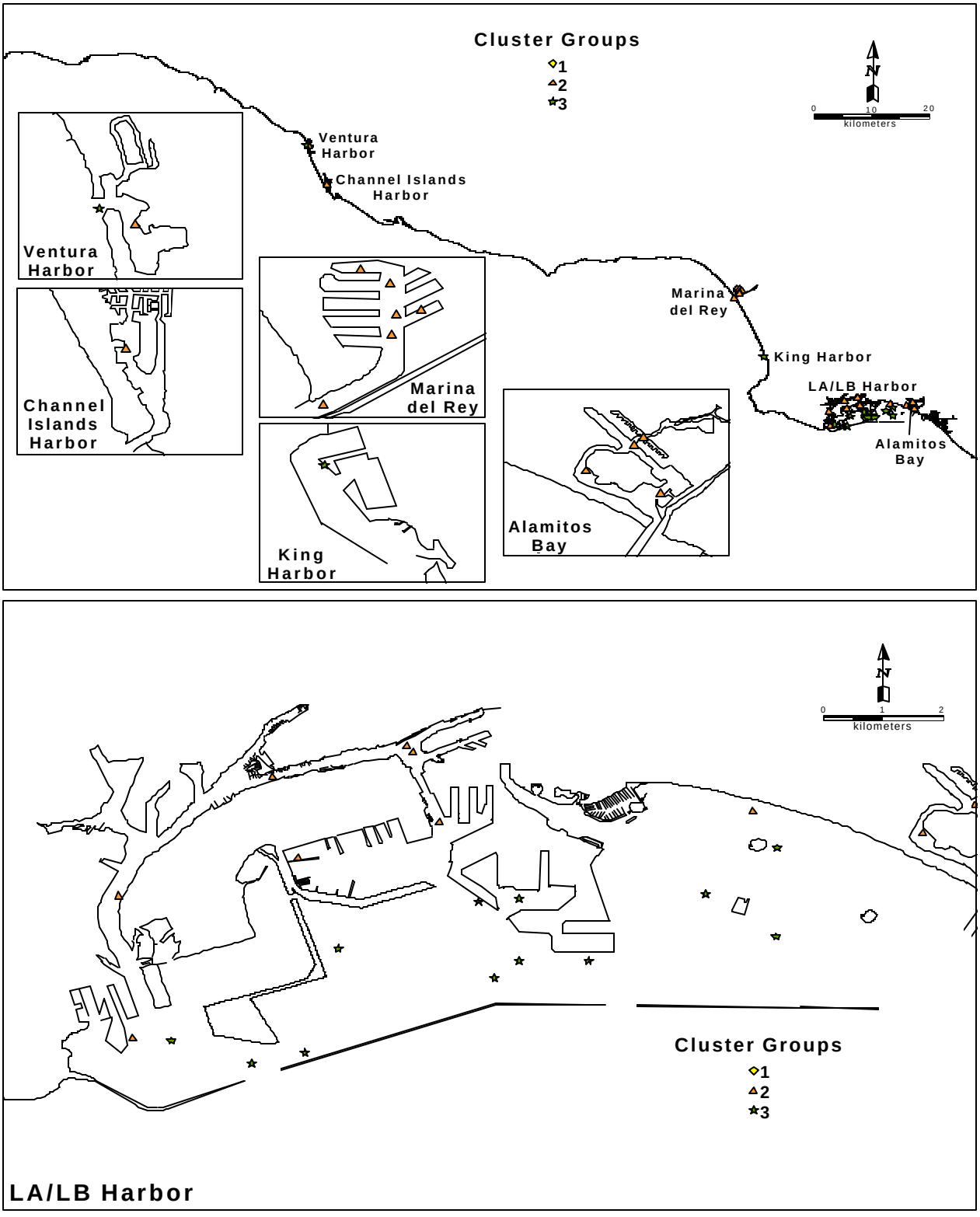

Figure 4.8

Distribution of station groups from classification analysis of megabenthic invertebrates collected from all bays and harbors sampled as part of Bight'98.

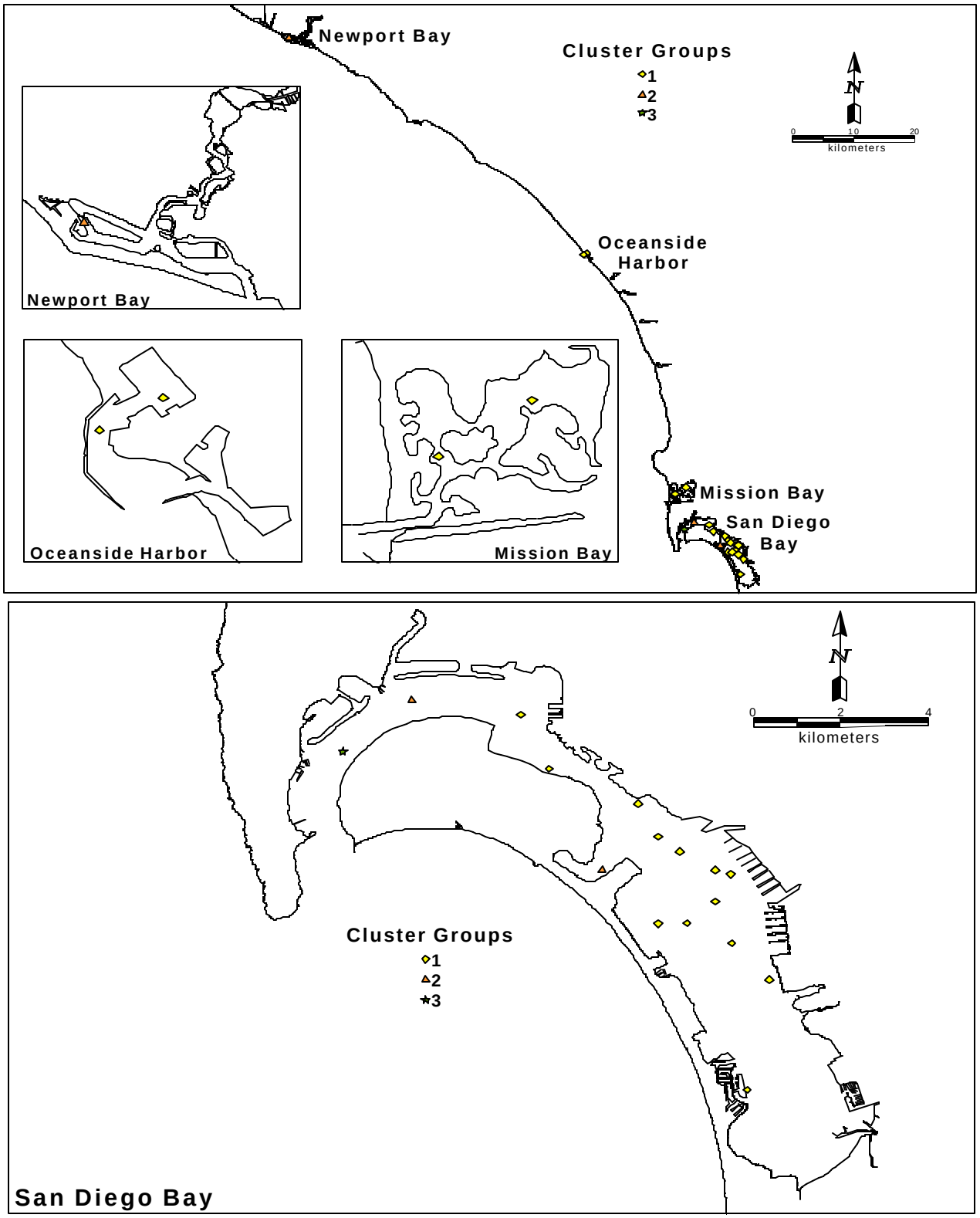

Figure 4.8 (continued)

Table 4.8

Distribution of the abundant and frequently occurring megabenthic invertebrate species among the main station cluster groups for all bays and harbors sampled as part of Bight'98. '—'= not present. The three most abundant species per group are shown in bold type.

	SG1	SG2	SG3
Number of hauls	17	23	15
Mean No. of species per haul	6	8	5
(Range)	(1-13)	(2-15)	(2-14)
Mean No. of individuals per haul	69	95	19
(Range)	(3-387)	(6-567)	(2-78)
Mean depth per haul (m)	7	9	16
(Range)	(2-11)	(3-25)	(7-27)
Species	**Mean Abundance**		
Crepidula onyx	4.4	0.1	—
Porifera sp SD4	0.5	—	—
Ostrea sp	4.6	0.2	—
Musculista senhousia	**29.0**	0.7	—
Argopecten ventricosus	0.8	0.2	—
Microcosmus squamiger	**11.2**	2.7	—
Bulla gouldiana	**4.8**	**12.0**	—
Penaeus californiensis	0.1	5.5	0.9
Navanax inermis	—	1.0	0.3
Styela sp	0.4	1.8	—
Mytilus galloprovincialis	—	7.8	—
Pyromaia tuberculata	0.3	**21.4**	**4.8**
Crangon nigromaculata	—	**12.4**	**2.0**
Philine auriformis	—	7.4	**6.0**
Astropecten armatus	—	0.0	0.5

Philine auriformis, the decapods *P. tuberculata, Crangon nigromaculata* and *P. californiensis*, and the seastar *Astropecten armatus*.

SUMMARY & DISCUSSION

This survey provided a snapshot of the demersal fish and megabenthic invertebrate assemblages that were present in soft bottom areas of San Diego Bay during the summer of 1998. Populations of these organisms appeared healthy during this time, as indicated by the lack of physical abnormalities on both fishes and invertebrates. The absence of fin erosion in the fish community suggests that conditions have generally improved since 1984-1988 when there was a relatively high prevalence of fin erosion in black croaker and barred sea bass (see McCain et al. 1992). Overall, relatively few species of fish and invertebrates were encountered in the various trawls conducted during 1998. The round stingray, spotted sand bass, and barred sand bass were the dominant species of fish captured in terms of abundance and frequency of occurrence, although California halibut and diamond turbot were also common in the Bay. Many of the spotted sand bass and round stringrays, and almost all of the barred sand bass and California halibut appeared to be juveniles. The presence of significant numbers of immature fishes in San Diego Bay is expected since many species are known to use the Bay as nursery grounds (Cross and Allen 1993, Allen et al. 2002).

The dominant trawl-caught invertebrate in San Diego Bay was *Musculista senhousia*, a non-indigenous bivalve that was also prevalent in benthic grab samples (see Chapter 3). Other frequently occurring invertebrates included another non-indigenous species, the ascidian *Microcosmus squamiger*, and two species of previously undescribed sponges, Porifera sp SD4 and Porifera sp SD5. The contribution of marine sponges to the megabenthic invertebrate community was significant in terms of biomass. For example, Porifera sp SD4 and Porifera sp SD5 contributed as much as 97% of the biomass at a station.

The fish and invertebrate assemblages that occurred in the central part of San Diego Bay differed from those found near the entrance of the Bay, as well as from assemblages occurring in most other embayments sampled during Bight'98. Species that characterized the central and southern parts of San Diego Bay in 1998 were typical of embayments in general. These included the round stingray and spotted sand bass, as well as the bivalve *Musculista senhousia* , the ascidean *Microcosmus squamiger,* the oyster *Ostrea* sp., and the slipper shell *Crepidula onyx*. Fish and invertebrates that were found towards the mouth of San Diego Bay and in other Southern California Bight bays and harbors (e.g., Los Angeles/Long Beach Harbor) are typically more representative of open coastal areas. In terms of fish these included specklefin midshipman, California tonguefish and California lizardfish. Common invertebrates in these areas included the yellowleg shrimp *Penaeus californiensis*, the blackspotted bay shrimp *Crangon nigromaculata*, the northern kelp crab *Pugettia producta*, the California spiny lobster *Panulirus interruptus*, and the isopod *Synidotea harfodi*.

Overall, the species of fish and invertebrates encountered in San Diego Bay during 1998 were similar to those reported previously (e.g., USDoN, SWDIV and SDUPD 2000, Allen et al. 2002). For example, Allen et al. (2002) also found that the round stingray, spotted sand bass, barred sand bass and California halibut were dominant in the Bay in terms of frequency, abundance, and biomass. In addition, Allen et al. (2002) determined that the species composition was different in the north of the Bay than in the central and south regions. They attributed the higher number of species near the entrance of the bay to better water circulation and cited temperature, salinity, and distance from the mouth of the bay as environmental factors that impacted the distribution of fish. However, these authors also reported 78 species of fish from the surveys they performed between 1994 and 1999, which contrasts sharply with the 16 species reported herein for 1998. This discrepancy is mostly due to the fewer habitat types trawled in the present study and also to the fact that Allen et al. (2002) used multiple types of sampling gear (e.g., trawls, seines, gill nets). Consequently, the data reported for fish populations in this survey represent a relatively limited portion of San Diego Bay (i.e., trawlable areas deeper than 3 m).

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