chapter 6

TRAWL COMMUNITIES AND ORGANISM HEALTH

Chapter 6
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INTRODUCTION

The Orange County Sanitation District (District) Ocean Monitoring Program (OMP) samples the demersal (bottom-dwelling) fish and epibenthic macroinvertebrate (EMI = large invertebrates) organisms to assess effects of the wastewater discharge on these epibenthic communities and the health of the individual fish within the monitoring area (Figure 6-1). The District's National Pollutant Discharge Elimination System (NPDES) permit requires evaluation of these organisms to demonstrate that the biological community within the influence of the discharge is not degraded and that the outfall is not an epicenter of diseased fish (see box). Species, such as California halibut (*Paralichthys californicus*), white croaker (*Genyonemus lineatus*), California scorpionfish (*Scorpaena guttata*), ridgeback rockshrimp (*Sicyonia ingentis*), sea cucumbers (*Parastichopus* spp.), and crabs (Cancridae species) are commercially and/or recreationally important.

The wastewater outfall has two primary impacts to the biota of the receiving waters: reef and discharge effects (OCSD 2001, 2004). Reef effects are changes related to the physical presence of the outfall structure and associated rock ballast, which provide a three dimensional hard substrate habitat that harbors a different suite of species than that found on the surrounding soft bottom. As a result, stations located near the outfall pipe can have greater species diversity and an increased number of predators.

Compliance criteria pertaining to trawl communities and organism health contained in the District's NPDES Ocean Discharge Permit (Order No. R8-2004-0062, Permit No. CAO110604).

Criteria		Description
C.5.a	Marine Communities	Marine communities, including vertebrates, invertebrates, and algae shall not be degraded.
C.5.b	Marine Resources	The natural taste, odor, and color of fish, shellfish, or other marine resources used for human consumption shall not be altered.
C.5.c	Human Health Concerns	The concentration of organic materials in fish, shellfish, or other marine resources used for human consumption shall not bioaccumulate to levels that are harmful to human health.

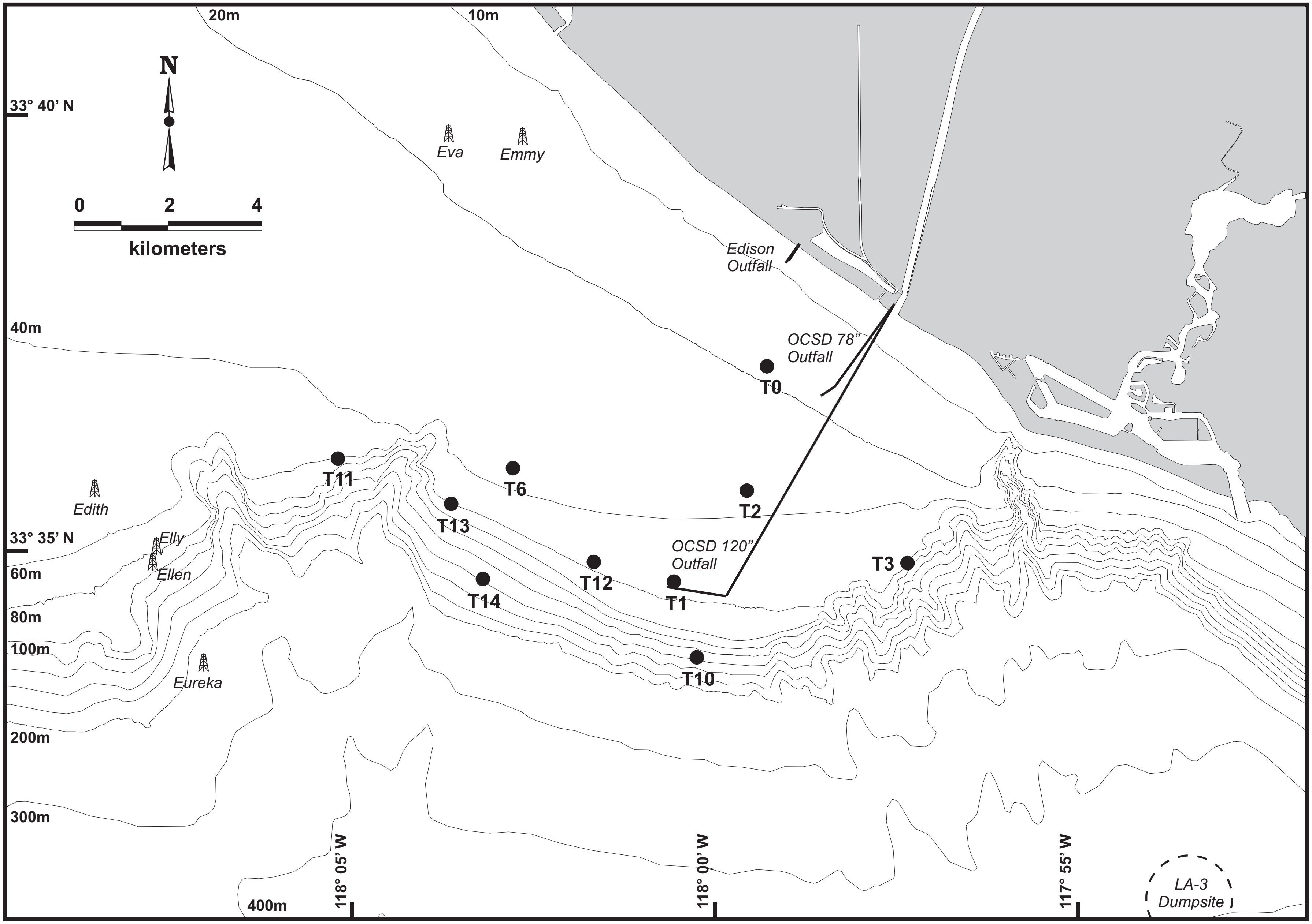

Figure 6-1. **Otter trawl stations for semi-annual surveys, 2009-10.**

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Discharge effects are changes related to the release of treated effluent. Contaminants adhere to organic particulates in the effluent, which then sink to the ocean bottom where they become a food resource for many invertebrate species. These, in turn, may be consumed by fish. The contaminants that accumulate in the invertebrates may then be transferred up the food chain to fish and other, higher order predators. Many demersal fish (e.g., flatfish) feed directly or indirectly on invertebrate prey that live in or on the bottom sediments. Furthermore, they live in direct contact or in close association with these sediments and consequently have an increased probability of direct exposure to sediments containing discharged particles. The transfer of chemical contaminants through consumption of benthic infauna can make demersal fish species particularly susceptible to physical abnormalities and diseases (Johnson *et al.* 1992, 1993; Moore *et al.* 1997; Myers *et al.* 1993; Stehr *et al.* 1997, 1998).

Contaminants, especially lipid-soluble (lipophilic) compounds, such as chlorinated pesticides (e.g., DDT) and polychlorinated biphenyls (PCBs) can accumulate in organisms at concentrations several orders of magnitude higher than in surrounding sediments or water through the process of bioaccumulation. Further, certain organic compounds can increase in concentration in organisms at higher levels of the food chain via biomagnification, including humans and marine mammals. Whether bioaccumulated or biomagnified, high tissue contaminant concentrations may result in greater susceptibility to disease or reproductive impairment (Arkoosh *et al.* 1998).

To assess this issue, the District uses tissue contaminant data to evaluate the following aspects of permit compliance: 1) are contaminant concentrations in fish muscle tissue sufficient to pose a potential human health concern; 2) are there temporal and/or spatial patterns relative to the ocean outfall; and 3) are the marine organisms in the monitoring area generally healthy?

METHODS

Field Methods

Demersal fish and epibenthic macroinvertebrates (EMI) species were collected in July 2009 and January 2010 using a 7.6 meter wide, Marinovich, semi-balloon otter trawl net fitted with a 0.64 cm cod-end mesh net. The net was towed on the ocean bottom for 450 m at approximately 2 knots along a pre-determined course. Sampling was conducted at 9 permit stations: inner shelf (36 m) Stations T2 and T6; middle shelf (60 m) Stations T1, T3, T11, T12, and T13; and outer shelf (137 m) Stations T10 and T14 (Figure 6-1). Two replicate hauls were conducted at the inner and outer shelf stations and 3 replicate hauls were conducted at the middle shelf stations during both surveys. Additionally, 1 haul was collected at T0 (18 m) in July 2009 to maintain a historical database, but the data are not presented in this report.

Trawl caught specimens were identified to the lowest possible taxon, typically to species. A minimum of 30 individuals of each fish species were measured individually to the nearest millimeter (standard length) and weighed to the nearest gram. Fish in excess of 30 individuals were enumerated in 1 cm size classes and batch weighed. All fish specimens were examined for external tumors, other lesions, and parasites since gross external manifestations may indicate contaminated sediments (Murchelano 1982). The first 100 EMI were also enumerated by species and weighed to the nearest gram. Specimens with abundance greater than 100 individuals were weighed in batches and abundance calculated based on the weight/abundance ratio. Fish and EMI specimens that could not be identified in the field were retained for further identification (FID) and weighed and measured in the laboratory. Fish from 4 target species were also collected for bioaccumulation studies: hornyhead turbot (*Pleuronichthys verticalis*), bigmouth sole (*Hippoglossina stomata*), English sole (*Parophrys vetulus*), and Pacific sanddab (*Citharichthys sordidus*). Pacific sanddabs were collected as composite samples. The sampling objective was to collect 10 individuals of at least 3 of the 4 target species at both outfall (T1/T12) and farfield (T11/T13) sites. More detailed field and laboratory methods are provided in Appendix A.

Data Analyses

Fish and EMI populations were summarized in terms of total abundance and species, percent abundance, frequency of occurrence, and mean abundance per haul. In addition, mean number of species, number of individuals, biomass, and diversity indices including Shannon-Wiener (H'), Margalef's Species Richness (SR), and Swartz's 75% Dominance (75DOM) were calculated for both fish and EMI. In some analyses, stations were grouped into the following categories to assess spatial or depth-related patterns: "outfall" (Stations T1 and T12); "shallow" (Stations T2 and T6); "deep" (Stations T10 and T14); "farfield downcoast" (Station T3); and "farfield upcoast" (Stations T11 and T13).

PRIMER v6 (Plymouth Routines in Multivariate Ecological Research) multivariate statistical software was used to examine the spatial patterns of the fish assemblages in the District's monitoring area (Clarke 1993, Warwick 1993). Analyses included hierarchical clustering with group-average linking based on Bray-Curtis similarity indices, and ordination clustering of the data using non-metric multidimensional scaling (MDS). Data were averaged by station and truncated to include only the middle shelf (60 m) stations since depth is a strong environmental factor in delineating species clusters (OCSD 2004, 2010). Clarke and Warwick (2001) warn that clustering is less useful and may be misleading where there is a strong environmental forcing, such as depth. Prior to the calculation of the Bray-Curtis indices, the data were square-root transformed in order to down-weight the highly abundant species and incorporate the importance of the less common species (Clarke and Warwick 2001). The SIMPER ("similarity percentages") routine was also used to determine inter- and intra-group species differences.

Community measures from Stations T1 and T11 were evaluated for long-term temporal and spatial patterns, and compared with regional reference conditions, such as 1994 Southern California Bight Pilot Project (SCBPP), Bight'98, Bight'03, and Bight'08 regional monitoring programs (Allen *et al*. 1998, 2002, 2007, respectively).

Fish biointegrity in the District's monitoring area was assessed using the fish response index (FRI). The FRI is a multivariate weighted-average index produced from an ordination analysis of calibrated species abundance data (see Allen *et al*. 2001, 2006). The FRI was calculated for all 9 stations in 2009-10. For a historical perspective, FRI was calculated from 1985 to 2009 for outfall Station T1 and upcoast reference Station T11.

In order to evaluate human health risk, the non-lipid normalized muscle tissue concentrations of hornyhead turbot and English sole were compared to state and federal human consumption guidelines. Nearfield and farfield station muscle and liver tissues from the 2 target fish species and whole Pacific sanddabs were compared for concentrations of mercury, pesticides, and PCBs as a function of fish size and tissue lipid content. Pacific sanddab whole-fish analysis cannot be used for human health risk assessment as no whole-fish consumption standards exist. These data, except mercury, were lipid-normalized prior to the calculation of summary statistics. External parasites and other abnormalities in fish are not prevalent in the District's monitoring area; therefore preclude hypothesis testing.

RESULTS AND DISCUSSION

Fish Community

Abundance

A total of 22,969 fish were collected in 2009-10 (Tables 6-1 and B-13). Yellowchin sculpins (*Icelinus quadriseriatus*), California lizardfish (*Synodus lucioceps*), and Pacific sanddabs were the most abundant fish collected, representing 33%, 18%, and 18% of the total catch, respectively. All other species comprised 4% or less of the total catch. Of the 23 families represented, just 7 families accounted for 95% of the total abundance: Cottidae (sculpins), Paralichthidae (sand flounders), Synodontidae (lizardfish), Pleuronectidae (right-eye flounders), Hexagrammidae (greenlings), Soleidae (soles), and Embotiotocidae (surfperches) (Table 6-2).

In 2009-10, Synodontidae became a dominant family, ranking third by abundance and comprising 18% of the total fish abundance. Synodontidea was represented by just 1 species, the California lizardfish, which was the second most abundant fish with 4,165 individuals collected in 2009-10. In contrast, Synodotidae represented < 1% of the total fish abundance and California lizardfish accounted for only 1% of the total fish abundance with 165 individuals in 2008-09.

Variability in the 2009-10 abundance data was due primarily to population fluctuations of a few common species. For example, abundances of yellowchin sculpin ranged from 0 to 1,053 individuals per haul, while Pacific sanddab abundances ranged from 0 to 309 per haul. On average, there were slightly more individuals collected from the 60 m stations in winter than in summer primarily due to high abundance at T11 where the greatest numbers of yellowchin sculpins were collected (Figure 6-2 and Table B-14). In contrast, the shallow and deep stations had higher abundances in summer than winter.

Fish abundance has historically been highly variable, although some patterns are consistent (Figure 6-3). The shallow stations have had the lowest abundances, while the deep and farfield downcoast stations generally had the highest. However, abundances in 2009-10 were highest at farfield upcoast stations due to large catches of yellowchin sculpins, and lowest at the farfield downcoast due to a decline in pink seaperch (*Zalembius rosaceus*), and longspine combfish (*Zaniolepis latipinnis*) at this station group. Overall, fluctuations in abundance over time reflect population changes of several dominant species, especially Pacific sanddab, yellowchin sculpin, longspine combfish, and English sole (see OCSD 2009 Figure 6-4).

Biomass

A total of 482 kg of fish was collected in 2009-10, with 3 families (Paralichthyidae, Pleuronectidae, and Synodontidae) accounting for 72% of the fish biomass. As with abundance, biomass data were highly variable (ranging from 2 to 29 kg per haul) due to population fluctuations of dominant species and variability in the size of individuals collected. Mean biomass per survey was slightly greater in summer than winter due to winter declines at Stations T3, T10, and T14. The greatest biomass

Table 6-1. Summary of demersal fish species collected during the summer (July 2009) and winter (January 2010) surveys. Data for each species are expressed as total abundance (Total), percent abundance (%A), percent frequency of occurrence (%FO), and mean abundance per haul (MAH).

Orange County Sanitation District, California.

Common name	Scientific name	Total	%A	%FO	MAH
Yellowchin sculpin	*Icelinus quadriseriatus*	7,659	33	89	167
California lizardfish	*Synodus lucioceps*	4,165	18	100	91
Pacific sanddab	*Citharichthys sordidus*	4,097	18	100	89
Longfin sanddab	*Citharichthys xanthostigma*	938	4	89	20
Roughback sculpin	*Chitonotus pugetensis*	930	4	89	20
Longspine combfish	*Zaniolepis latipinnis*	917	4	89	20
California tonguefish	*Symphurus atricaudus*	671	3	100	15
English sole	*Parophrys vetulus*	643	3	89	14
Pink seaperch	*Zalembius rosaceus*	571	3	100	12
Stripetail rockfish	*Sebastes saxicola*	366	2	44	8
Shortspine combfish	*Zaniolepis frenata*	284	1	44	6
Hornyhead turbot	*Pleuronichthys verticalis*	280	1	89	6
Plainfin midshipman	*Porichthys notatus*	251	1	89	5
Slender sole	*Lyopsetta exilis*	248	1	22	5
Blackbelly eelpout	*Lycodes pacificus*	210	1	22	5
Dover sole	*Microstomus pacificus*	196	1	44	4
Bigmouth sole	*Hippoglossina stomata*	123	1	100	3
Speckled sanddab	*Citharichthys stigmaeus*	79	<1	22	2
Pygmy poacher	*Odontopyxis trispinosa*	75	<1	78	2
Fantail sole	*Xystreurys liolepis*	74	<1	56	2
White croaker	*Genyonemus lineatus*	32	<1	22	1
Halfbanded rockfish	*Sebastes semicinctus*	31	<1	56	1
California skate	*Raja inornata*	21	<1	67	<1
Calico rockfish	*Sebastes dallii*	18	<1	44	<1
California scorpionfish	*Scorpaena guttata*	15	<1	67	<1
Greenstriped rockfish	*Sebastes elongatus*	14	<1	22	<1
Southern spearnose poacher	*Agonopsis sterletus*	8	<1	44	<1
Northern spearnose poacher	*Agonopsis vulsa*	6	<1	22	<1
Spotted cuskeel	*Chilara taylori*	6	<1	22	<1
California halibut	*Paralichthys californicus*	4	<1	11	<1
Swell shark	*Cephaloscyllium ventriosum*	3	<1	11	<1
Bearded eelpout	*Lyconema barbatum*	3	<1	11	<1
Bluebarred prickleback	*Plectobranchus evides*	3	<1	22	<1
Blackeye goby	*Rhinogobiops nicholsii*	3	<1	11	<1

Table 6-1 continues.

Table 6-1 Continued.

Common name	Scientific name	Total	%A	%FO	MAH
Pink rockfish	*Sebastes eos*	3	<1	22	<1
Treefish	*Sebastes serriceps*	3	<1	11	<1
Sablefish	*Anoplopoma fimbria*	2	<1	11	<1
Shiner perch	*Cymatogaster aggregata*	2	<1	11	<1
Lingcod	*Ophiodon elongatus*	2	<1	22	<1
Cowcod	*Sebastes levis*	2	<1	22	<1
Vermillion rockfish	*Sebastes miniatus*	2	<1	11	<1
Wolf-eel	*Anarrhichthys ocellatus*	1	<1	11	<1
Spotted ratfish	*Hydrolagus colliei*	1	<1	11	<1
Pacific hake	*Merluccius productus*	1	<1	11	<1
Stripedfin ronquil	*Rathbunella alleni*	1	<1	11	<1
Oarfish	*Regalecus glesne*	1	<1	11	<1
Darkblotched rockfish	*Sebastes crameri*	1	<1	11	<1
Tiger rockfish	*Sebastes nigrocinctus*	1	<1	11	<1
Flag rockfish	*Sebastes rubrivinctus*	1	<1	11	<1
Blackedge poacher	*Xeneretmus latifrons*	1	<1	11	<1
	Total	**22,969**	**100**		
	Total no. of species	**50**			

n = 42 hauls

Table 6-2. Summary of demersal fish species and abundance by family for the summer (July 2009) and winter (January 2010) surveys.

Orange County Sanitation District

Family	Number of Species		Family Abundance	
	Total	Percentage	Total	Percentage
Cottidae (Sculpins)	2	4	8,589	37
Paralichthyidae (Sand flounders)	6	12	5,315	23
Synodontidae (Lizardfish)	1	2	4,165	18
Pleuronectidae (Righteye flounders)	4	8	1,367	6
Hexagrammidae (Greenlings)	3	6	1,203	5
Soleidae (Soles)	1	2	671	3
Embiotocidae (Surfperches)	2	4	573	3
Scorpaenidae (Scorpionfishes)	12	24	457	2
Batrachoididae (Toadfishes)	1	2	251	1
Zoarcidae (Eelpouts)	2	4	213	1
Agonidae (Poachers)	4	8	90	< 1
Sciaenidae (Drums)	1	2	32	< 1
Rajidae (Skates)	1	2	21	< 1
Ophidiidae (Cusk-eels)	1	2	6	< 1
Scyliorhinidae (Cat sharks)	1	2	3	< 1
Gobiidae (Gobies)	1	2	3	< 1
Stichaeidae (Pricklebacks)	1	2	3	< 1
Anoplopomatidae (Sablefish)	1	2	2	< 1
Anarhichadidae (Wolffishes)	1	2	1	< 1
Bathymasteridae (Ronquils)	1	2	1	< 1
Chimaeridae (Chimaeras)	1	2	1	< 1
Gadidae (Cods)	1	2	1	< 1
Regalecidae (Oarfishes)	1	2	1	< 1
Total	50	100	22,969	100

Data for each family are ranked by number of species and abundance for all stations and surveys combined.

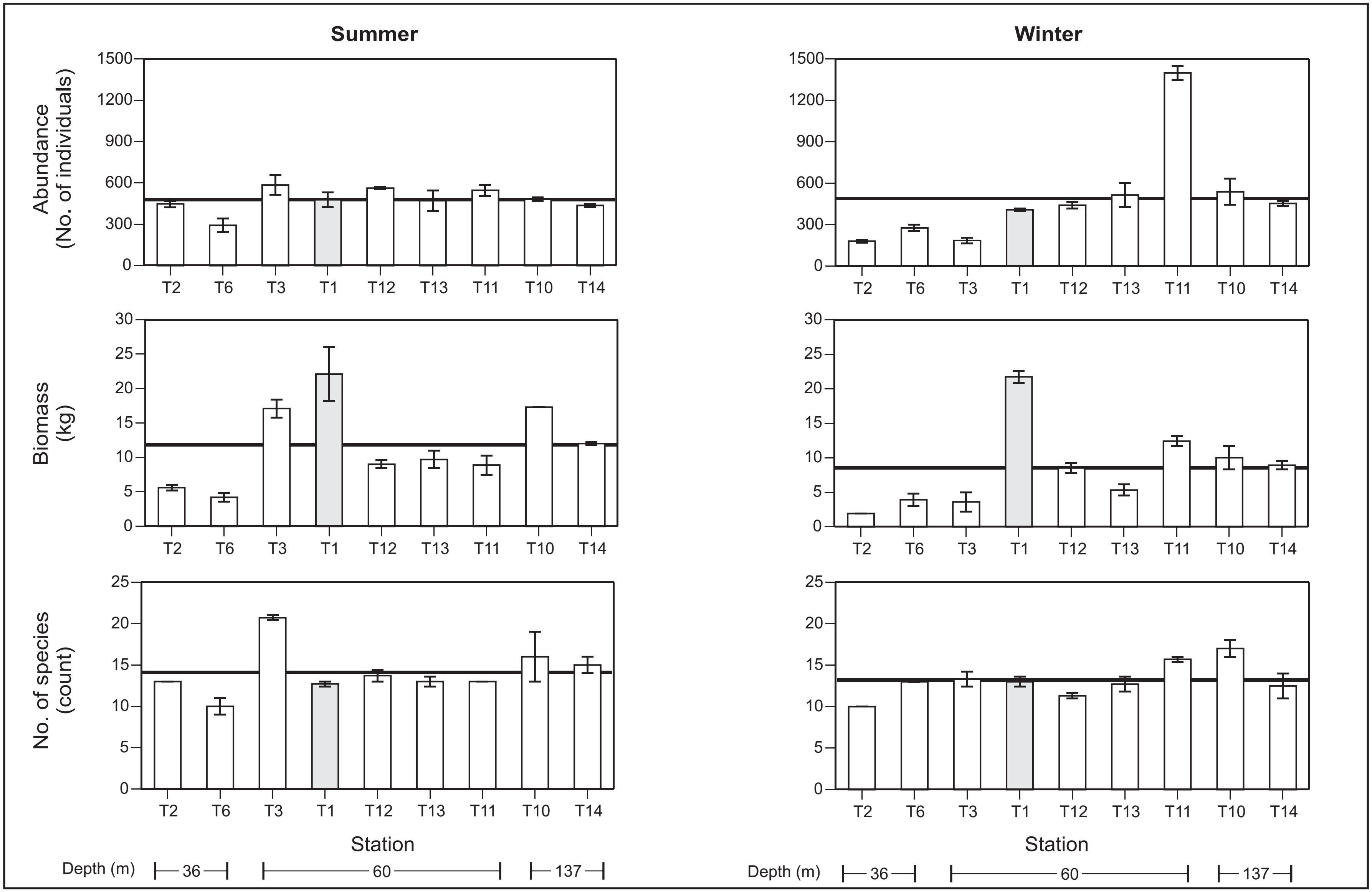

Figure 6-2. **Mean and 95% confidence interval for number of individuals (abundance), biomass, and number of species of demersal fish collected during the summer (July 2009) and winter (January 2010) surveys.**
Outfall Station T1 indicated in gray. Survey mean indicated by heavy line.

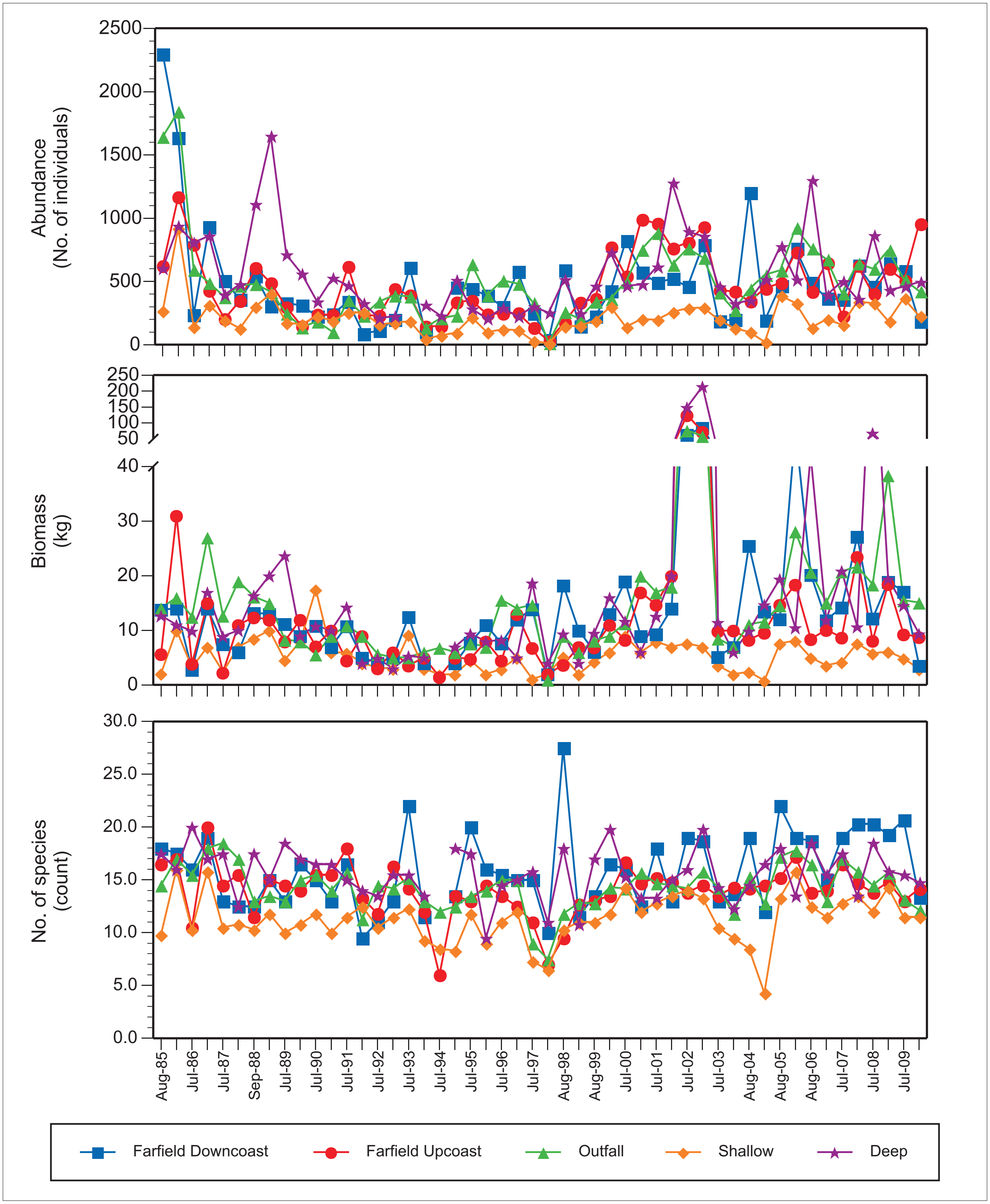

Figure 6-3. **Comparison of demersal fish parameters by station groups: farfield downcoast (T3), farfield upcoast (T11 and T13), outfall (T1 and T12), shallow (T2 and T6), and deep (T10 and T14). All data for mean abundance, biomass, and number of species by station group are for the period 1985–2010.**

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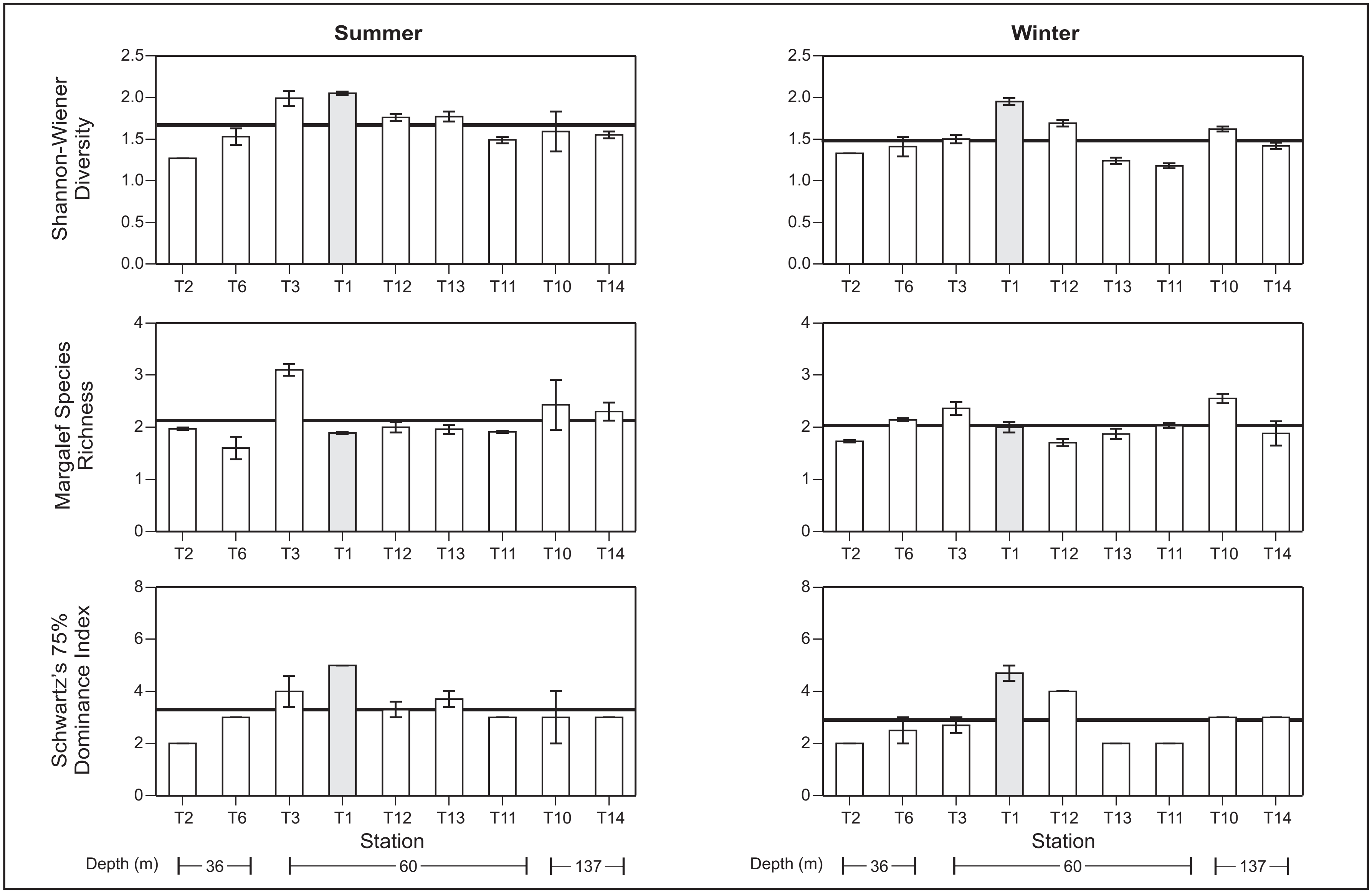

Figure 6-4. **Mean and 95% confidence interval for diversity indices — Shannon-Wiener Diversity Index (H'), Margalef Species Richness (SR), and Schwartz's 75% Dominance Index of demersal fish collected during the summer (July 2009) and winter (January 2010) surveys.**
Outfall Station T1 indicated in gray. Survey mean indicated by heavy line.

Orange County Sanitation District, California.

occurred at Outfall Station T1 in both surveys (Figure 6-2 and Table B-14). The annual mean biomass at outfall Station T1 was at least double the biomass of any other 60 m station in both seasons, except for T3 in summer. These hefty catches at T1 were primarily due to an abundant catch of large Pacific sanddabs and English sole in summer and longfin sanddabs (*Citharichthys xanthostigma*) in winter. Increased fish biomass in the outfall area may be due to both a reef effect, created by the by outfall structure, as well as a discharge effect (Diener et al 1997). Artificial reefs enhance habitat diversity and support higher fish biomass. The wastewater discharge contains organic particles that serve as a direct or indirect food source, thereby, enhancing fish biomass. Invertebrates feed upon the increased concentrations of organic particles in the outfall area and fish, in turn, feed upon the abundant invertebrates. Over time, biomass has followed the same patterns as abundance described above (Figure 6-3).

Number of Species

A total of 50 fish species representing 23 families were collected in the District's study area in 2009-10 (Tables 6-1, 6-2, and B-13). Thirteen of the species were widely distributed and occurred at >75% of the stations. The 5 most frequently occurring species were the California lizardfish, Pacific sanddab, California tonguefish (*Symphurus atricaudus*), pink seaperch, and bigmouth sole, each of which occurred at 100% of the stations. Four families, Scorpaenidae, Paralichthyidae, Pleuronectidae, and Agonidae (poachers) comprised 52% of the species collected (Table 6-2). Only 8 of the 23 families collected were represented by more than 1 species (Table B-13).

During 2009-10, the mean number of species per station ranged from 10 to 21 (Figure 6-2 and Table B-14). Differences between seasons were minimal. The most notable changes occurred at Station T3, which declined from a mean of 21 species in summer to 13 in winter. The 2 shallow stations (T2 and T6) had the lowest number of species, and 60 m Station T3 and deep water Station T10 had the highest. Annual mean number of species by station group has been variable since 1985 and is depth-dependent (Figure 6-3). Overall, the fewest number of species occur at the shallow station group, while the greatest numbers of species occur at the deep station group and farfield downcoast Station T3. This pattern of increasing abundance from the inner shelf to outer shelf was also observed in the regional Bight surveys and may be related to daytime light levels and the variability in environments (temperature, salinity, turbulence, food availability, etc.) at the various depths. Allen et al. (2006a) suggested that "high daytime light levels on the inner shelf may make active benthic fishes more susceptible to predations than in deeper water, resulting in less diurnal benthic activity and increased selection for schooling in water-column species." Also, higher light levels at shallow depths may facilitate net avoidance by fish.

Diversity

There was no evidence of significant impact on species diversity (Shannon-Wiener, Margalef Species Richness, and 75% Dominance) near the outfall (Station T1) relative to the other stations. For example, mean Shannon-Wiener diversity index values at Station T1 were high in comparison to the other 60 m stations, with H' values of 2.05 in summer and 1.95 in winter (Figure 6-4 and Table B-14). Overall, H' values at the 60 m stations ranged from 1.44 to 2.17 in summer and 1.12 to 1.77 in winter and were similar to the central Bight, middle shelf areas, which had a mean H' of 1.69 (Allen *et al.* 2007).

Ordination and Classification

Ordination and classification analyses of 2009-10 trawl fish data at the 60 m stations resulted in 2 significant cluster groups: middle shelf and downcoast Station T3 in winter (Figure 6-5). Station T3 had a significantly different assemblage in winter than summer. The composition of each station group and the species characteristic of each assemblage are described in Table 6-3. The mean abundance per haul for the dominant species of each cluster group is shown in Figure 6-6.

The middle shelf station group consisted of Stations T1, T3 (in summer only), T11, T12, and T13. It comprised 12 trawls with a mean abundance of 1,351 individuals and a mean species richness of 34 species. It was characterized by yellowchin sculpin, California lizardfish, longfin sanddab, roughback sculpin (*Chitonotus pugetensis*), longspine combfish, California tonguefish, pink seaperch, and hornyhead turbot (Figure 6-6). Outfall Station T1 separated from the other middle shelf cluster sites at the 65% resemblance level, which is likely due to a large catch of English sole at T1, but the difference from the other middle shelf stations was not statistically significant to warrant a separate cluster.

The downcoast T3 winter cluster was comprised of a single station (3 hauls). It consisted of 22 species with a mean abundance of 185 individuals per haul (Table 6-3). SIMPER could not be applied to this group to determine characteristic species because there were too few samples in the group; however, the most abundant species were yellowchin sculpin and California lizardfish with mean abundance per haul of 107 and 24, respectively. This station likely formed a unique cluster in winter due to the large number (14) of rare species, those with mean abundance < 2 individuals per haul.

Station T3 has often differed in the past from other middle shelf stations, possibly due to location, habitat, and difficulty in sampling. Station T3 is located in close proximity to Newport Canyon and is depositional in nature, as opposed to the rest of the middle shelf trawl stations in the study area that are erosional (Maurer et al. 1993). Trawl sampling is inconsistent at T3 due to variable bottom topography. For example, the time that the net was on the bottom in summer ranged from 4 minutes and 30 seconds to 7 minutes and 36 seconds and the trawl exceeded the upper and lower limits (10%) of the nominal depth in both surveys (Figures C-2, C-4; Tables C-30, C-32).

<u>Regional Comparisons</u>

The Fish Response Index (FRI) is a biointegrity index developed by Allen *et al.* (2001). The index was developed using the abundances of all species relative to the pollution gradient away from the Palos Verdes shelf during the 1970s. Allen *et al*. (2001) noted that the FRI index was an effective surrogate of fish community assemblages, especially in the middle shelf zone of the SCB. FRI values less than 45 are classified as reference (normal) and those greater than 45 are non-reference (abnormal or disturbed). For example, FRI values exceeded the threshold of 45 on the Palos Verdes shelf from 1970 to 1983 when sediment contamination by organics and other constituents was high (Allen 2006b). By 1990, FRI values at Palos Verdes went down to about 25 and remained near this value through 2002. In 2009-10, mean FRI values at the District's core stations ranged from 10 to 25, indicating reference conditions (Figure 6-7). Historically, mean FRI values for outfall Station T1 and upcoast reference Station T11 have consistently been below 45, ranging from 14 to 30. These values are consistent with Allen *et al.* (2007), who reported that 96% of the SCB area in 1998 was classified as reference. The remaining 4% of non-reference areas occurred on the inner shelf and in bays and harbors.

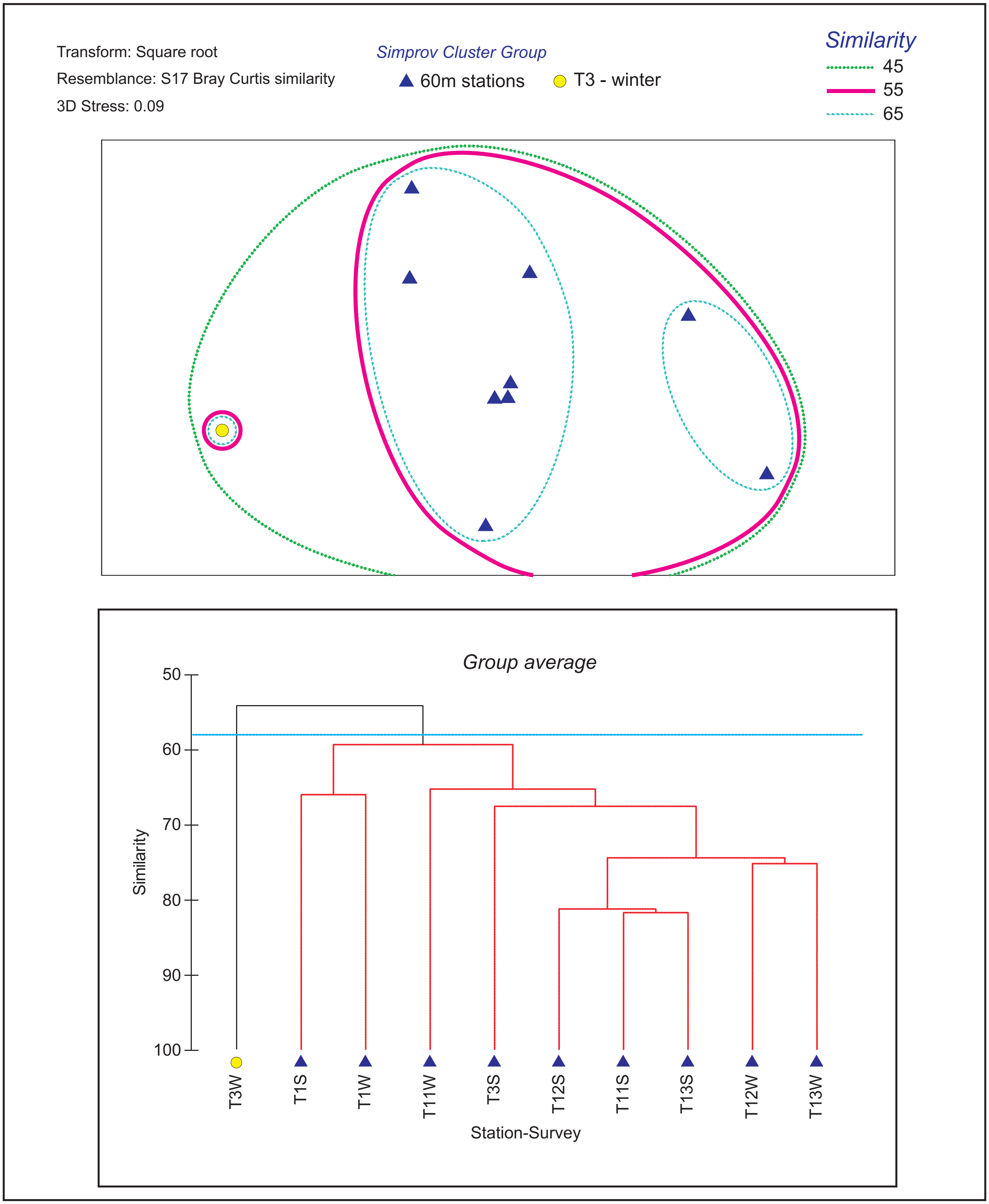

Figure 6-5. **Results of classification analysis of demersal fish assemblages collected at the five 60-m stations during the summer (July 2009) and winter (January 2010) trawl surveys. Data are presented as a non-metric multi-dimensional scaling (MDS) ordination plot and a dendrogram of major station clusters. Stations-surveys are denoted by S for summer and W for winter.**

Table 6-3. Description of cluster groups (Middle Shelf and Middle-T3 Winter) defined in Figure 6-5. Data include number of hauls, species richness, mean total abundance, and mean abundance of the five most abundant species for each station group. Bold values indicate species that were considered "characteristic" of that group according to SIMPER analyses (i.e. similarity/standard deviation >2.0).

Orange County Sanitation District, California.

	Middle Shelf	**Middle T3W***
Number of Hauls	12	3
Species Richness	34	22
Mean Abundance/Haul	1351	185
Species	**Mean Abundance**	
Yellowchin sculpin	**563**	107
California lizardfish	**223**	24
Pacific sanddab	156	5
Longfin sanddab	**72**	2
Roughback sculpin	**67**	5
Longspine combfish	**62**	1
English sole	51	---
California tonguefish	**48**	2
Pink seaperch	**41**	5
Hornyhead turbot	**20**	8

* Note that Simper was not applied due to too few samples in group.

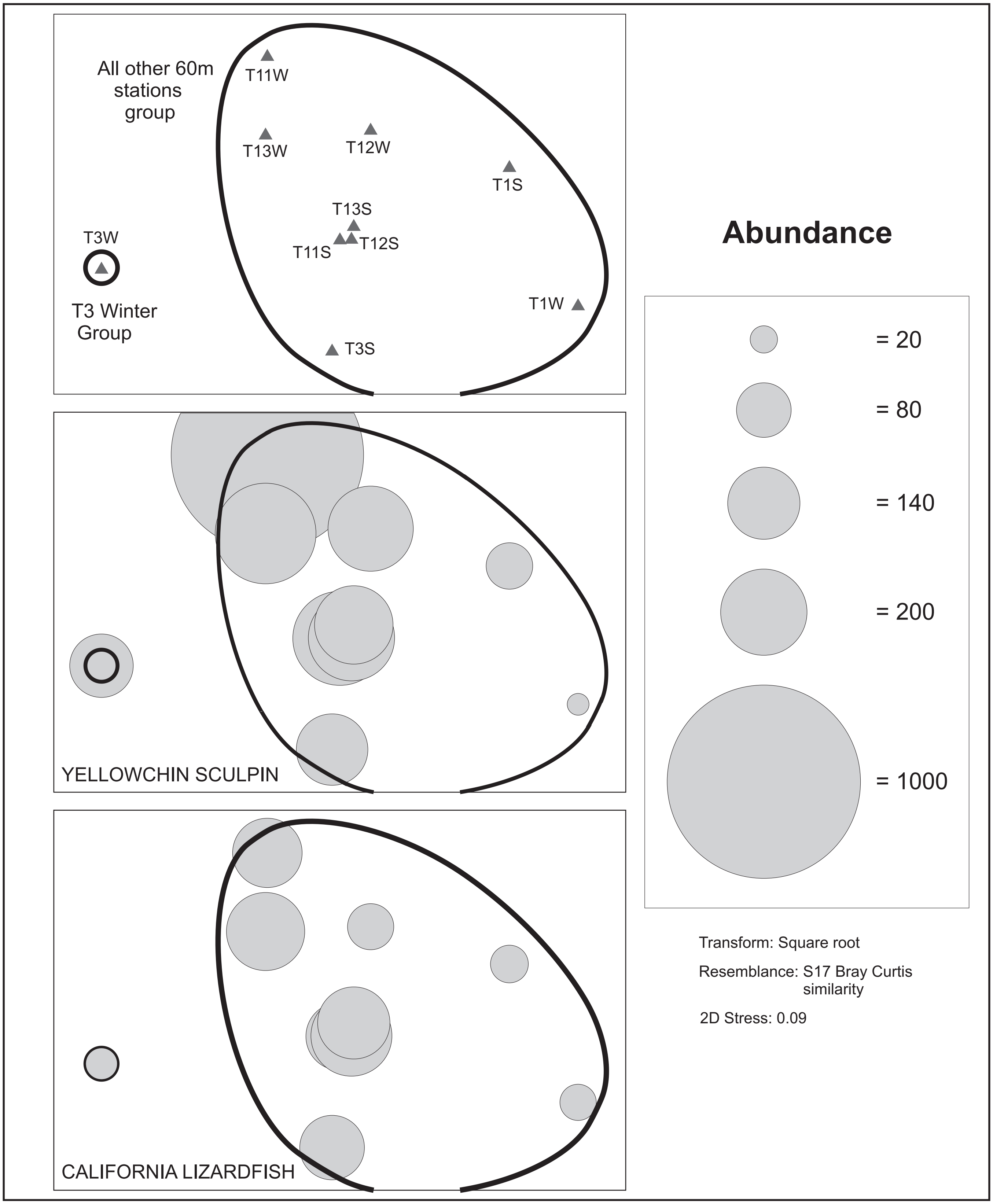

Figure 6-6. Two-dimensional MDS plots of square-root transformed species abundance data at five 60-m stations sampled in summer (July 2009) and winter (January 2010). Mean abundances per trawl for the dominant species in each cluster group are super-imposed as bubbles, where increased size corresponds to greater abundance. Abundance must be interpolated from the bubble sizes in the legend, which represent absolute values.

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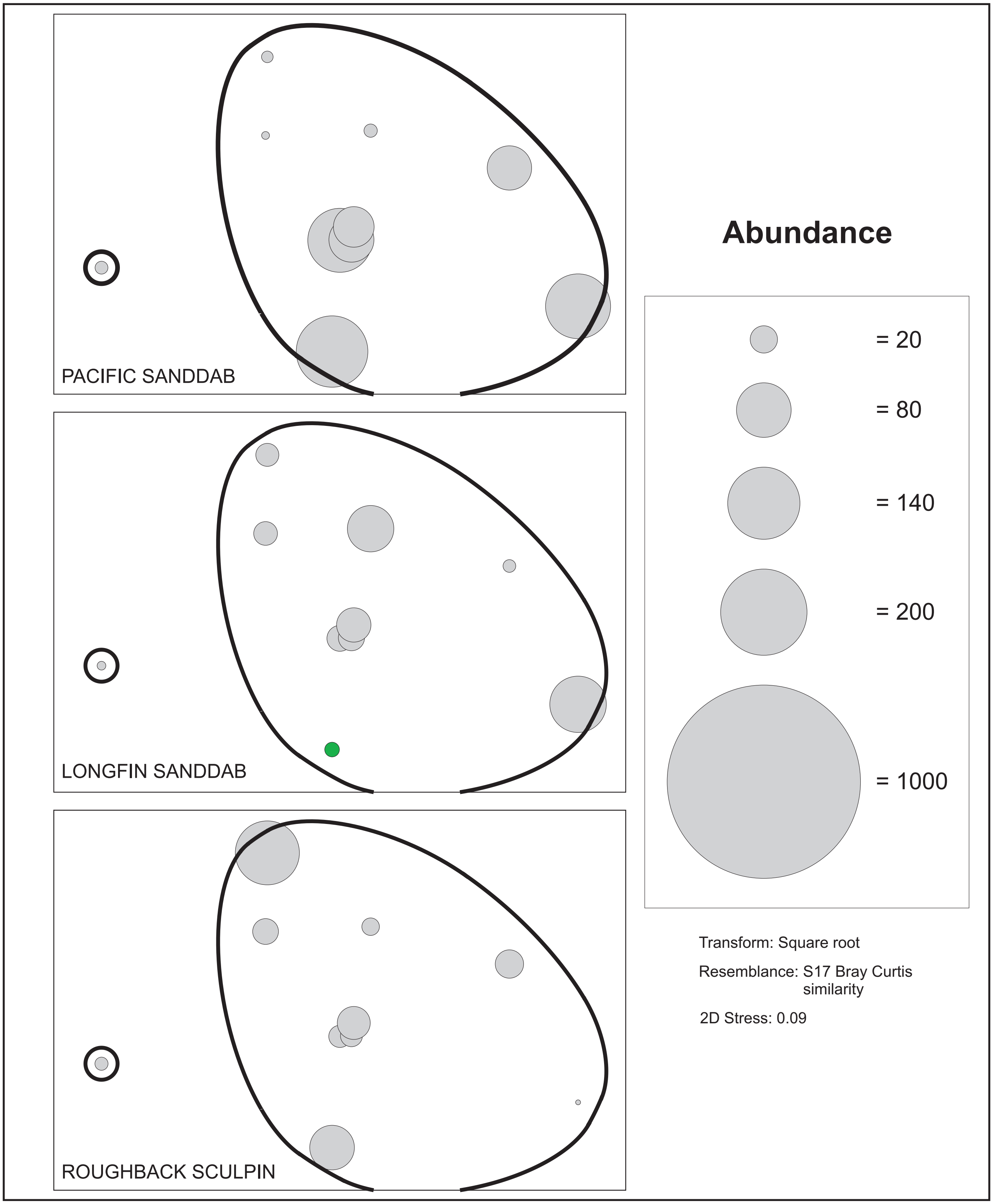
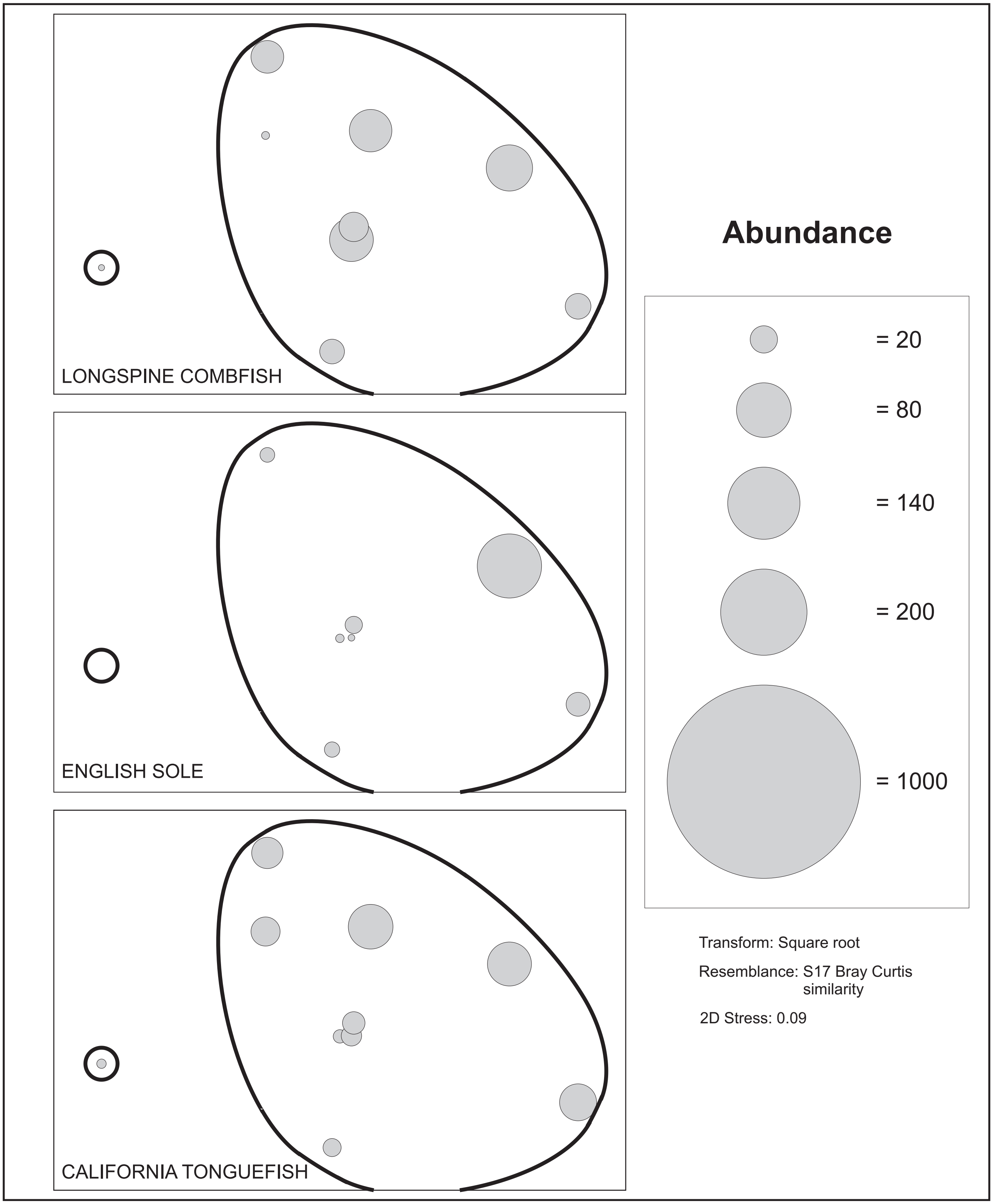


Figure 6-6 continued.



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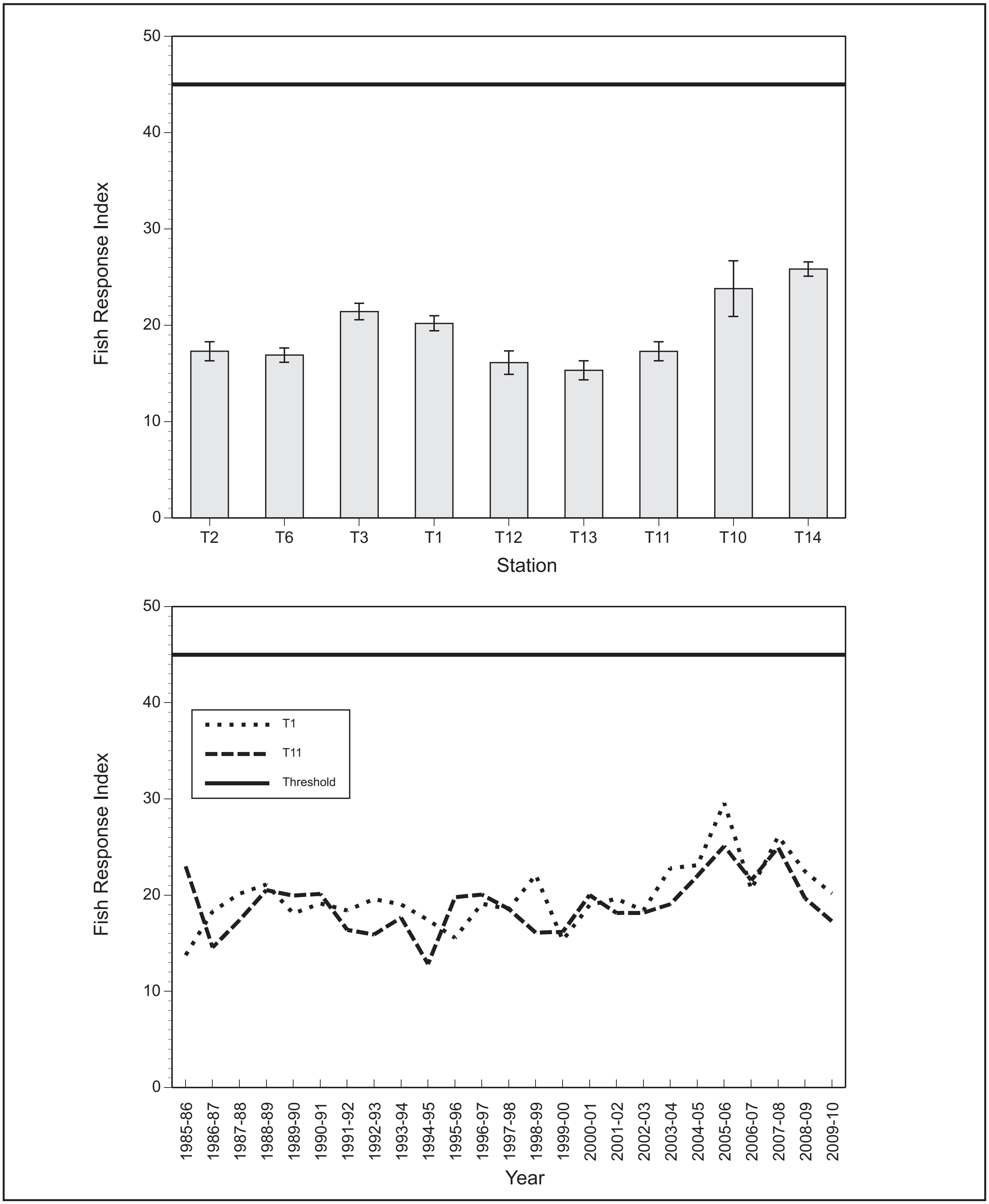

Figure 6-7. **Mean Fish Response Index (FRI) by station in 2009-10 and annual mean FRI for outfall Station T1 and farfield upcoast Station T11.**
Solid black line represents threshold value.

Orange County Sanitation District, California.

The District's summer data at outfall Station T1 and farfield upcoast Station T11 also followed trends in abundance and biomass similar to those described previously for the regional survey (see OCSD 2008). The SCBPP, Bight'98, Bight'03, and Bight'08 regional monitoring surveys reported no degraded areas, but found enhancement of mean fish abundance and biomass at some locations near wastewater outfalls (Figure 6-8). The Bight'08 survey did not include a large publicly owned treatment works (LPOTW) stratum so no data are available for the most recent regional survey. The fish populations at the District's Outfall Station T1 also showed enhanced abundance and biomass. In 2009, mean abundance at T1 decreased from years 2003 – 2008, but was within the ranges for the regional LPOTW stations. Biomass at T1 was at the high end of regional values. Mean biomass at T1 in 2009 was high due to a number of large individuals of English sole. Such patterns were observed in the regional studies and are expected at near-discharge areas.

The regional surveys reported slightly more species at LPOTW compared to non-POTW areas in 1994 and 1998, though the number of species was similar between the 2 groups in 2003. The number of species at T1 was lower than the Bight LPOTW and non-POTW areas in 1994 and 2003, but not in 1998. In 2009, the mean number of species at the District's sites were most similar to regional values in 1994 and 2008, though reduced from years 2003 through 2008. Diversity at the Outfall Station T1 has been consistently high and similar to other SCB stations in the 1994, 1998, and 2003 surveys; however T1 diversity was much higher than the SCB stations in 2008. Since fish community measures at outfall Station T1 approximately equaled or exceeded values characterizing the SCB at similar depths, the fish community is not being degraded by the wastewater discharge.

EMI Community

Abundance

A total of 6,705 EMI were collected during 2009-10 (Tables 6-4 and B-15). Three species accounted for 65% of the total abundance. The ridgeback rockshrimp comprised 32% of the total catch (2,151 individuals), and was followed by the white sea urchin (*Lytechinus pictus*) at 18% (1,198 individuals) and trailtip sea pen (*Acanthoptilum* sp) at 15% (1,010 individuals). The trailtip sea pen has been occurring in large numbers at the outfall station since 2002 (Figure 6-9). While it was a dominant species in 2009-10, the number of individuals collected decreased by 7,255 individuals from the 2008-09 survey. Other abundant species included the brokenspine brittlestar (*Ophiura luetkenii*), yellow sea twig (*Thesea* sp), gray sand star (*Astropecten verrilli*), and California blade barnacle (*Hamatoscalpellum californicum*).

Overall, mean abundances, ranged widely from 46 to 361 in summer and from 26 to 294 in winter (Figure 6-10 and Table B-16). All but 4 stations (T2, T13, T10, and T14) had greater abundances in summer than winter, although there was little difference between mean values (149 and 137, respectively).

Through time, abundance for the 5 station groups (outfall, farfield upcoast, farfield downcoast, shallow, and deep) has been highly variable over the past 23 years with ranges from 17 to 5,700 individuals (Figure 6-11). These fluctuations typically reflect changes in several dominant species, such as the trailtip seapen, white sea urchin, brokenspine brittlestar, yellow sea twig, and ridgeback rockshrimp (Figure 6-9). Overall, the only potential indication of impact at the discharge site is the increase in sea pen abundances.

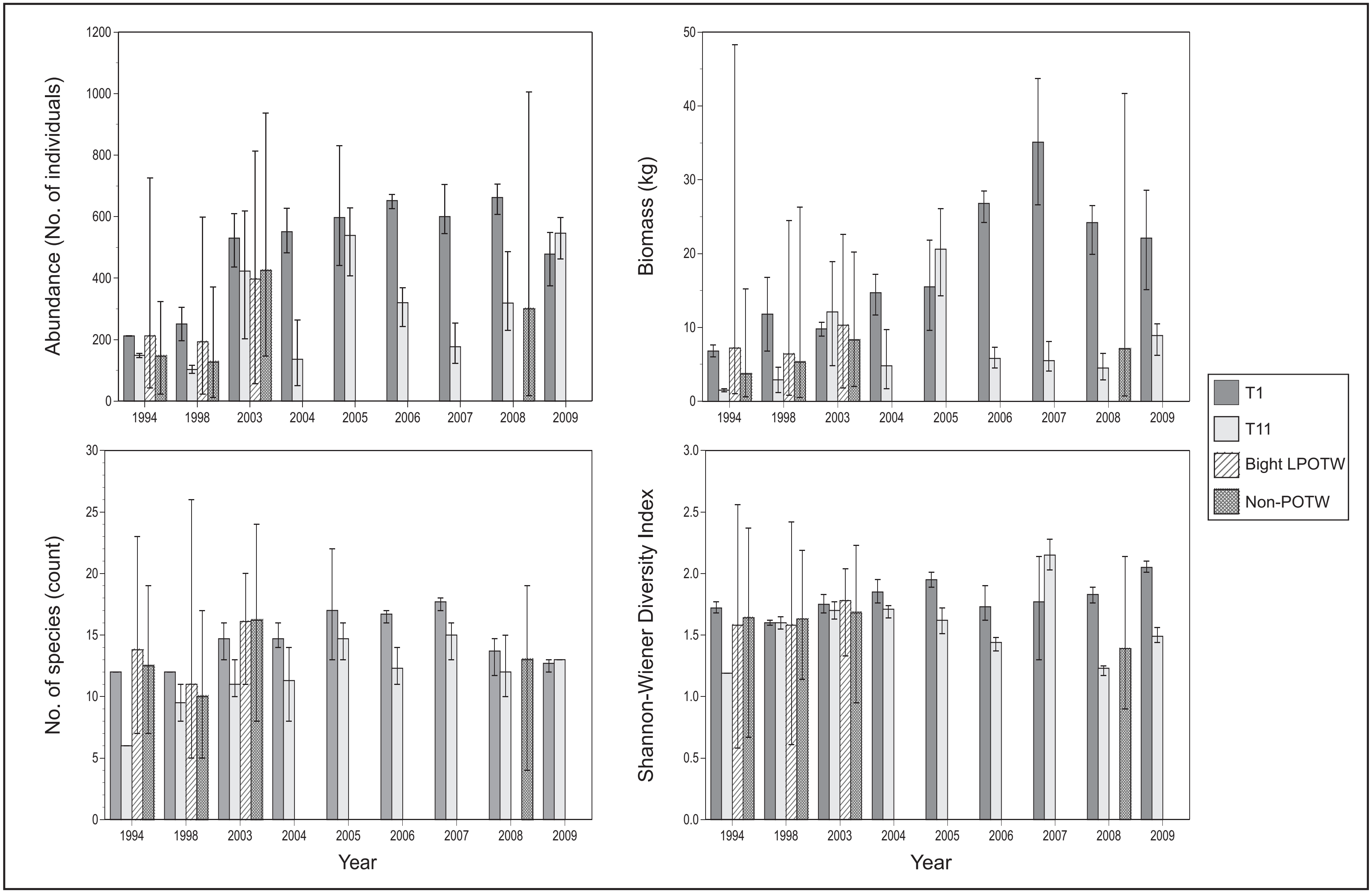

Figure 6-8. **Comparison of demersal fish parameters at OCSD stations T1 and T11 in 1994, 1998, 2003, 2004, 2005, 2006, 2007, 2008, and 2009 and regional POTW and non-POTW stations from the 1994, 1998, 2003, and 2008 regional monitoring surveys. All data for mean abundance, biomass, number of species, and Shannon-Wiener diversity (H') are for summer surveys only. Error bars represent the range of values (minimum and maximum) for each station group per survey.**

Note: N values = 1994: LPOTW = 16, nonPOTW = 3; 1998: LPOTW = 25, nonPOTW = 15;
2003: LPOTW = 18, nonPOTW = 13; 2008: LPOTW = not analyzed, nonPOTW = 13

Table 6-4. Summary of epibenthic macroinvertebrates species collected during the summer (July 2009) and winter (January 2010) surveys. Data for each species are expressed as total abundance (Total), percent abundance (%A), frequency of occurrence (%FO), and mean abundance per haul (MAH).

Orange County Sanitation District, California.

Species	Total	%A	%FO	MAH
Sicyonia ingentis	2,151	32	100	47
Lytechinus pictus	1,198	18	89	26
Acanthoptilum sp	1,010	15	89	22
Ophiura luetkenii	778	12	67	17
Thesea sp	579	9	89	13
Astropecten verrilli	200	3	78	4
Hamatoscalpellum californicum	180	3	89	4
Luidia foliolata	100	1	89	2
Ophiothrix spiculata	73	1	78	2
Neocrangon zacae	66	1	33	1
Sicyonia penicillata	51	1	33	1
Dendronotus frondosus	36	1	44	1
Parastichopus californicus	36	1	78	1
Rossia pacifica	22	<1	22	<1
Acanthodoris brunnea	20	<1	78	<1
Amphichondrius granulatus	16	<1	33	<1
Luidia asthenosoma	15	<1	67	<1
Stylatula elongata	15	<1	22	<1
Pleurobranchaea californica	13	<1	56	<1
Octopus rubescens	12	<1	44	<1
Neocrangon resima	11	<1	22	<1
Crangon alaskensis	9	<1	44	<1
Heterogorgia sp	8	<1	44	<1
Barbarofusus barbarensis	7	<1	11	<1
Pandalus platyceros	7	<1	11	<1
Strongylocentrotus fragilis	7	<1	44	<1
Tunicate	7	<1	44	<1
Neocrangon sp	5	<1	11	<1
Tritonia diomedea	5	<1	22	<1
Armina californica	4	<1	33	<1
Heptacarpus stimpsoni	4	<1	11	<1
Virgularia californica	4	<1	33	<1
Baptodoris mimetica	3	<1	22	<1
Calliostoma turbinum	3	<1	33	<1
Hemisquilla californiensis	3	<1	22	<1
Loxorhynchus crispatus	3	<1	33	<1
Loxorhynchus grandis	3	<1	22	<1

Table 6-4 continues.

Table 6-4 continued.

Species	Total	PA	FO	MAH
Orthopagurus minimus	3	<1	11	<1
Paguristes bakeri	3	<1	11	<1
Peltodoris nobilis	3	<1	11	<1
Philine auriformis	3	<1	33	<1
Randallia ornata	3	<1	11	<1
Silicea	3	<1	33	<1
Virgularia sp	3	<1	22	<1
Amphipholis squamata	2	<1	11	<1
Doris montereyensis	2	<1	11	<1
Doryteuthis opalescens	2	<1	11	<1
Metacarcinus anthonyi	2	<1	22	<1
Amphioda psara	1	<1	11	<1
Dendronotus albus	1	<1	11	<1
Diaulula sandiegensis	1	<1	11	<1
Dromalia alexandri	1	<1	11	<1
Flabellina pricei	1	<1	11	<1
Heptacarpus tenuissimus	1	<1	11	<1
Metacrangon spinosissima	1	<1	11	<1
Parastichopus sp	1	<1	11	<1
Pisaster brevispinus	1	<1	11	<1
Podochela hemphillii	1	<1	11	<1
Pteropurpura macroptera	1	<1	11	<1
Pyromaia tuberculata	1	<1	11	<1
Total	**6,705**	**100**		
Total no. of species	**58**			

n = 46 hauls

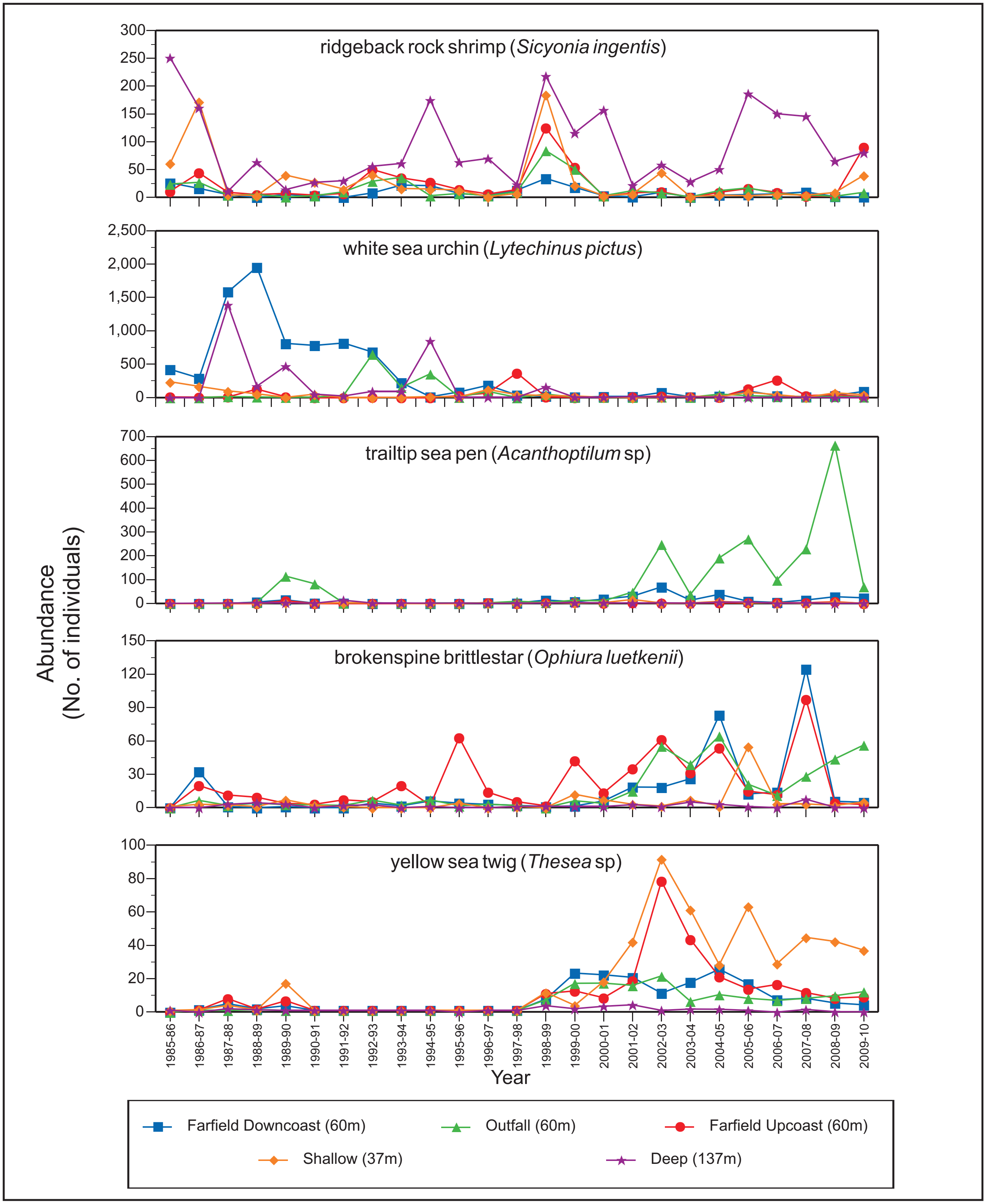

Figure 6-9. Comparisons of the most abundant epibenthic macroinvertebrates: ridgeback rock shrimp (*Sicyonia ingentis*), white sea urchin (*Lytechinus pictus*), trailtip sea pen (*Acanthoptilum* sp), brokenspine brittlestar (*Ophiura luetkenii*), and yellow sea twig (*Thesea* sp) by station group — farfield downcoast (T3), farfield upcoast (T11 and T13), outfall (T1 and T12), shallow (T2 and T6), and deep (T10 and T14). Data are expressed as annual mean abundance (July–June) from 1985 to 2010; n=4–6 replicates/station/year.

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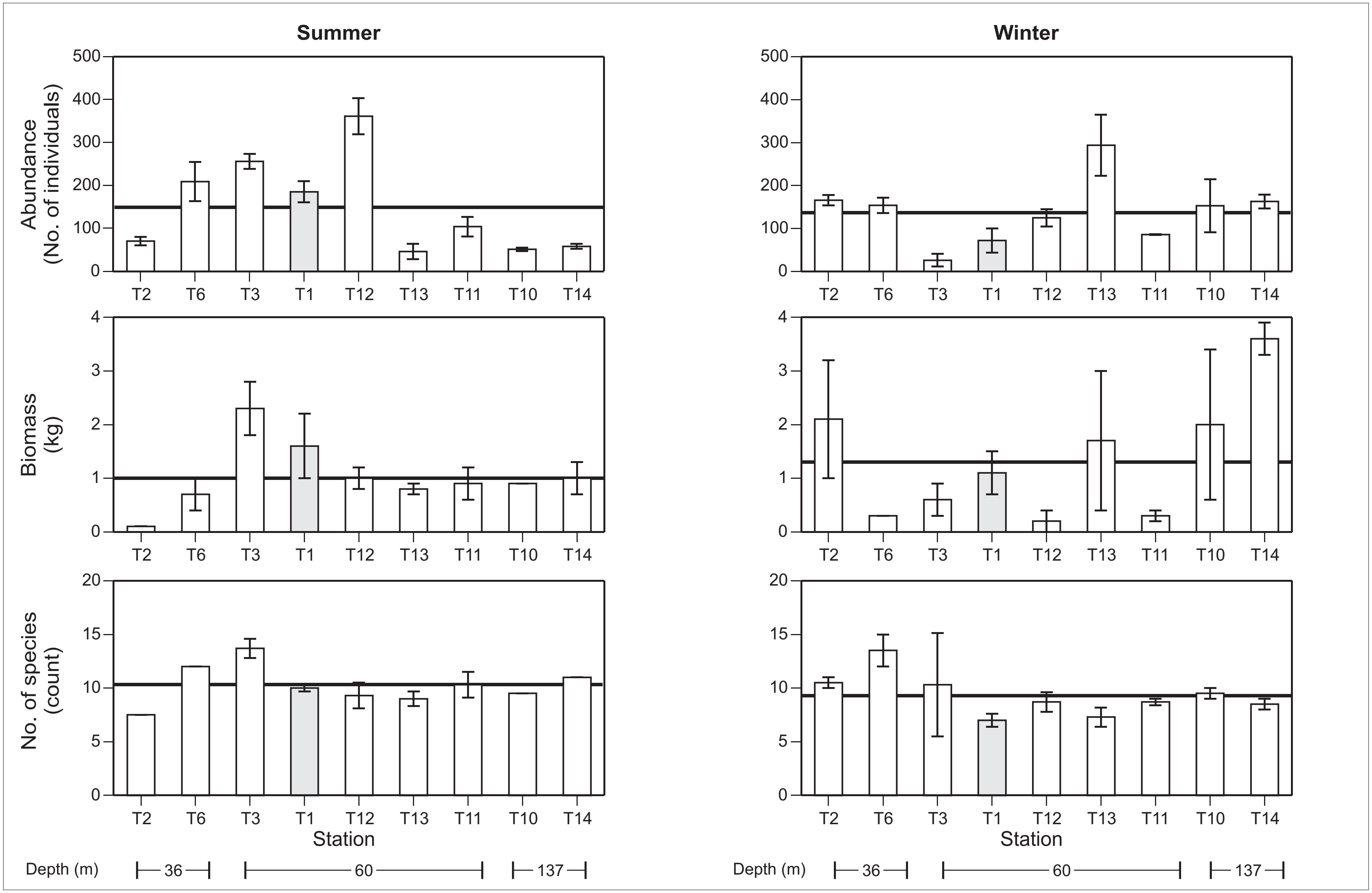


Figure 6-10. Mean and 95% confidence interval for number of individuals (abundance), biomass, and number of species of epibenthic macroinvertebrates collected during the summer (July 2009) and winter (January 2010) surveys.
Outfall Station T1indicated in gray. Survey mean indicated by heavy line.

Orange County Sanitation District, California.

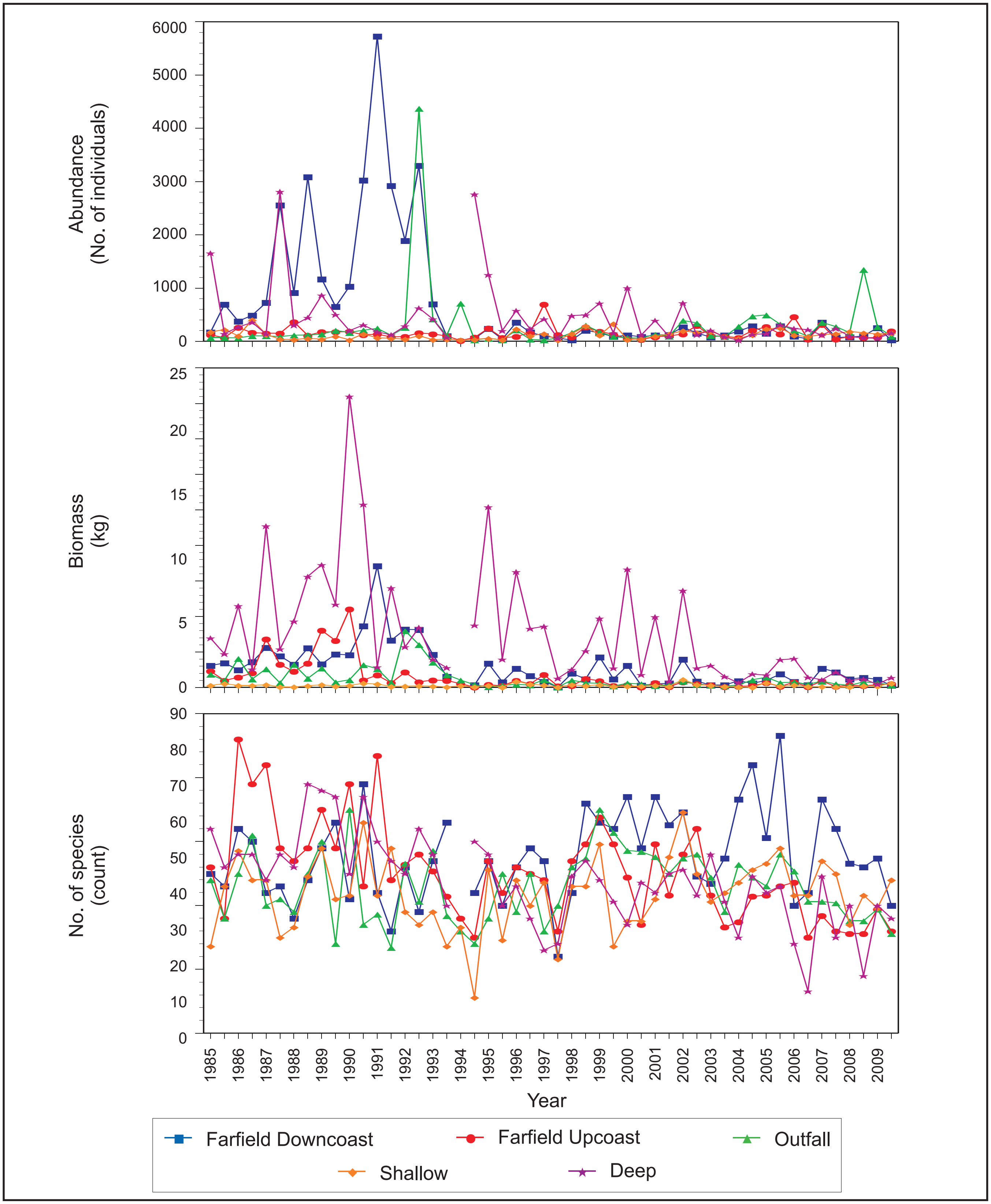


Figure 6-11. **Comparison of epibenthic macroinvertebrate parameters by station groups: farfield downcoast (T3), farfield upcoast (T11 and T13), outfall (T1 and T12), shallow (T2 and T6), and deep (T10 and T14). All data for mean abundance, biomass, and number of species by station group are for the period August 1985–January 2010.**

Orange County Sanitation District, California.

Biomass

In 2009-10, a total of 52.4 kg of EMI were collected in the District's monitoring area. The California sea cucumber (*Parastichopus californicus*) comprised 36% (19 kg) of this biomass and the ridgeback rockshrimp made up 24% (12 kg). The highest biomass values occurred at the 60 m downcoast Station T3 in summer due to the California sea cucumber, and at the deep Stations T10 and T14 in winter due to the ridgeback rockshrimp (Figure 6-10).

Historically, biomass has ranged from 0.1 to 82 kg by station group (Figure 6-11). Trawl invertebrate biomass are generally highest at the outer shelf stations and lowest at the inner shelf stations; however, biomass values at the deep stations have declined in recent years primarily due to smaller catches of the fragile pink urchin (*Strongylocentrotus fragilis*) and California sea cucumber.

Number of Species

A total of 58 EMI taxa were collected during 2009-10 (Tables 6-4 and B-15). Only the ridgeback rock shrimp occurred at every station. Another 9 species, consisting of 5 echinoderms, 1 crustacean, 2 cnidarians, and 1 mollusk were wide-ranging and occurred at over 75% of the stations. No seasonal differences were apparent for mean number of species (Figure 6-10 and Table B-16). The greatest number of species occurred at Station T3 in summer and at shallow Station T6 in winter. Outfall Station T1 had an average of 10 species in summer, which was the same as the survey mean. However, the outfall station fell short of the survey mean and had the least number of species of all stations in winter, except T13, with an average of 7 species. Mean number of species by station group has been variable since 1985, ranging from 3 to 23 species (Figure 6-11). The mean number of species in 2009-10 was well within the historical range.

Diversity

Survey means of H', SR, and Dominance were similar in summer and winter, suggesting little seasonal differences; however, some individual stations (i.e. the 60 meter Station T13 and the deep Stations T10 and T14) had significantly different diversity indices between the seasons (Figure 6-12 and Table B-16). Overall, diversity was consistent across the depth strata in summer and variable in winter. Mean diversity at outfall Station T1 was generally comparable to the other 60 m stations, with the exception of T3. Community measures at Station T3 are typically much different than the other 60 m stations, primarily due to its proximity to the Newport submarine canyon and depositional environment (Mauer et al. 1993).

Regional Comparisons

The District's summer 2009 EMI data for outfall Station T1 and upcoast reference Station T11 were compared to regional data collected during the 1994 SCBPP, Bight'98, Bight'03, and Bight'08 surveys (Figure 6-13). The regional studies found that invertebrate population attributes at LPOTW areas and non-POTW were generally similar (Allen *et al.* 2007). OCSD (2008) presented more detailed comparison between OCSD data and Regional Bight results. Differences in the EMI assemblages among the 3 surveys were likely due to the prevailing oceanographic regime associated with the Pacific Decadal Oscillation (PDO, Francis et al 1998). The Bight'03 report concluded that, in contrast to fish, mean EMI abundance was highest in 1994 (warm regime), but biomass was highest in 2003 (cold regime).

Mean community measures at Station T1 and T11 in 2009 fell within the range of values for the Bight stations. However, meaningful comparisons among the regional surveys and the District's trawl data are limited due to the high variability,

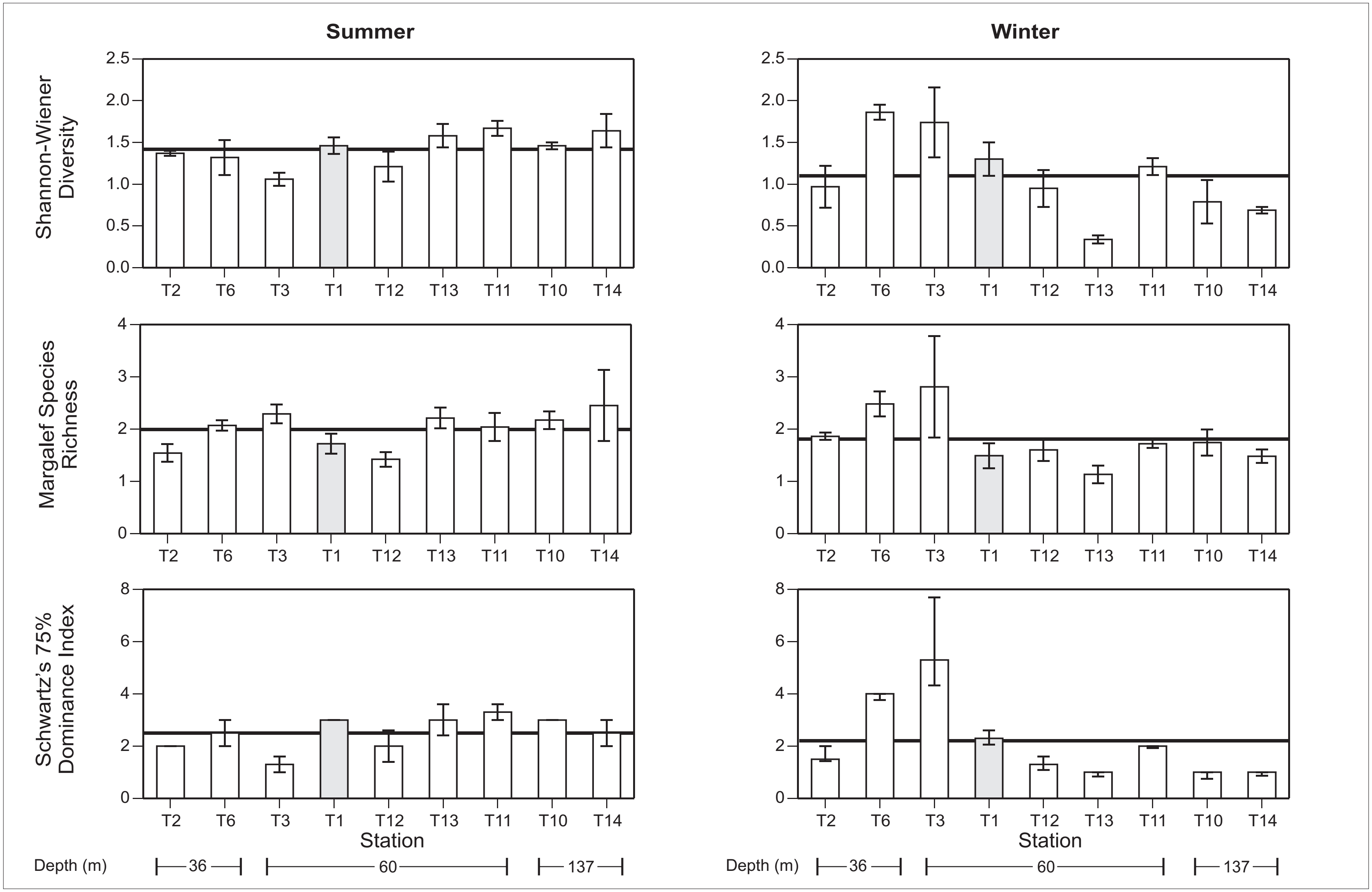


Figure 6-12. Mean and 95% confidence interval for diversity indices — Shannon-Wiener Diversity Index (H'), Margalef Species Richness (SR), and Schwartz's 75% Dominance Index of epibenthic macroinvertebrates collected during the summer (July 2009) and winter (January 2010) surveys.
Outfall Station T1 indicated in gray. Survey mean indicated by heavy line.

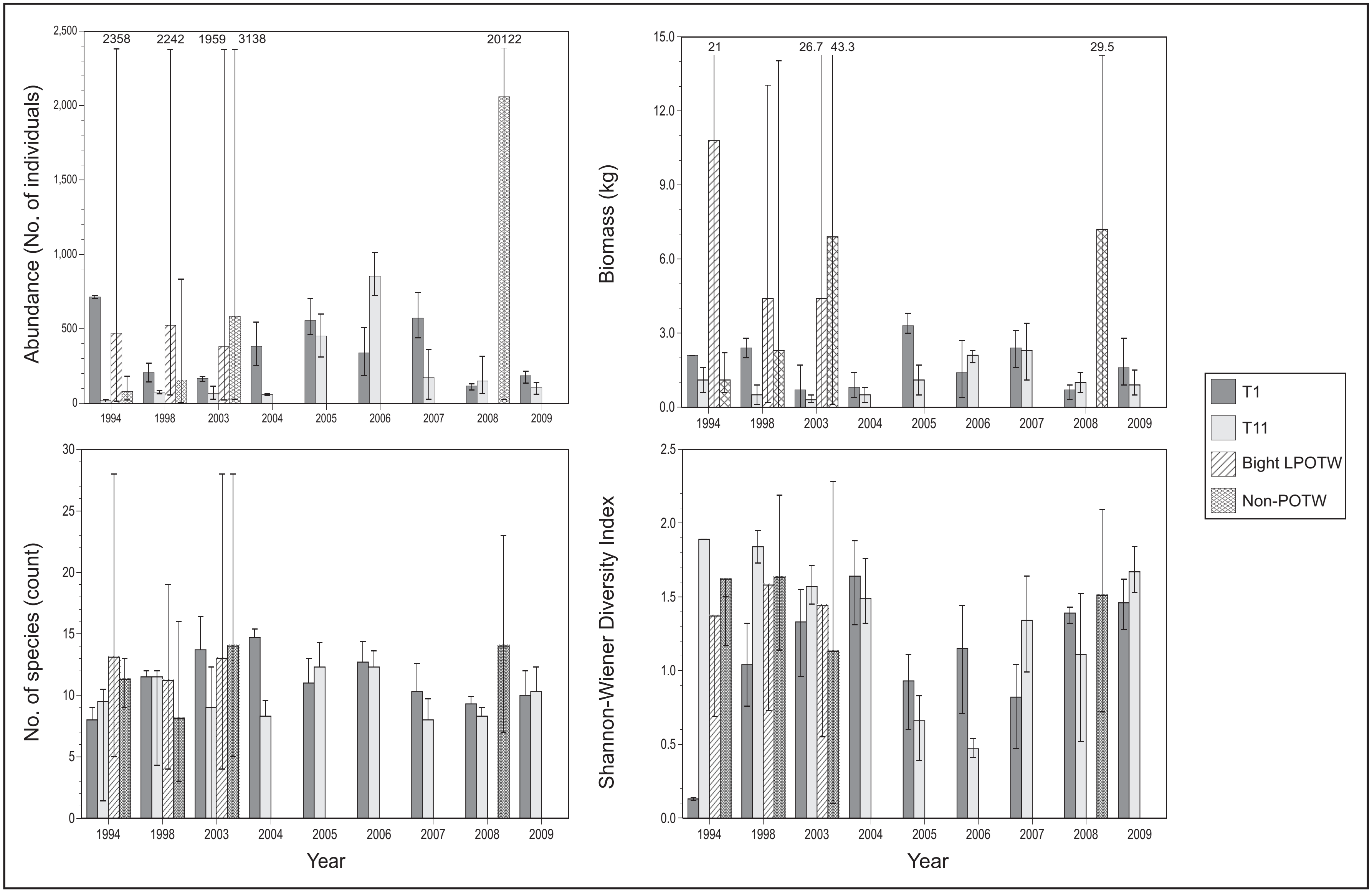


Figure 6-13. **Comparison of epibenthic macroinvertebrate parameters at OCSD Stations T1 and T11 in 1994, 1998, 2003–2009 and regional POTW and non-POTW stations from the 1994, 1998, 2003, and 2008 regional monitoring surveys. All data for mean abundance, biomass, number of species, and Shannon-Wiener diversity (H') are for summer surveys only. Error bars represent the range of values (minimum and maximum) for each station group per survey.**

Note: N values = 1994: LPOTW = 16, nonPOTW = 3; 1998: LPOTW = 25, nonPOTW = 15;
2003: LPOTW = 18, nonPOTW = 13; 2008: LPOTW = not analyzed, nonPOTW = 13

Orange County Sanitation District, California.

in particular, the wide ranges observed for trawl invertebrate data. For example, non-POTW abundance and biomass in 2008 were extraordinarily high due to a large catch of white sea urchins at just 2 stations. White sea urchin populations often appear in vast "herds," usually on sandy bottoms and population fluctuations have been documented in OCSD's study area and throughout the SCB (Dean et al. 1984, Thompson et al. 1993, Allen et al. 2007). Overall, the EMI population attributes at the District's outfall and within the SCB area were highly variable, mostly due to changes in oceanographic conditions, but also due to fluctuations in the dominant species. The EMI populations do not seem to show significant trends of increasing or decreasing values, based on the 5 years considered for this evaluation (Figure 6-13).

Fish Tissue Contaminants

Muscle and liver contaminant concentrations from hornyhead turbot, English sole, and the whole-body tissue of Pacific sanddabs were measured at both outfall and farfield stations. Three size classes (lengths) of Pacific sanddabs were tested: 0 (5–8 cm), 1 (9–13 cm), and 2 (14–16 cm). In 2009-10 no 0 size class fish were collected at the outfall station. The analytes include mercury, total DDT (tDDT; the sum of 6 DDT isomers), total PCB (tPCB; the sum of 45 PCB congeners), and 12 other chlorinated pesticides. The means and ranges of tissue concentrations of the analytes are presented in Table 6-5. Organic analyte data is lipid normalized. A complete list of analytes tested is presented in Appendix A.

<u>Outfall vs. Farfield Stations Comparisons</u>

Hornyhead turbot

Hornyhead turbots collected at the farfield and outfall stations were about the same size. The mean standard length between the two stations differed by only 1.3 cm. Size matters because contaminant concentrations can relate to the age/size of the fish. For example, Phillips *et al.* (1997) found that tissue concentrations of mercury in barred sandbass (*Paralabrax nebulifer*) were highest in larger, older fish and that size/age was more important to the contaminate level than location of capture.

Percent muscle tissue lipid was < 0.15 at the outfall and farfield stations (Table 6.5), while muscle tissue tDDT levels were similar at both stations. tPCB concentrations were two times higher in outfall collected fish than in the farfield fish. Mercury concentrations were three times higher at the outfall than at the farfield stations but still well below California advisory limit (Figures 6-14 through 6-17). Contaminant concentrations in Hornyhead turbot muscle tissue were generally low. For example percent lipid was < 0.15 % at outfall and nearfield stations and total DDT was undetected (Table 6.5). Pesticides concentrations were non-detectable at both stations.

Similar to muscle tissue, percent lipid in liver tissue was somewhat higher in outfall than in farfield fish. Liver tissue mercury was three times higher at the farfield station, tPCB levels were approximately three times higher at the outfall, and tDDT was about the same at both stations. Pesticides were about five times higher in liver tissue at the outfall but overall contaminant concentrations in liver tissue of all contaminants were low.

English sole

The mean standard length of English sole collected at the outfall and those from the farfield station differed by less than 1 cm. Muscle lipid concentration was slightly higher in the outfall fish than farfield fish. Muscle tissue tDDT concentrations were slightly higher at the farfield stations, while tPCB levels were three times higher at the

Table 6-5. Results of tissue contaminant analysis of trawl fish collected at outfall and farfield station groups.

Orange County Sanitation District, California.

Species	Tissue	Station Group	n	Range	Standard Length / Size Class	Percent Lipid	Mercury (mg/kg)	Total DDT (ug/kg)	Total PCB (ug/kg)	Other Pest (ug/kg)
Hornyhead Turbot	Muscle	Outfall	10	Mean	152	0.138	0.033	74.0	21.0	ND
				Min.	125	0.100	0.012	25.4	1.40	ND
				Max	170	0.132	0.058	163	36.9	ND
		Farfield	10	Mean	165	0.100	0.083	65.6	11.1	ND
				Min.	113	0.100	0.021	11.4	nd	ND
				Max	243	0.100	0.301	211	36.4	ND
	Liver	Outfall	10	Mean	152	12.4	0.071	58.3	23.5	1.34
				Min.	125	4.05	0.029	16.8	8.23	ND
				Max	170	25.6	0.134	156	57.9	10.5
		Farfield	10	Mean	165	7.10	0.192	78.4	7.84	0.220
				Min.	113	3.30	0.098	17.8	ND	ND
				Max	243	13.2	0.270	207	25.9	1.32
English Sole	Muscle	Outfall	10	Mean	181	0.386	0.049	148	96.8	ND
				Min.	162	0.100	0.021	27.0	2.90	ND
				Max	195	0.770	0.081	390	800	ND
		Farfield	10	Mean	179	0.288	0.054	273	33.3	ND
				Min.	142	0.260	0.033	50.0	7.70	ND
				Max	238	0.320	0.072	1506	117	ND
	Liver	Outfall	10	Mean	181	12.4	0.044	658	414	ND
				Min.	162	6.02	0.023	157	35.0	ND
				Max	195	21.8	0.069	1448	2438	ND
		Farfield	10	Mean	179	6.74	0.059	1237	78.9	ND
				Min.	142	2.85	0.038	87.0	nd	ND
				Max	238	16.4	0.074	8622	387	ND
Pacific Sanddab	Whole Fish	Outfall	3	Mean	0 (5–8 cm)	NS	NS	NS	NS	NS
				Min.		NS	NS	NS	NS	NS
				Max		NS	NS	NS	NS	NS
		Farfield	3	Mean		0.423	0.016	21.77	9.37	ND
				Min.		0.310	0.015	10.800	5.06	ND
				Max		0.510	0.018	32.44	13.0	ND
		Outfall	3	Mean	1 (9–13 cm)	0.657	0.023	88.32	9.34	ND
				Min.		0.510	0.022	64.5	4.84	ND
				Max		0.860	0.026	116.66	15.0	ND
		Farfield	3	Mean		0.810	0.023	61.73	10.4	ND
				Min.		0.660	0.020	34.68	8.53	ND
				Max		1.04	0.025	99.030	12.4	ND
		Outfall	3	Mean	2 (14–16 cm)	0.627	0.037	103.85	27.0	ND
				Min.		0.520	0.035	27.83	16.0	ND
				Max		0.750	0.040	221,07	37.1	ND
		Farfield	3	Mean		0.673	0.031	70.48	13.6	ND
				Min.		0.630	0.029	48.88	9.80	ND
				Max		0.700	0.034	103.34	19.0	ND

Data for total DDT, total PCB, and total other pesticides are lipid-normalized. ND = not detected, NS = no sample.

outfall (Table 6-5; Figures 6-14 through 6-17). No fish at either site had measurable muscle pesticide concentrations and mercury was similar at both sites. Overall, contaminate concentrations were low for all parameters measured.

Liver lipid concentrations were comparable in outfall and farfield fish. Liver tissue mercury levels were also comparable at both sites. Total liver tissue PCB was five times higher in outfall collected fish (414 ug/kg) than at the farfield stations (78.9 ug/kg). Total liver tissue DDT was 2 times higher in farfield fish. Chlorinated pesticides were not detected in any of the fish collected.

Pacific sanddab
Pacific sanddab whole-fish contaminant concentrations generally showed the expected pattern of higher tissue concentrations with increased size (size class) for all analytes. Values for all parameters were lower than last year (Table 6-5; Figures 6-14 through 6-17).

Long-term Trends
Muscle tissue contaminant data has been consistently collected and analyzed for hornyhead turbot since July 2004 and English sole and Pacific sanddabs since July 2005. Contaminant concentrations have been generally well below any action limits for all analytes, but certain contaminants have shown high interannual and interspecies variability.

Total DDT
Muscle tissue tDDT concentrations have been well below action limits in all 3 species with occasional periods of increased concentrations (Figure 6-14). There has been no consistent pattern of higher concentrations between outfall and farfield site collected fish. Elevated station concentrations are usually due to high concentrations in 1 or 2 individuals with the majority of fish having low tissue levels. The highest tissue concentrations for hornyhead turbot and Pacific sanddab occurred in the 2008-09 monitoring year, while the highest tissue concentration in English sole occurred at the farfield site in 2007-08.There were no apparent reasons for the high values since there were no concomitant increases in sediment tDDT concentrations.

Total PCB
Tissue concentrations of tPCB showed a similar interannual pattern as tDDT for all 3 species (Figure 6-15). The highest concentrations in hornyhead turbot and pacific sanddab occurred in the 2008-9 monitoring year. English sole at the outfall collected in 2009-10 had the highest in tPCB concentration. Like tDDT, long-term trends were unrelated to sediment tPCB concentrations.

Chlorinated Pesticides
Fish tissue samples were analyzed for 12 chlorinated pesticides other than DDT. Detection of these compounds in fish tissue is sporadic with more than half the annual surveys yielding results below the detection limit for all 3 species.

Since July 2004, 8 of these 12 pesticide compounds have been measured in only 56 of the 432 fish collected in the monitoring area. Pesticides have been detected more commonly in fish near the outfall. For example, of the 56 individual detections, 36 occurred in fish collected from the outfall and 20 from the farfield station. The most frequently occurring pesticide was trans-Nonachlor, which was detected 24 times or in approximately 6% of the 432 samples tested. The 7 other pesticides were detected in less than 10 instances each: hexachlorobenzene (8), gamma-chlordane (6), alpha-chlordane (5), gamma-BHC (5), cis-nonachlor (4), aldrin (2), and heptachlor epoxide (2). Rates of pesticide detection between 13–14% and below 2 parts per billion for all 3 species indicate that

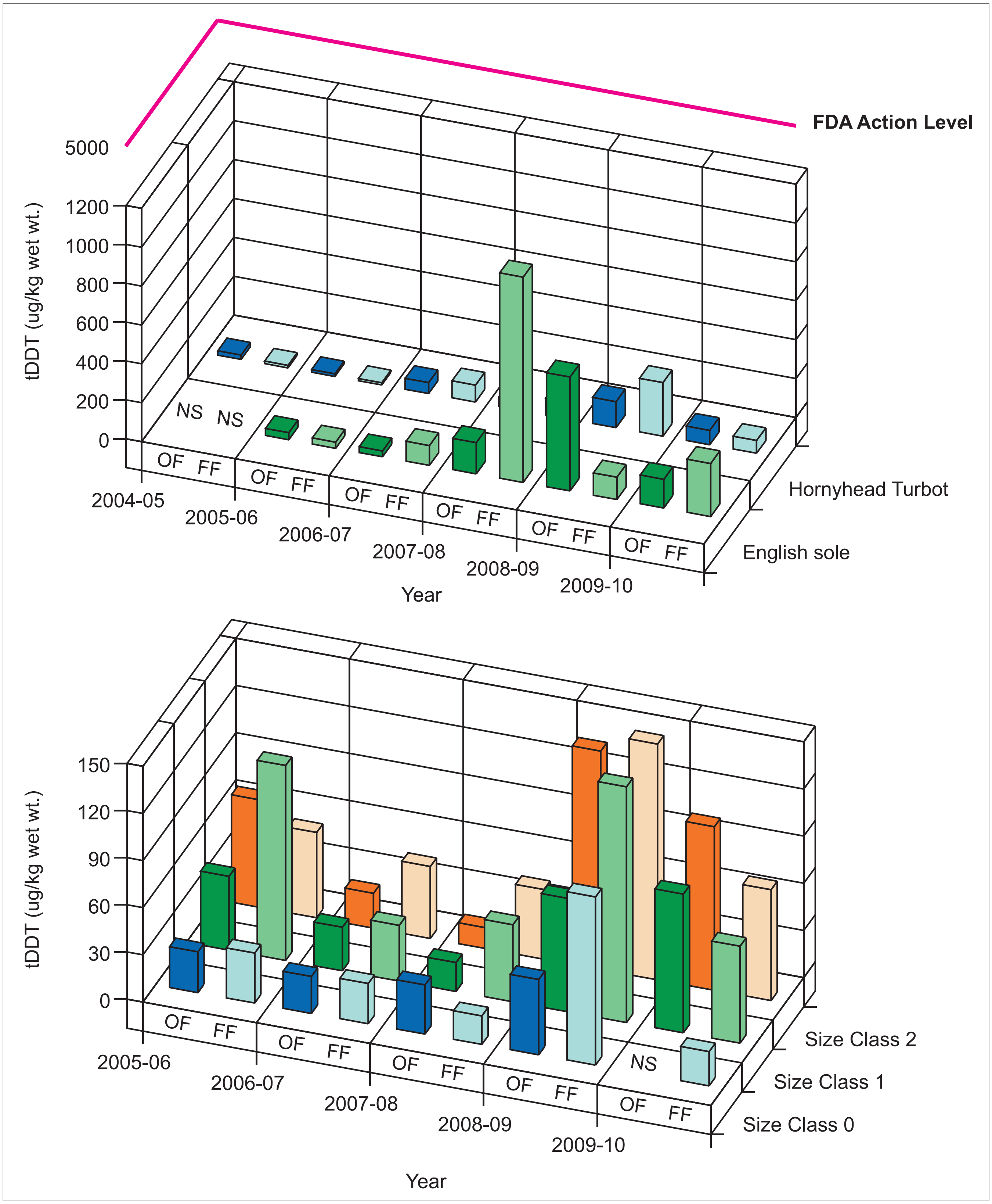
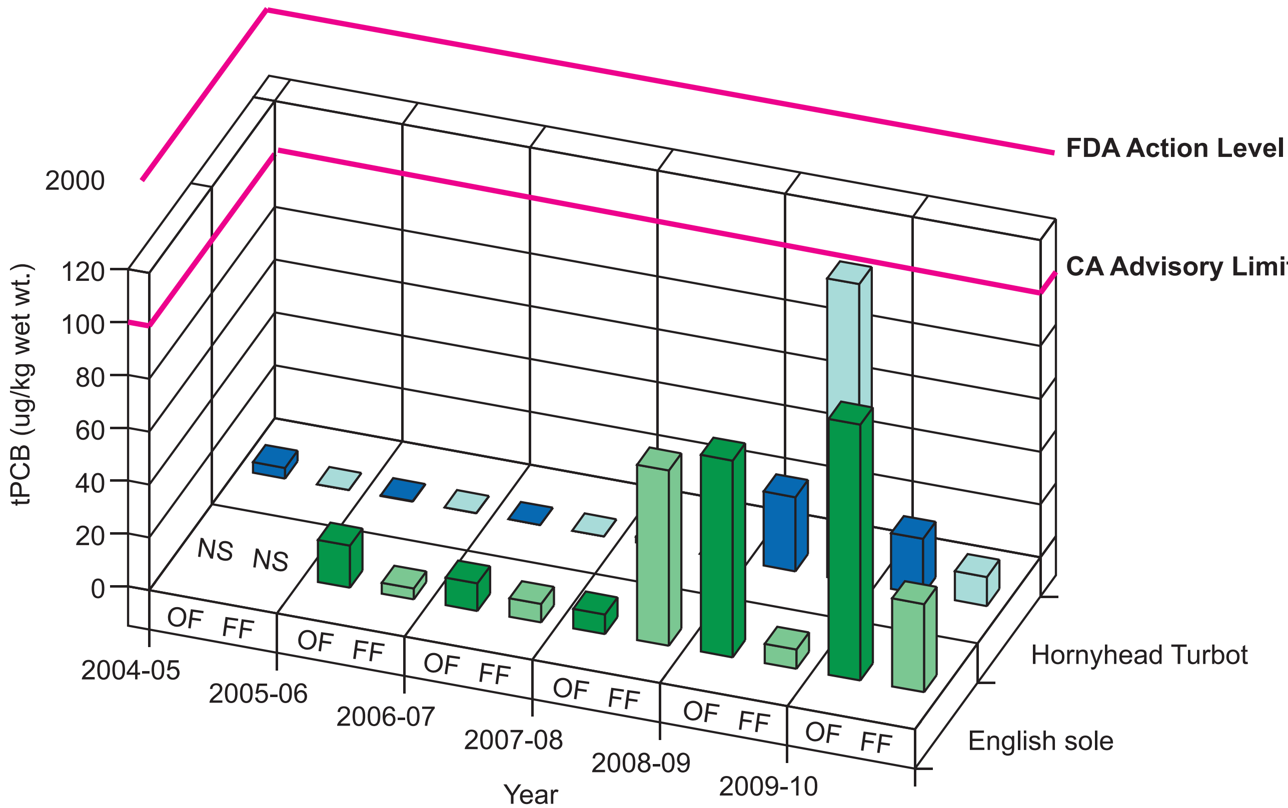


Figure 6-14. **Mean concentrations of total DDT (ug/kg wet weight) in hornyhead turbot (*Pleuronichthys verticalis*) muscle tissue, English sole (*Parophrys vetulus*) muscle tissue, and Pacific sanddab (*Citharichthys sordidus*) whole body tissue for size classes 0 (5–8 cm), 1 (9–13 cm), and 2 (14–16 cm) in July 2009 at outfall (OF) versus farfield (FF) sites.**
Data normalized to % lipids. NS signifies data not collected.

Orange County Sanitation District, California.



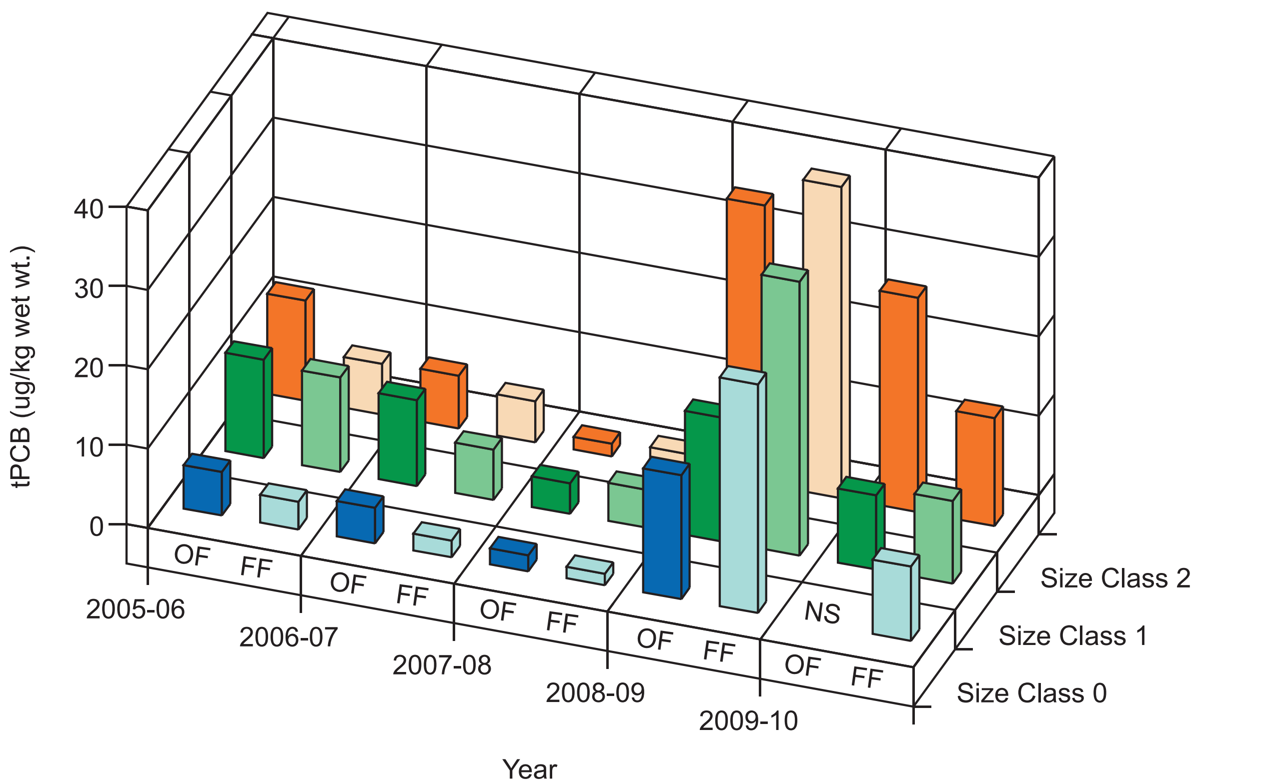


Figure 6-15. **Mean concentrations of total PCB (ug/kg wet weight) in hornyhead turbot (*Pleuronichthys verticalis*) muscle tissue, English sole (*Parophrys vetulus*) muscle tissue, and Pacific sanddab (*Citharichthys sordidus*) whole body tissue for size classes 0 (5–8 cm), 1 (9–13 cm), and 2 (14–16 cm) in July 2009 at outfall (OF) versus farfield (FF) sites.**
Data normalized to % lipids. NS signifies data not collected.

Orange County Sanitation District, California.

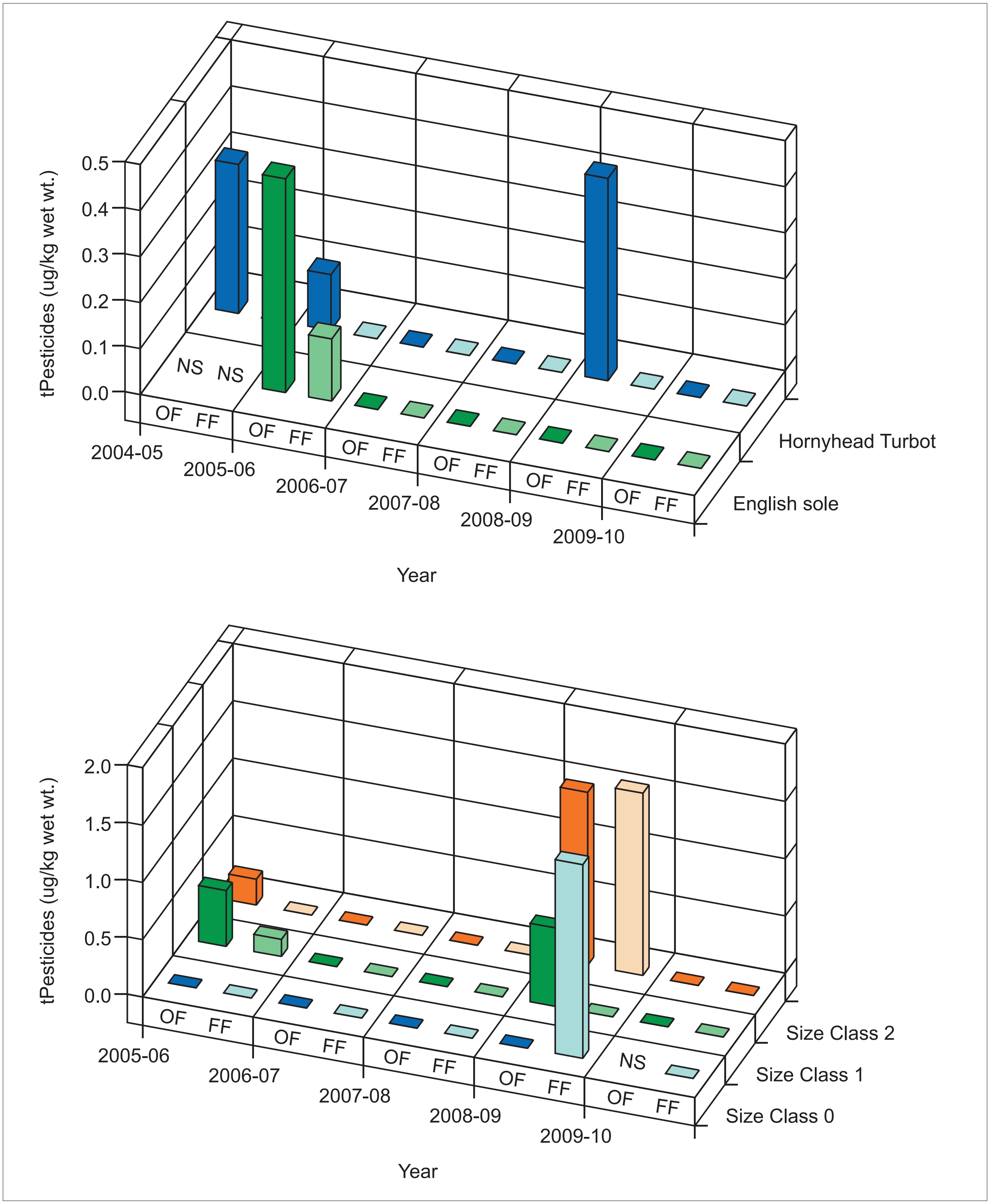


Figure 6-16. **Mean concentrations of total chlorinated pesticides (ug/kg wet weight) in hornyhead turbot (*Pleuronichthys verticalis*) muscle tissue, English sole (*Parophrys vetulus*) muscle tissue, and Pacific sanddab (*Citharichthys sordidus*) whole body tissue for size classes 0 (5–8 cm), 1 (9–13 cm), and 2 (14–16 cm) in July 2009 at outfall (OF) versus farfield (FF) sites.**
Data normalized to % lipids. NS signifies data not collected.

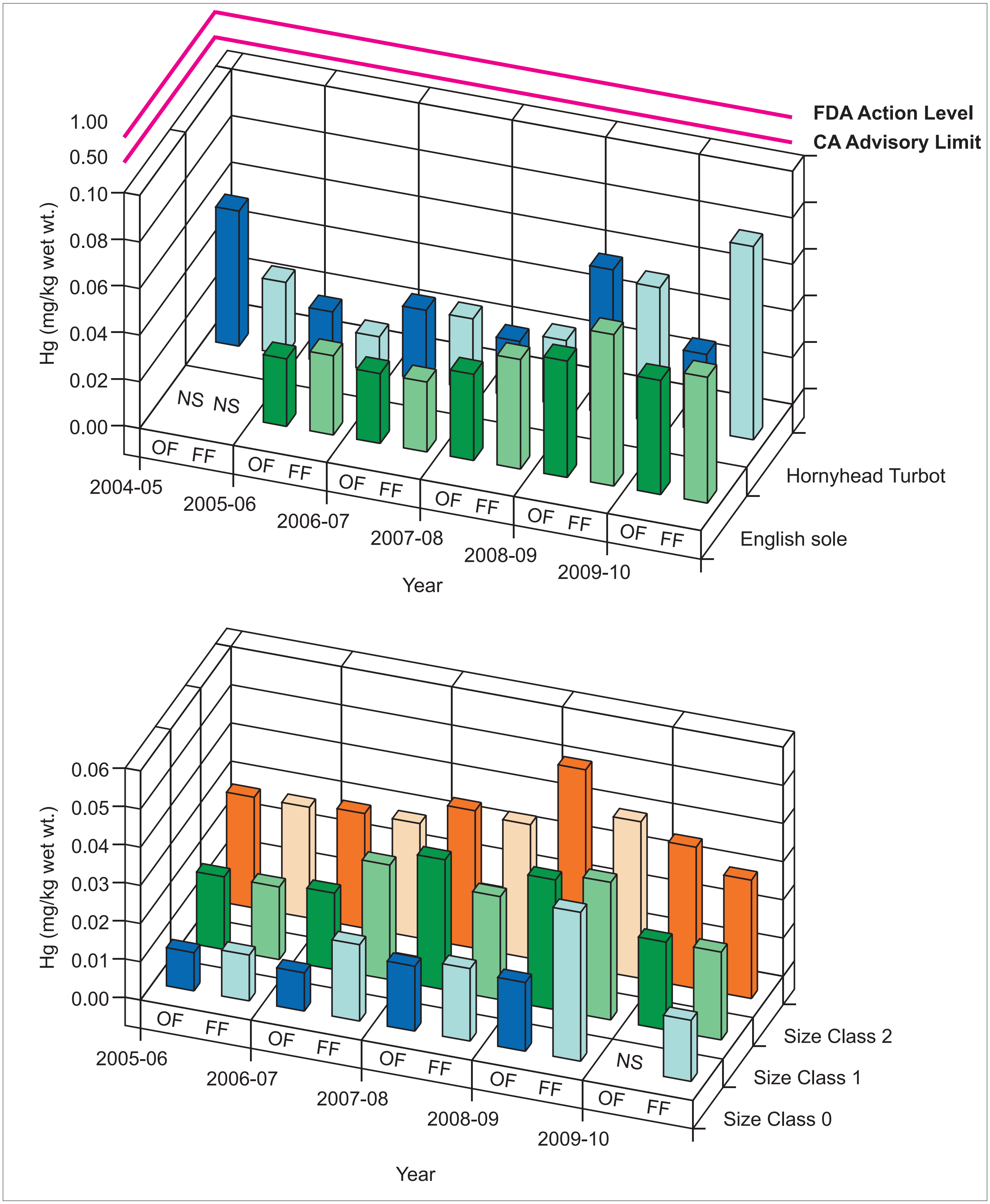


Figure 6-17. **Mean concentrations of mercury (mg/kg wet weight) in hornyhead turbot (*Pleuronichthys verticalis*) muscle tissue, English sole (*Parophrys vetulus*) muscle tissue, and Pacific sanddab (*Citharichthys sordidus*) whole body tissue for size classes 0 (5-8 cm), 1 (9-13 cm), and 2 (14-16 cm) in July 2009 at outfall (OF) versus farfield (FF) sites.**
Data normalized to % lipids. NS signifies data not collected.

chlorinated pesticides do not occur in high concentrations in fish in the monitoring area.

Mercury

Mercury tissue concentrations were comparable to previous years. Overall mercury contamination has been fairly consistent since 2004-05 and do not show the depressed values from 2006–08 seen in DDT, PCB, and the other chlorinated pesticides (Figure 6-17). Mercury concentrations in fish from outfall and farfield sites are generally comparable. The largest difference occurred in 2009-10 when the hornyhead turbot farfield fish had a mean concentration (0.083 mg/kg); almost three times that of outfall fish (0.033 mg/kg; Table 6-5).

<u>Health Advisory Assessments</u>

Mercury concentrations in hornyhead turbot and English sole muscle tissue samples were well below the Federal Food and Drug Administration (FDA) Action Level of 1.0 mg/kg and the California State Department of Health Services (CDHS) advisory limit of 0.5 mg/kg. All concentrations of tDDT and tPCB in muscle tissue samples were below the FDA Action Levels of 5,000 and 2,000 µg/kg, respectively. Two English sole exceeded the 100 µg/kg advisory limit in 2009-10: One at the outfall station with 800 µg/kg and one at a farfield station with117 µg/kg (Figure 6-17).

The State of California Office of Environmental Health Hazard Assessment (OEHHA) has published safe eating guidelines on several sport fish species from Ventura to San Mateo Point in south Orange County (OEHHA 2009). Mercury is the most common contaminant in southern California sport fish. Mercury has several sources into the environment including aerial deposition from coal-burning power plants and point sources, including wastewater discharge. DDT was also very common in fish tissues, but in relatively low concentrations except in white croaker on the Palos Verdes Shelf near Los Angeles. PCBs are found in higher concentrations than DDT and are considered more of a regional human health concern through fish consumption. DDT and PCBs are legacy contaminants that are still found in sediments from previous, now discontinued, discharges due to their long degradation times. In the region encompassing the District's outfall, Seal Beach Pier to San Mateo Point, 19 fish species have consumption advisories. However, no advisories exist based specifically on the District's wastewater discharge.

No human consumption advisory levels exist for whole-fish tissue, so human health risk could not be assessed for Pacific sanddab.

<u>Regional Comparisons</u>

The sanddab guild was used for tissue contaminant assessment in the Bight'98 survey and subsequently by the District for making a Bight-wide comparison of the District's Pacific sanddab whole-fish tDDT, tPCB, and mercury data.

In the Bight'98 regional study, 99% of all SCB mainland shelf stations tested had detectable levels of tDDT, including 100% of both LPOTW and non-POTW stations. Total DDT concentrations ranged from ND to 10,462 µg/kg at LPOTW sites and 4.2 µg/kg to 1,061 µg/kg at non-POTW locations (Allen *et al.* 2002). In 2009-10, tDDT was detected in all Pacific sanddab composites tested with concentrations ranging from10.8 (farfield size class 0) µg/kg to 221µg/kg (outfall size class 2). In the present survey, all Pacific sanddab composites tested fell within the range of mainland shelf non-POTW tissue concentrations.

In the Bight'98 study, 46% of the sanddab guild samples from the mainland shelf stations had detectable tissue concentrations of tPCB (range = ND–710 μg/kg), while 72% of the large POTW stations and 40% of the non-POTW stations had detectable tissue concentrations of tPCB (range = ND–710 μg/kg and ND–105 μg/kg, respectively) (Allen *et al.* 2002). In the present survey, all Pacific sanddab composite samples were below 45 ug/kg, well within the range of mainland shelf non-POTW tissue concentrations.

<u>The Outfall as an Epicenter for Fish Tissue Contamination</u>

The mercury, tDDT, and tPCB values for all fish composites and the station means of composite samples (Table 6-5) are within the ranges of non-POTW strata within the SCB and do not show patterns of measured concentrations near the outfall. Consequently, the outfall does not seem to be causing degradation due to the bioaccumulation of contaminants in fish.

Parasites and Abnormalities

<u>External Parasites and Abnormalities</u>

External parasites and abnormalities, such as skeletal deformities, tumors, lesions, and abnormal coloring occurred in less than 1% of the fish collected. The most common occurrence was the presence of the parasitic eye copepod *Phrixocephalus cincinnatus*, which occurred in 1.6% (66 occurrences) of Pacific sanddabs. This parasite was found at nearly all of the 60 m and 137 m stations in both surveys, the exceptions being T12, T13, and T3 in summer. No outfall trend was evident. Only 9 of the 66 *P. cincinnatus* were found at T1 and the 1.6% incidence rate is within the range found regionally in the SCB (Perkins and Gartman 1997; Allen *et al.* 1998, 2002). *P. cincinnatus* is found throughout the SCB, most often occurring on Pacific sanddabs. Perkins and Gartman (1997) found that *P. cincinnatus* occurred in 1.4% of the Pacific sanddabs collected near SCB wastewater outfalls, while the SCB regional monitoring surveys found occurrences of 1.1% in 1994 and 3.5% in 1998 (Allen *et al*. 1998, 2002).

In addition to the parasitic eye copepod, 8 other abnormalities were found in 2009-10. Three Dover sole collected at the deep stations were infected with tumors. Ambicolorism occurred in 3 fish: 2 California tonguefish and 1 hornyhead turbot. Two unidentified parasites were found on 2 bigmouth sole.

CONCLUSIONS

In summary, there was no indication that the wastewater discharge caused adverse effects on fish and epibenthic macroinvertebrates residing near the outfall. Community measures of the fish and EMI populations remained within historical ranges and concentrations of contaminants in fish were comparable to regional non-POTW values and below both state and federal human health advisory levels. These results support the conclusion that the outfall area was not degraded by the wastewater discharge, that the outfall was not an epicenter of disease, and that the species assemblages present near the outfall were representative of those found elsewhere on the southern San Pedro shelf.

Comparisons between outfall and reference sites are complicated by evidence suggesting that there are no areas of the SCB sufficiently free of contamination to be considered a reference site (Brown et al. 1986). For example, Schiff and Allen (1997) concluded that 100% of certain flatfish species in the SCB are contaminated with DDT and PCB. Similarly, Mearns *et al.* (1991) found that there are no regional patterns in fish tissue mercury concentrations within the SCB.

Comparison between sites is further complicated by the transitory nature of fishes. In making these comparisons we assume that the location of capture is also the location of exposure. Generally, concentrations of contaminants in fish tissues are highest in fish residing near the source of the contaminant (Mearns *et al.* 1991). However, demersal fish with large ranges may transport contaminants away from the source or be captured away from the primary location of exposure (Allen 2006b). Little is known about the migratory patterns of the fish species used in the District's ocean monitoring program. Immigration of fish into the monitoring area may account for the occasional high tissue concentrations of some contaminants (e.g., DDT and PCB).

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