chapter 6

TRAWL COMMUNITIES AND ORGANISM HEALTH

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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) communities to assess affects of the wastewater discharge on the epibenthic community 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). Moreover, several 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.

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.

The wastewater outfall has 2 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.

Discharge effects are changes related to the release of treated effluent. The effluent contains low concentrations of contaminants and organic particles. Contaminants adhere

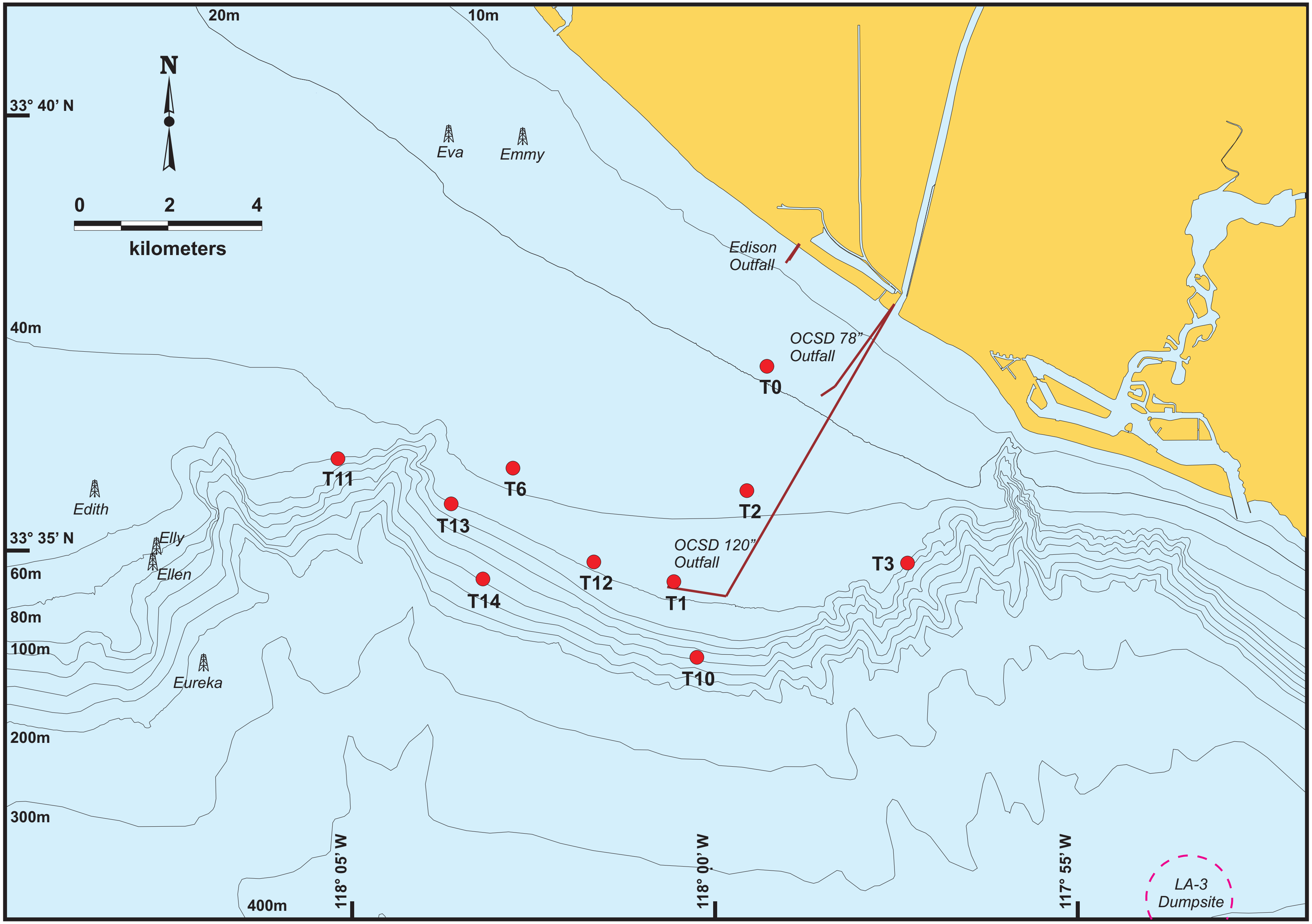

Figure 6-1. **Otter trawl stations for semi-annual surveys, 2008-09.**

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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). Thus, 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 trends and spatial patterns relative to the ocean outfall; and 3) are the marine organisms in the monitoring area generally healthy, as defined in the permit? Spatial patterns in tissue contaminant data are evaluated to determine whether organisms collected near the outfall, or at other specified locations, contain elevated concentrations compared to a farfield site or other regional "background" locations within the Southern California Bight (SCB).

METHODS

Field Methods

Demersal fish and epibenthic macroinvertebrates (EMI) species were collected in July 2008 and January 2009 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 2.0 knots along a pre-determined course. Sampling was conducted at 9 permit stations: inner shelf (36 m) Stations T2 and T6; middle shelf (55 m) Stations T1, T3, T11, T12, and T13; and outer shelf (136 m) Stations T10 and T14 (Figure 6-1). One replicate haul was conducted at the inner and outer shelf stations in summer, whereas 2 replicate hauls were conducted at these stations in winter. Three replicate hauls were conducted at the middle shelf stations during both surveys. Additionally, 1 haul was collected at T0 (18 m) in each survey 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). Fish species with abundances of up to 30 individuals were measured individually to the nearest millimeter (standard length) and weighed to the nearest gram. Fish species with more than 30 individuals were enumerated in 1 cm size classes and weighed in bulk. All fish specimens were examined for external tumors, other lesions, and parasites since gross external manifestations may indicate contaminated sediments (Murchelano 1982). EMI were also enumerated by species and weighed to the nearest gram. Specimens with abundance greater than 100 individuals were weighed in batches. 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 are collected as composite samples. The sampling objective was to collect 10 individuals of at least three of the four 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 percent abundance, frequency of occurrence, and mean abundance per haul. In addition, mean number of species per trawl, number of individuals per trawl, total abundance, biomass, and diversity indices including Shannon-Wiener (H'), Margalef's Species Richness (SR), Pielou's Evenness (J'), and Swartz's 75% Dominance 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 (Clark 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). 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 (Clark 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), the Bight'98, and Bight'03 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 2008-09. For a historical perspective, FRI was calculated from 1985 to 2008 for outfall Station T1 and upcoast reference Station T11.

In order to evaluate human health risk, the non-lipid normalized muscle tissue concentrations were compared to state and federal human consumption guidelines. Muscle and liver tissue from 2 target fish species were analyzed for concentrations of mercury, pesticides, and PCBs as a function of fish size and tissue lipid content.

Differences among outfall and farfield sites were tested using the T-test. The Pacific sanddab whole-fish analysis cannot be used for human health risk assessment as no whole-fish consumption standards exist so the Pacific sanddab whole fish analysis was for station comparison only. All data, except mercury, were lipid-normalized prior to testing. External parasites and other abnormalities in fish are not prevalent in the District's monitoring area; therefore precluding hypothesis testing. Data analysis consisted of summary statistics and qualitative comparisons only.

RESULTS AND DISCUSSION

Fish Community

Abundance

A total of 22,343 fish were collected in 2008-09 (Tables 6-1 and B-15). Pacific sanddabs and yellowchin sculpins (*Icelinus quadriseriatus*) were the most abundant fish collected, each representing 26% of the total catch. Longspine combfish, pink seaperch and English sole (*Parophrys vetulus*) each comprised 10, 7, and 6% of the total catch, respectively. All other species comprised 4% or less of the total catch. Of the 21 families represented, only 6 families accounted for 95% of the total abundance: Paralichthidae, Cottidae, Pleuronectidae, Hexagrammidae, Embotiotocidae, and Scorpaenidae (Table 6-2).

Variability in the abundance data was due primarily to population fluctuations of a few common species. For example, abundances of Pacific sanddabs ranged from 1 to 652 per haul, while yellowchin sculpin abundances ranged from 0 to 375 per haul. On average, there were more individuals collected in winter from the 55 m stations than in summer, while the opposite was true for the shallow and deep stations (Figure 6-2 and Table B-15). The largest catch per haul occurred in summer at deep Station T10 where the greatest numbers of Pacific sanddabs were collected.

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 have the highest. Fluctuations in abundance reflect population changes of several dominant species, especially Pacific sanddab, yellowchin sculpin, longspine combfish, and English sole (see Figure 6-4 in OCSD 2009).

Biomass

A total of 845 kg of fish was collected in 2008-09, with 2 families (Paralichthyidae and Pleuronectidae) accounting for 71% of the fish biomass. As with abundance, biomass data were highly variable (ranging from 5 to 82 kg per haul) due to population fluctuations of dominant species and variability in the size of individuals collected. Mean biomass per survey was greater in winter than summer due to the very high values at deep Stations T10 and T14 (Figure 6-2 and Table B-16). Large catches of vermillion (*Sebastes miniatus*) and halfbanded (*Sebastes semicinctus*) rockfish, along with Pacific sanddabs, accounted for the high biomass at these deep stations in summer. The annual mean biomass at outfall Station T1 was at least double the biomass of any other 55m station in both seasons, primarily due to an abundant catch of large Pacific sanddabs. Increased fish biomass in the outfall area is an outfall discharge effect. Invertebrates feed upon the increased

Table 6-1. Summary of demersal fish species collected during the summer (July 2008) and winter (January 2009) 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).

n = 42 hauls

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Common name	Scientific name	Total	%A	%FO	MAH
Pacific sanddab	*Citharichthys sordidus*	5,852	26	100	139
Yellowchin sculpin	*Icelinus quadriseriatus*	5,833	26	78	139
Longspine combfish	*Zaniolepis latipinnis*	2,210	10	100	53
Pink seaperch	*Zalembius rosaceus*	1,536	7	100	37
English sole	*Parophrys vetulus*	1,293	6	89	31
Longfin sanddab	*Citharichthys xanthostigma*	884	4	89	21
Hornyhead turbot	*Pleuronichthys verticalis*	638	3	100	15
Halfbanded rockfish	*Sebastes semicinctus*	567	3	56	14
California tonguefish	*Symphurus atricaudus*	508	2	100	12
Roughback sculpin	*Chitonotus pugetensis*	432	2	89	10
Stripetail rockfish	*Sebastes saxicola*	339	2	44	8
Slender sole	*Lyopsetta exilis*	318	1	22	8
Plainfin midshipman	*Porichthys notatus*	264	1	89	6
Dover sole	*Microstomus pacificus*	233	1	67	6
Shortspine combfish	*Zaniolepis frenata*	230	1	56	5
Speckled sanddab	*Citharichthys stigmaeus*	212	1	33	5
Bigmouth sole	*Hippoglossina stomata*	202	1	89	5
California lizardfish	*Synodus lucioceps*	165	1	89	4
Blackbelly eelpout	*Lycodes pacificus*	113	1	33	3
California scorpionfish	*Scorpaena guttata*	97	<1	44	2
Pygmy poacher	*Odontopyxis trispinosa*	78	<1	67	2
Calico rockfish	*Sebastes dallii*	75	<1	56	2
Fantail sole	*Xystreurys liolepis*	58	<1	78	1
Vermillion rockfish	*Sebastes miniatus*	44	<1	33	1
White croaker	*Genyonemus lineatus*	26	<1	56	1
Gulf sanddab	*Citharichthys fragilis*	22	<1	33	1
California skate	*Raja inornata*	17	<1	67	0
Southern spearnose poacher	*Agonopsis sterletus*	16	<1	33	0
Bocaccio	*Sebastes paucispinis*	14	<1	11	0
Specklefin midshipman	*Porichthys myriaster*	13	<1	33	0
Greenstriped rockfish	*Sebastes elongatus*	7	<1	22	0
Greenblotched rockfish	*Sebastes rosenblatti*	7	<1	22	0
Shiner perch	*Cymatogaster aggregata*	6	<1	33	0
Pacific hake	*Merluccius productus*	5	<1	22	0

Table 6-1 continues.

Table 6-1 Continued.

Common name	Scientific name	Total	%A	%FO	MAH
California halibut	*Paralichthys californicus*	5	<1	33	0
Flag rockfish	*Sebastes rubrivinctus*	5	<1	33	0
Spotted cuskeel	*Chilara taylori*	3	<1	22	0
Lingcod	*Ophiodon elongatus*	2	<1	22	0
Bluebanded ronquil	*Rathbunella hypoplecta*	2	<1	11	0
Chub mackerel	*Scomber japonicus*	2	<1	11	0
Sablefish	*Anoplopoma fimbria*	1	<1	11	0
Petrale sole	*Eopsetta jordani*	1	<1	11	0
Rex sole	*Glyptocephalus zachirus*	1	<1	11	0
Spotfin sculpin	*Icelinus tenuis*	1	<1	11	0
Barred sand bass	*Paralabrax nebulifer*	1	<1	11	0
Pacific pompano	*Peprilus simillimus*	1	<1	11	0
Spotted cuskeel	*Chilara taylori*	3	<1	22	0
Stripedfin ronquil	*Rathbunella alleni*	1	<1	11	0
Blackeye goby	*Rhinogobiops nicholsii*	1	<1	11	0
Brown rockfish	*Sebastes auriculatus*	1	<1	11	0
Pink rockfish	*Sebastes eos*	1	<1	11	0
	Total	**22,343**	**100**		
	Total no. of species	**50**			

Table 6-2. Summary of demersal fish species and abundance by family for the summer (July 2008) and winter (January 2009) surveys.
Data for each family are ranked by number of species and abundance for all stations and surveys combined.

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Family	Number of Species		Family Abundance	
	Total	Percentage	Total	Percentage
Paralichthyidae (Sand flounders)	7	14.00	7,235	32.38
Cottidae (Sculpins)	3	6.00	6,266	28.04
Pleuronectidae (Righteye flounders)	6	12.00	2,484	11.12
Hexagrammidae (Greenlings)	3	6.00	2,442	10.93
Embiotocidae (Surfperches)	2	4.00	1,542	6.90
Scorpaenidae (Scorpionfishes)	11	22.00	1,157	5.18
Soleidae (Soles)	1	2.00	508	2.27
Batrachoididae (Toadfishes)	2	4.00	277	1.24
Synodontidae (Lizardfish)	1	2.00	165	0.74
Zoarcidae (Eelpouts)	1	2.00	113	0.51
Agonidae (Poachers)	2	4.00	94	0.42
Sciaenidae (Drums)	1	2.00	26	0.12
Rajidae (Skates)	1	2.00	17	0.08
Gadidae (Cods)	1	2.00	5	0.02
Bathymasteridae (ronquils)	2	4.00	3	0.01
Ophidiidae (Cusk-eels)	1	2.00	3	0.01
Scombridae (Mackerels)	1	2.00	2	0.01
Anoplopomatidae (Sablefish)	1	2.00	1	0.00
Gobiidae (Gobies)	1	2.00	1	0.00
Serranidae (Sea Basses)	1	2.00	1	0.00
Stromateidae (Butterfish)	1	2.00	1	0.00
Total	50	100.00	22,343	100.00

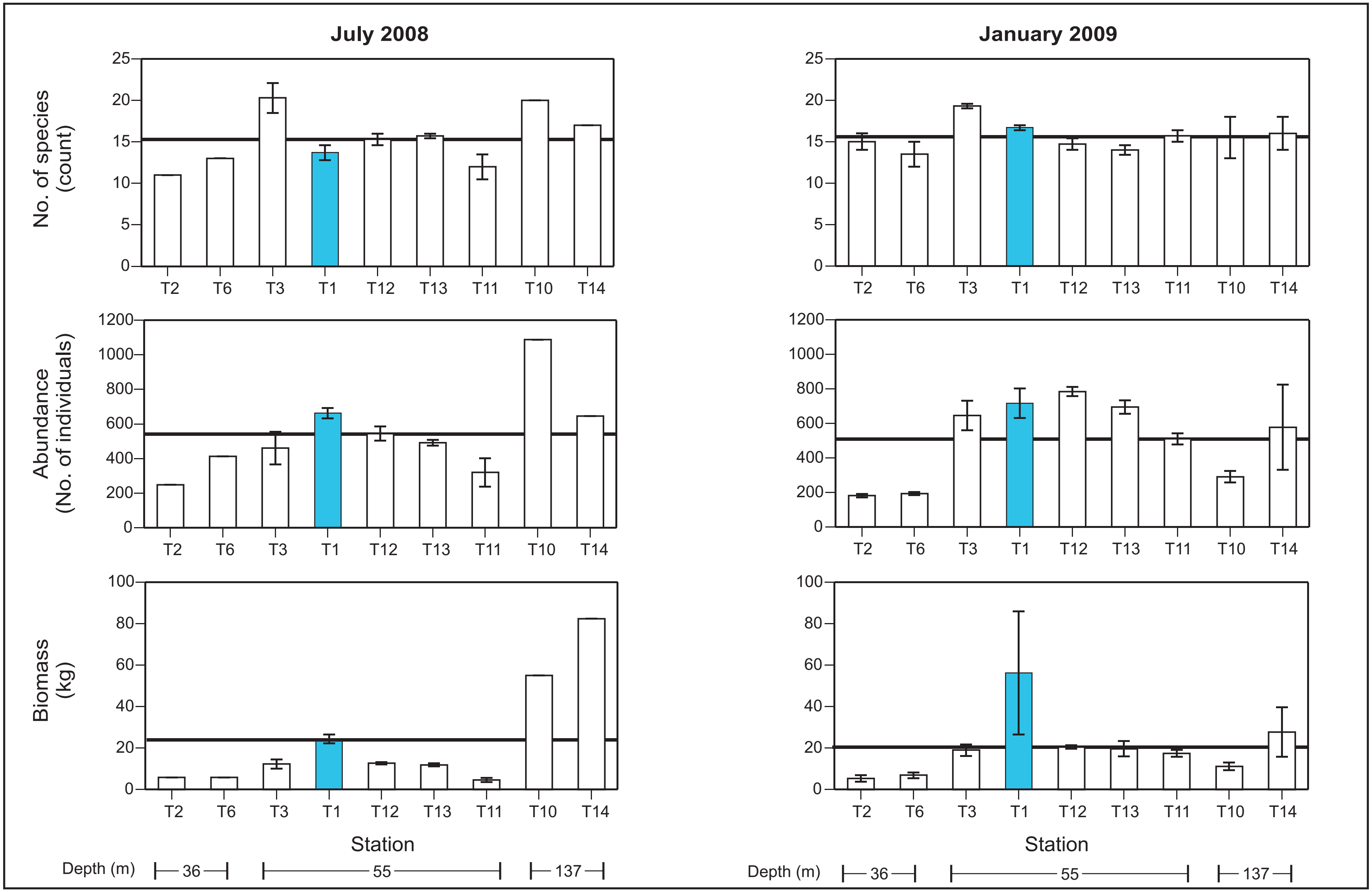

Figure 6-2. **Mean and 95% confidence interval for number of species, number of individuals (abundance), and biomass of demersal fish collected during the summer (July 2008) and winter (January 2009) surveys. Only one sample was collected at stations T2, T6, T10, and T14 during the summer of 2008 (see methods).**
Outfall Station T1 indicated in blue. Survey mean indicated by heavy line.

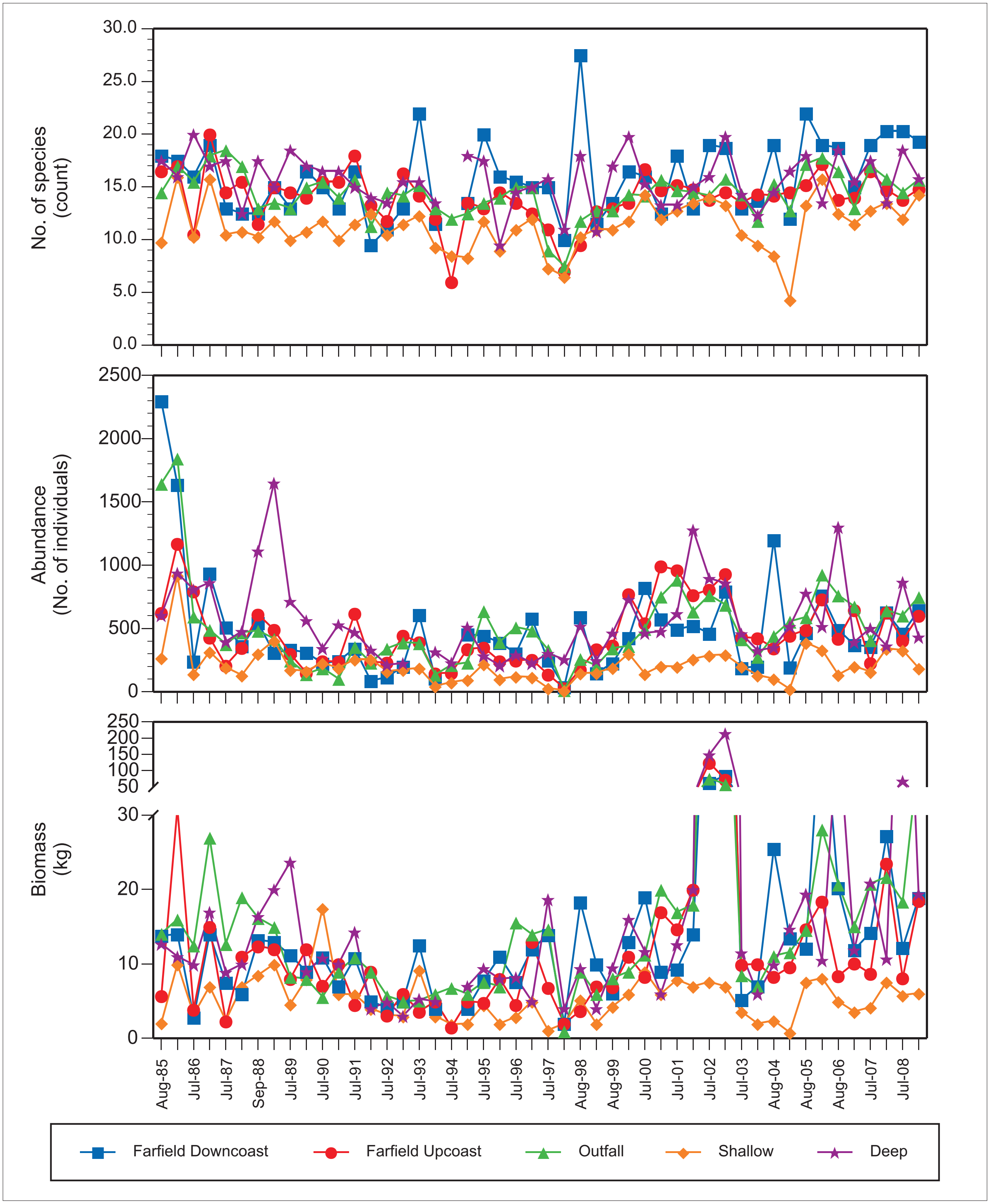

Figure 6-3. **Comparison of demersal fish parameters by station groups: farfield downcoast (T3), farfield upcoast (T11 and T13), outfall (T1 and T12), shallow (T2 and T6), and deep (T10 and T14). All data for mean number of species, abundance, and biomass by station group are for the period 1985–2009.**

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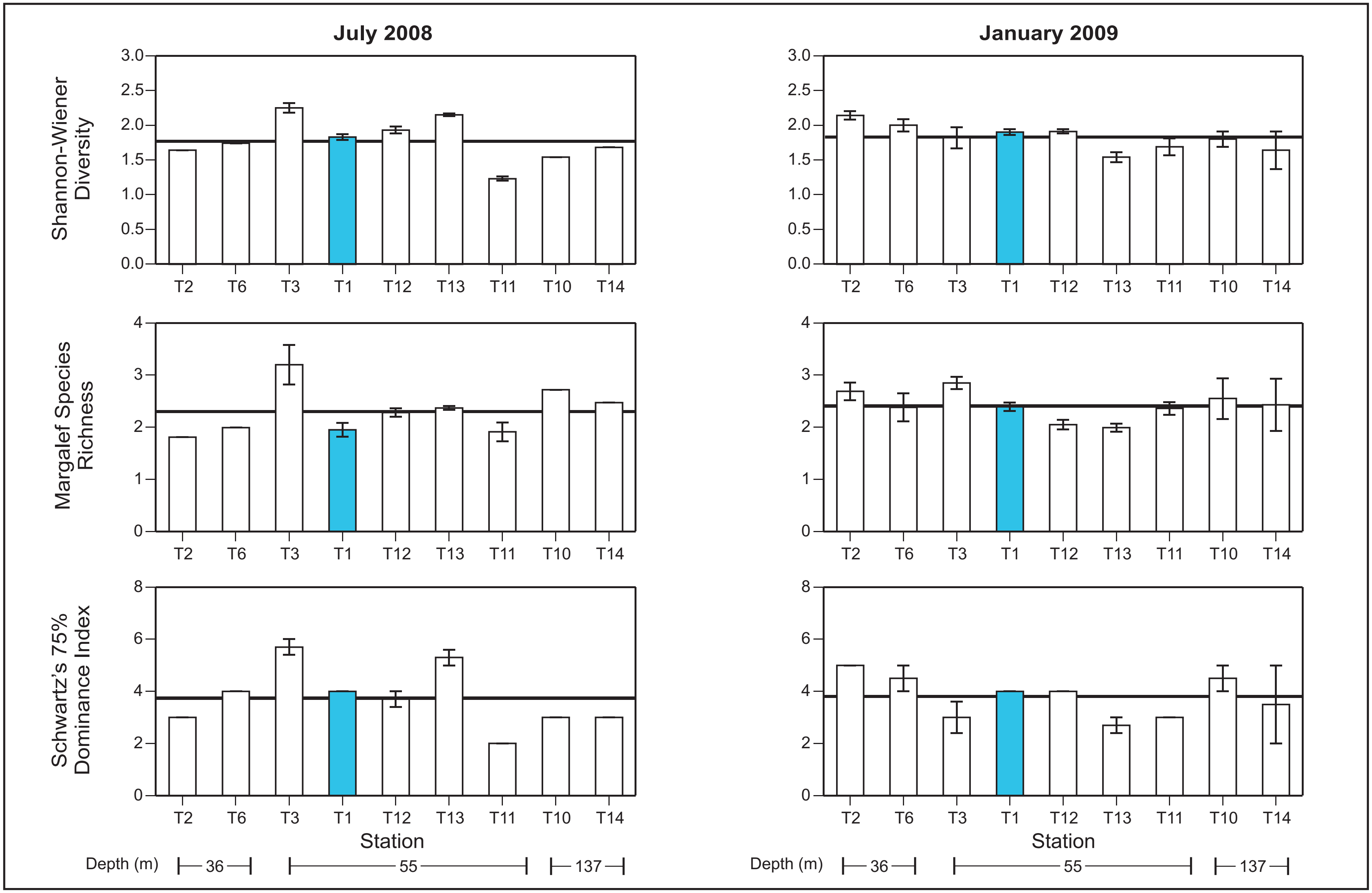

Figure 6-4. **Mean and 95% confidence interval for diversity indices — Shannon-Wiener Diversity Index (H'), Margalef Species Richness (SR), and Schwartz's 75% Dominance Index of demersal fish collected during the summer (July 2008) and winter (January 2009) surveys. Only one sample was collected at stations T2, T6, T10, and T14 during the summer of 2008 (see methods).** Outfall Station T1 indicated in blue. Survey mean indicated by heavy line.

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 21 families were collected in the District's study area in 2008-09 (Tables 6-1, 6-2, and B-15). Thirteen of the species were widely distributed and occurred at >75% of the stations. The 5 most frequently occurring species were the Pacific sanddab, longspine combfish (*Zaniolepis latipinnis*), pink seaperch (*Zalembius rosaceus*), hornyhead turbot, and California tonguefish (*Symphurus atricaudus*), each of which occurred at 100% of the stations. Four families, Scorpaenidae, Paralichthyidae, Pleuronectidae, and Cottidae comprised 54% of the species collected (Table 6-2). Nine families were represented by more than 1 species (Table B-15).

During 2008-09, the mean number of species per station ranged from 11 to 20 (Figure 6-2 and Table B-16). Differences between seasons were minimal, with fewer species collected in winter than summer for most stations. The 2 shallow stations (T2 and T6) had the lowest number of species and 55 m Station T3 had the highest. Annual mean number of species by station group has been variable since 1985 and depth-dependent (Figure 6-3). Overall, the fewest number of species occur at the shallow station group, while the greatest number of species occur at the deep station group and farfield downcoast Station T3.

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 relatively high in comparison to the other 55 m stations, with H' values of 1.83 in summer and 1.90 in winter (Figure 6-4 and Table B-16). Overall, H' values ranged from 1.23 to 2.25 in summer and 1.54 to 2.14 in winter and were high relative to central Bight, middle shelf area, which had a mean H' of 1.69 (Allen *et al.* 2007).

Ordination and Classification

Ordination and classification analyses of 2008-09 trawl fish data resulted in 3 depth-related cluster groups: outer (136 m), middle (55 m), and inner shelf (36 m) (Figure 6-5). Cluster groups were not affected by seasonality. The composition of each station group and the species characteristic of each assemblage are described in Table 6-3 and the mean abundance per haul for the dominant species of each cluster group are shown in Figure 6-6.

The inner shelf station cluster comprised stations T2 and T6 and had the fewest individuals per haul, with an average of 21 species and 234 individuals. This cluster group was characterized by yellowchin sculpin, speckled sanddab, and longfin sanddab, which had average mean abundances of 91, 35, and 31 respectively.

The middle shelf station group consisted of Stations T1, T3, T11, T12, and T13. It comprised the largest number of trawls and had the highest mean abundance (582 individuals) and mean species richness (38 species). It was characterized by yellowchin sculpin, Pacific sanddab, and longspine combfish, which have mean abundances of 176, 139, and 66, respectively (Figure 6-6). This middle shelf group also had dominant species

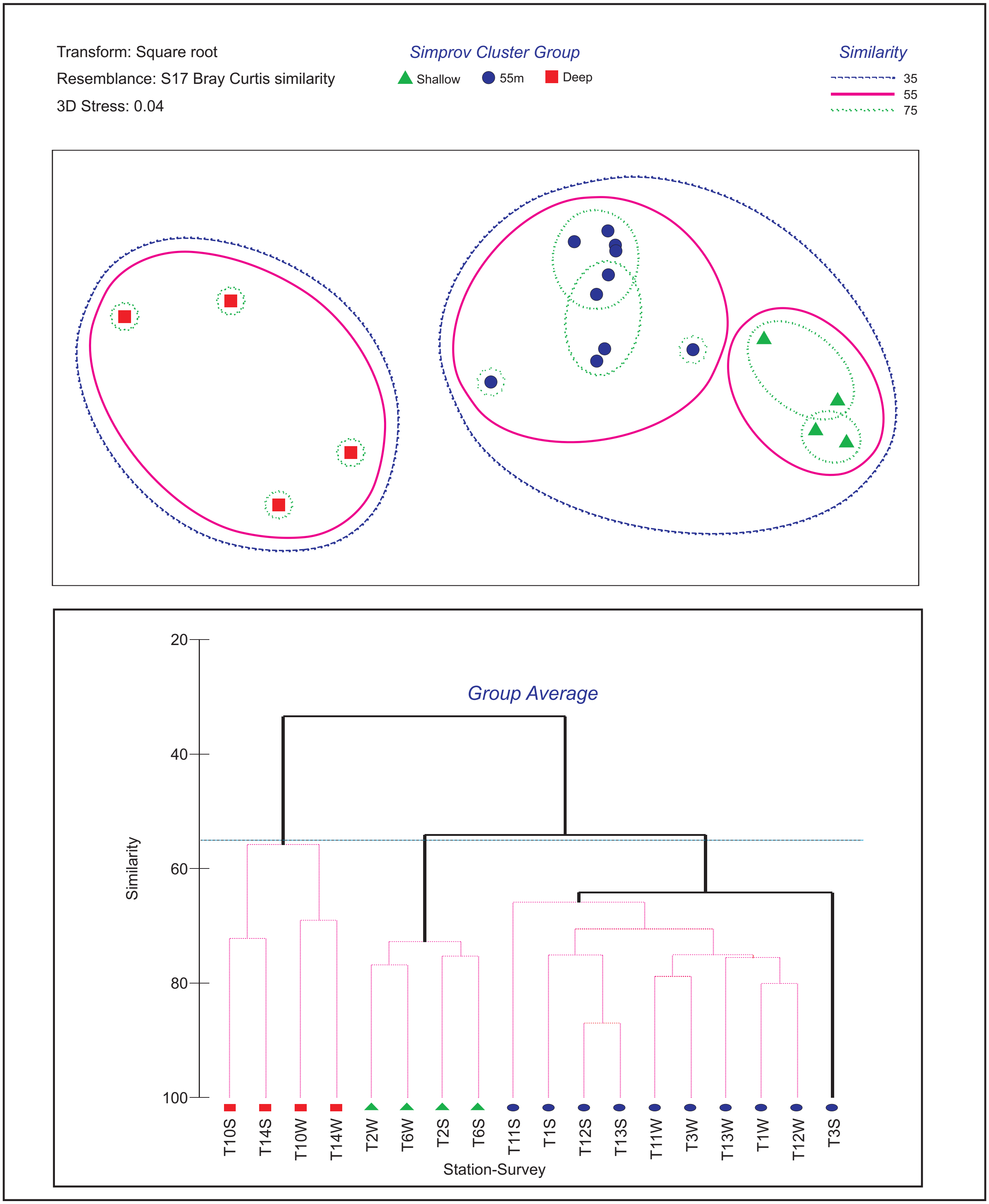

Figure 6-5. Results of classification analysis of demersal fish assemblages collected during the summer (July 2008) and winter (January 2009) trawl surveys. Data are presented as a non-metric multi-dimensional scaling (MDS) ordination plot and a dendrogram of major station clusters: inner (36 m), middle (55 m) and outer (137 m) shelf. Stations-surveys are denoted by S for summer and W for winter.

Table 6-3. Description of Inner, Middle, and Outer Shelf cluster groups 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. Underlined values indicate species that were considered "characteristic" of that group according to SIMPER analyses (i.e., similarity/standard deviation >2.0).

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	Inner Shelf	Middle Shelf	Outer Shelf
Number of Hauls	6	30	6
Species Richness	21	38	33
Mean Total Abundance	234	582	577
Species		**Mean Abundance**	
Pacific sanddab	15	<u>139</u>	<u>270</u>
Yellowchin sculpin	<u>91</u>	<u>176</u>	---
Longspine combfish	<u>12</u>	<u>66</u>	25
Pink seaperch	<u>15</u>	<u>47</u>	<u>9</u>
English sole	3	<u>40</u>	<u>17</u>
Longfin sanddab	<u>31</u>	<u>23</u>	1
Halfbanded rockfish		1	<u>133</u>
Roughback sculpin	<u>15</u>	11	1
Stripetail rockfish	2	7	<u>22</u>
Slender sole	---	---	53
Plainfin midshipman	2	6	17
Shortspine combfish	---	3	<u>22</u>
Speckled sanddab	<u>35</u>	< 1	---

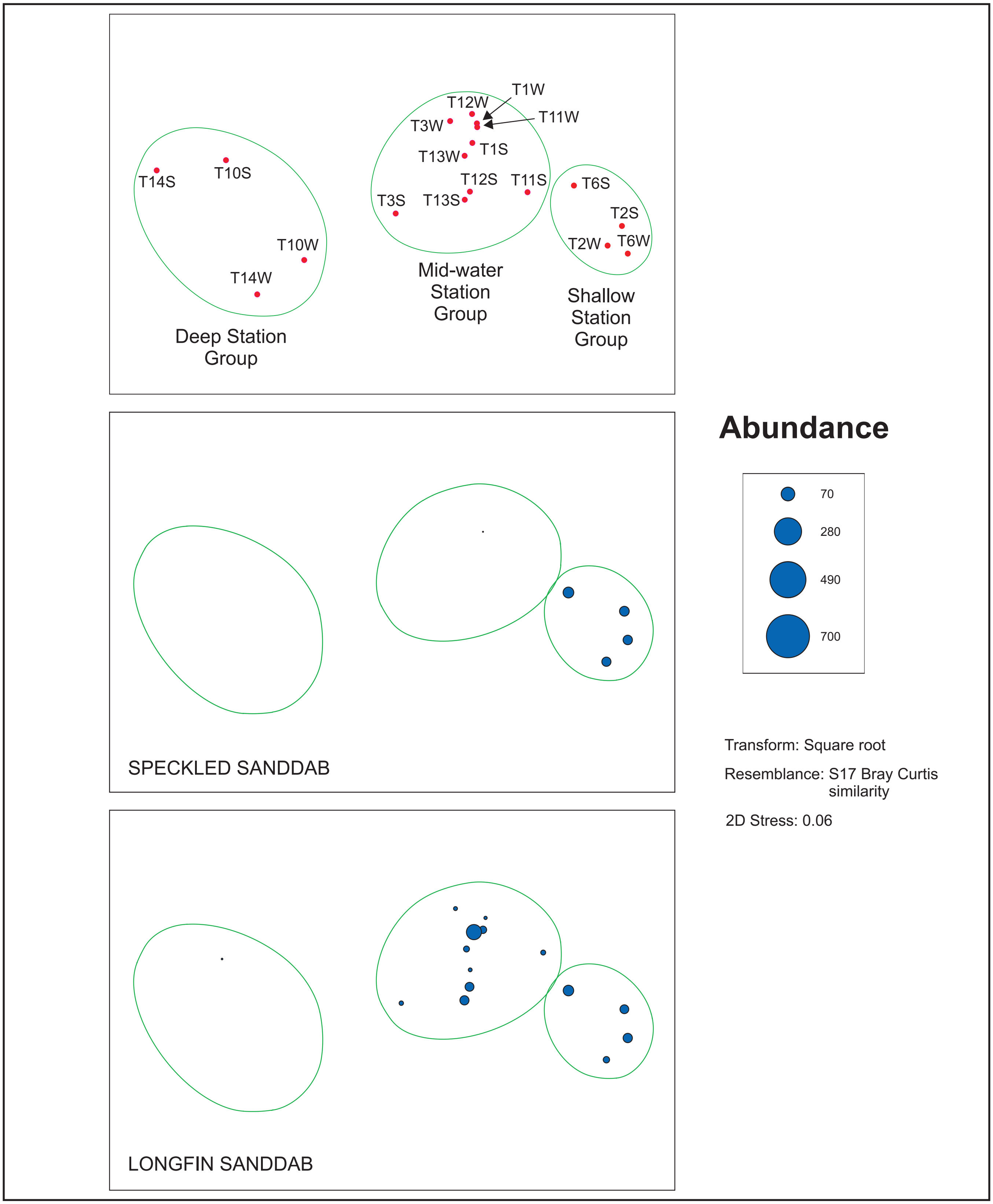

Figure 6-6. **Two-dimensional MDS plots of square-root transformed species abundance data at 9 stations sampled in summer (July 2008) and winter (January 2009). Mean abundances per trawl for the dominant species in each cluster group are super-imposed as bubbles, where increased size represents greater abundance.**

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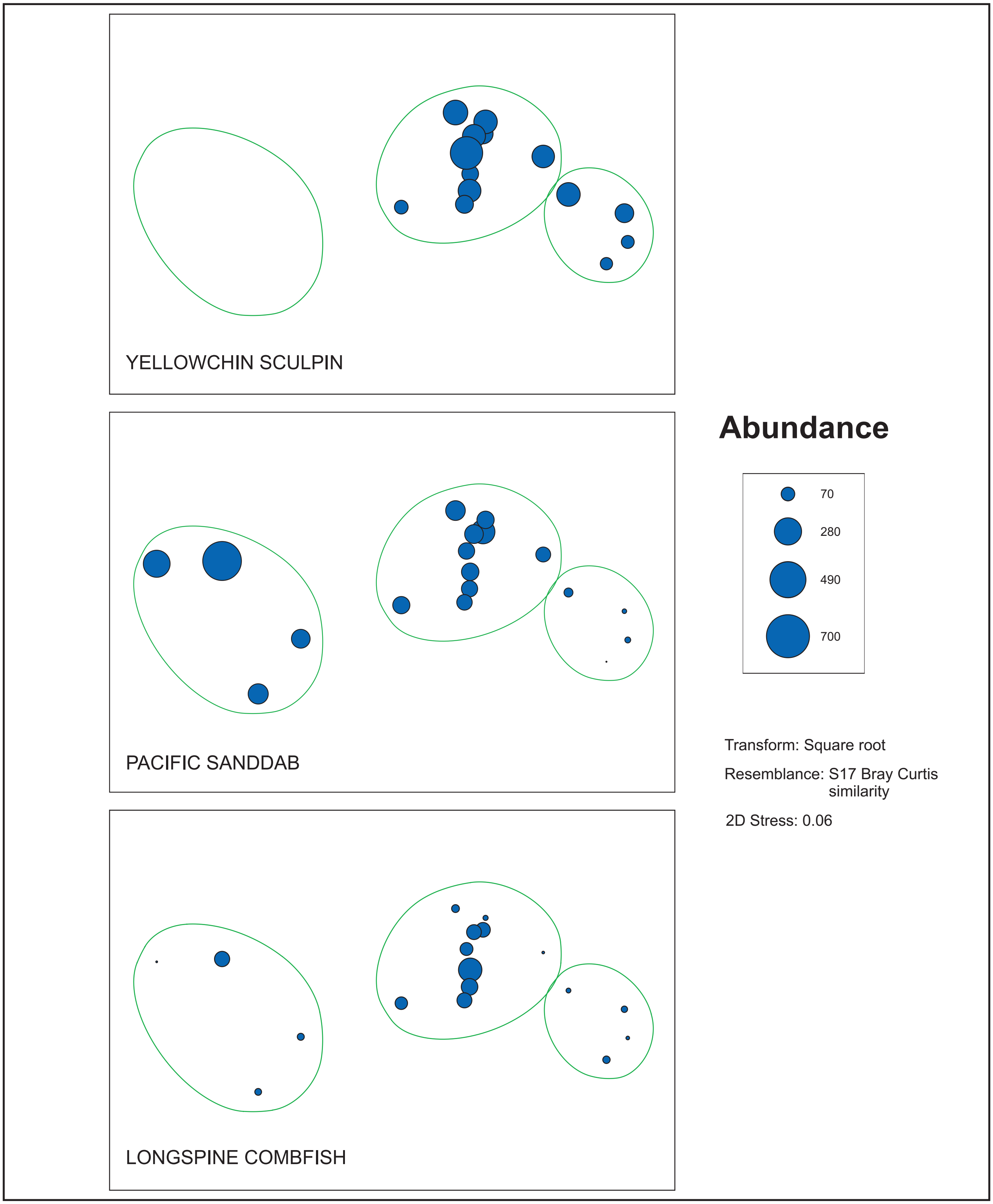

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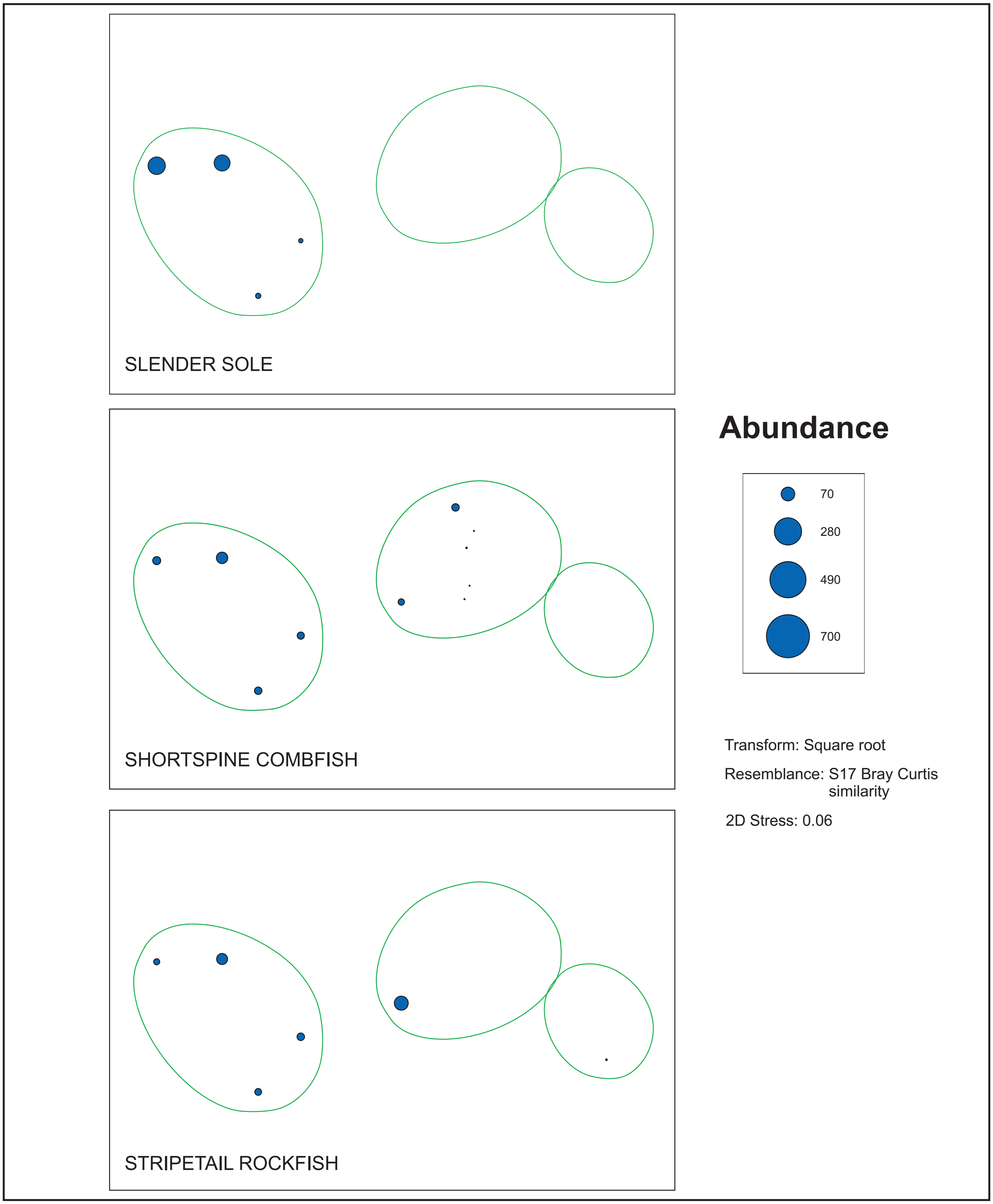

Figure 6-6 continued.

common to inner and outer shelf groups, for example, Pacific sanddabs were dominant in both the middle and outer station groups and yellowchin sculpins were dominant in the middle and inner shelf station groups. Upcoast Station T3 separated from the other middle shelf cluster sites in summer due to a large catch of stripetail rockfish (*Sebastes saxicola*), but the difference was not statistically significant to warrant a separate cluster. The fish assemblage at outfall Station T1 was statistically similar to all other 55 m stations' communities, but most closely resembled that of T12.

The outer shelf station cluster included stations T10 and T14. This assemblage had the second highest number of species (33 species) and mean abundance (577 individuals per haul, Table 6-3). The combination of relatively high numbers of pacific sanddabs and halfbanded rockfish, along with the presence of shortspine combfish and stripetail rockfish, distinguished this group from the others. The top 3 species by total abundance for this group were the Pacific sanddab, slender sole, and shortspine combfish.

Regional Comparisons

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 2006). By 1990, FRI values at Palos Verdes went down to about 25 and remained near this value through 2002. In 2008-09, 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.

Station T1 and T11 data from summer 2008 were compared with data from the SCBPP, Bight'98, and Bight'03 regional monitoring surveys (Figure 6-8). The 3 regional surveys reported no degraded areas, but found enhancement of demersal community measures (e.g., mean fish abundance and biomass) at some locations near wastewater outfalls. The District's summer data at outfall Station T1 and farfield upcoast Station T11 followed trends similar to those described previously for the regional survey (see OCSD 2008). Overall, the fish populations at the District's outfall showed enhanced abundance and biomass, especially in 2007 and 2008. Abundance means at T1 in 2008 were within the abundance ranges for the regional large publicly owned treatment works (LPOTW) stations. Biomass at T1 was at the high end of regional values. Mean biomass was high at T1 in July 2008 due to a number of large individuals of English sole and a large catch of Pacific sanddabs. Such patterns are expected at near-discharge areas. Diversity at T1 has been consistently high and similar to SCB stations, whereas, Station T11 has been more variable and the lowest in 1994 and 2008. Since fish community measures at outfall Station T1 approximately equaled or exceeded values characterizing the SCB at similar depths, the fish community near the discharge appears healthy and prolific.

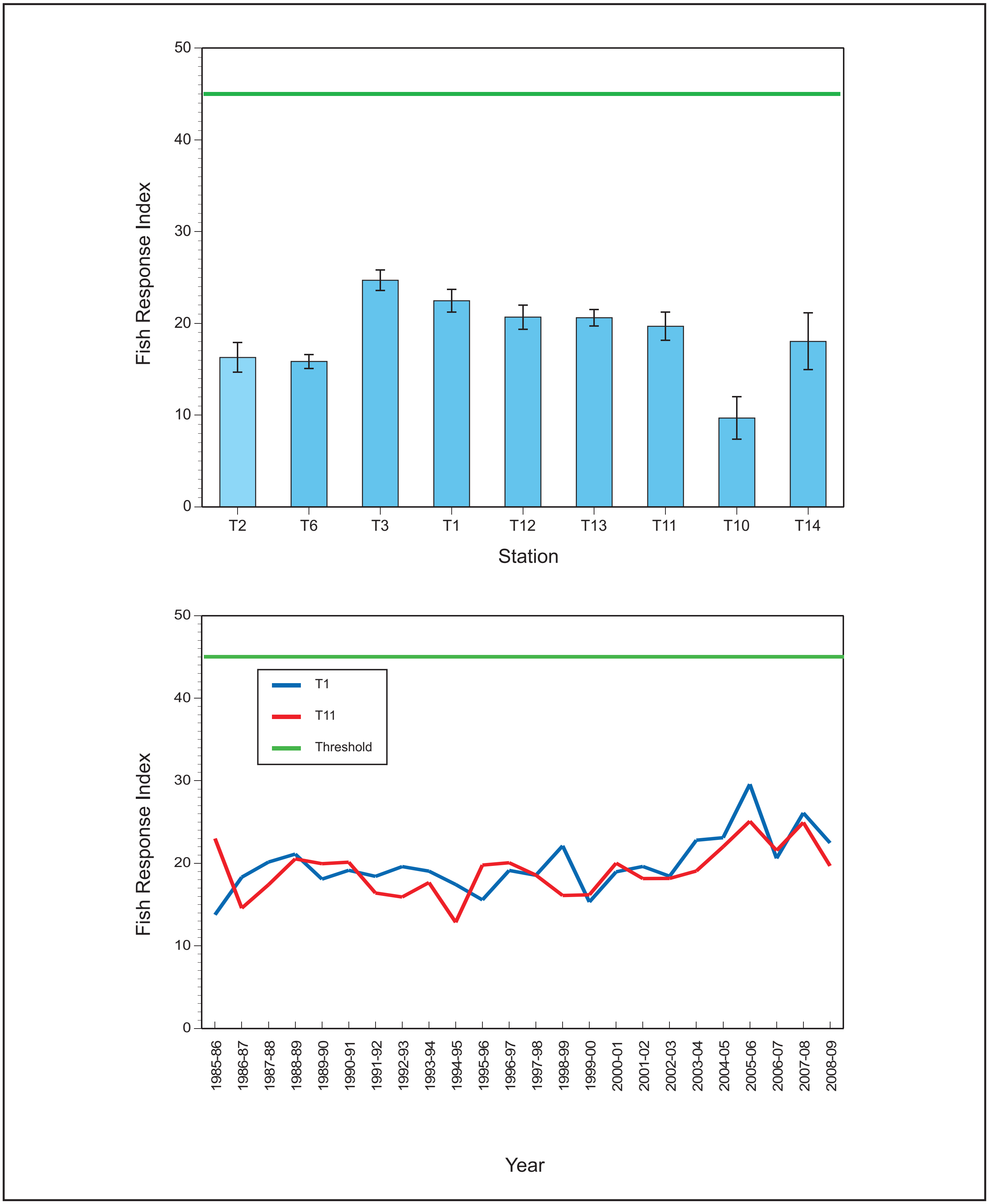

Figure 6-7. **Mean Fish Response Index (FRI) by station in 2008-09 and annual mean FRI for outfall Station T1 and farfield upcoast Station T11.**
Green line represents threshold value.

Orange County Sanitation District, California.

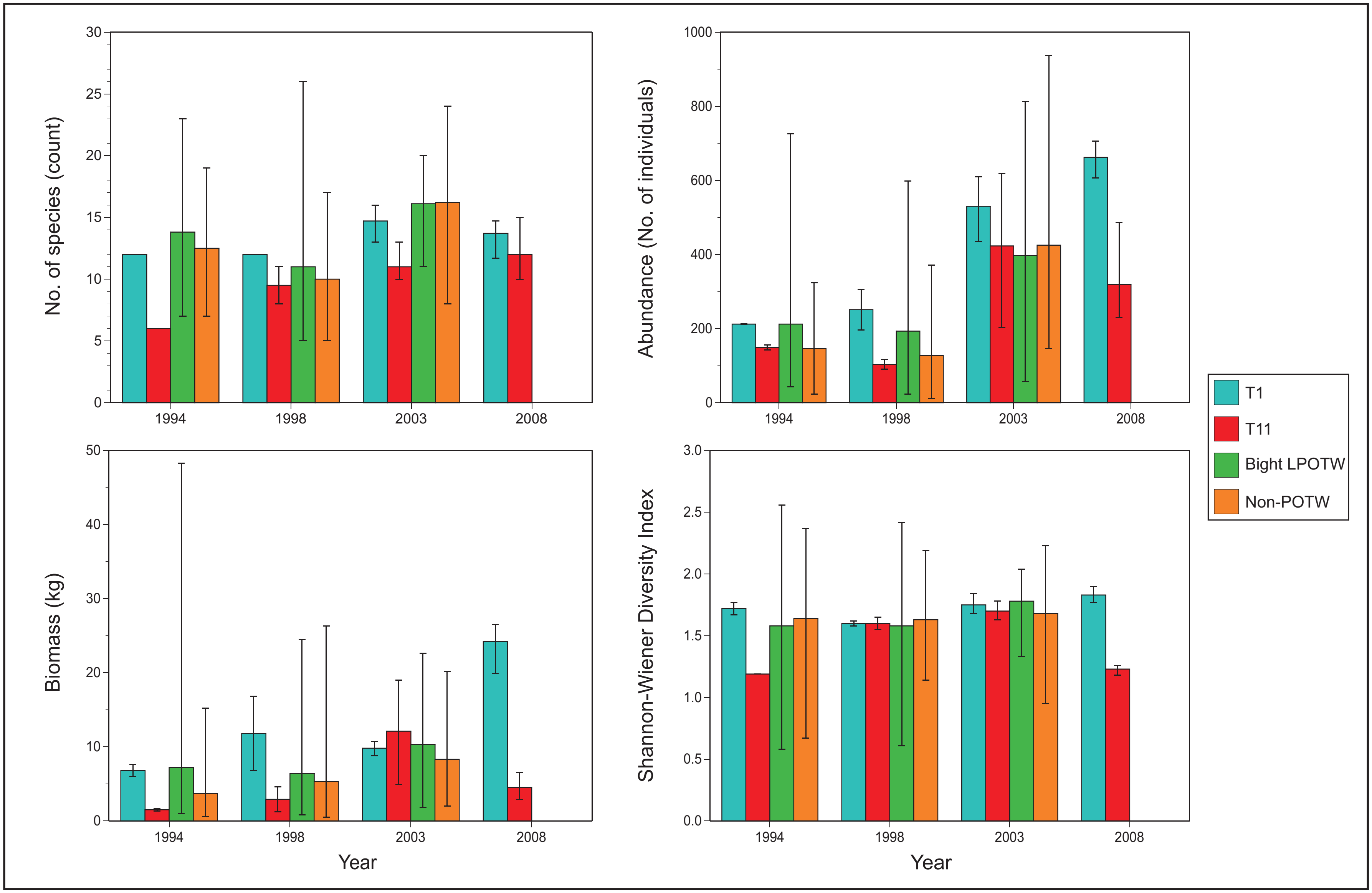

Figure 6-8. **Comparison of demersal fish parameters at OCSD stations T1 and T11 in 1994, 1998, 2003, and 2008 and regional POTW and non-POTW stations from the 1994, 1998, and 2003 regional monitoring surveys. All data for mean number of species, abundance, biomass, and Shannon-Wiener diversity (H') 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: POTW = 16, nonPOTW = 3; 1998: POTW = 25, nonPOTW = 15; 2003: POTW = 18, nonPOTW = 13

EMI Community

Abundance

A total of 12,026 EMI were collected during 2008-09 (Tables 6-4 and B-17). Two species accounted for over 75% of the total abundance: the trailtip sea pen (*Acanthoptilum* sp.) comprised 69% of the total catch (8,265 individuals), followed by the white sea urchin (*Lytechinus pictus*) at 10% (1,254 individuals). The number of individual trailtip sea pens collected increased by 5,371 from the 2007-08 survey. Other abundant species included the brokenspine brittlestar (*Ophiura luetkenii*), yellow sea twig (*Thesea* sp.), ridgeback rockshrimp, and California blade barnacle (*Hamatoscalpellum californicum*).

Overall, mean abundances at each station did not show seasonal differences, with the exception of T1 and T12 (Figure 6-9 and Table B-18). Mean abundances ranged from 28 to 295 in summer and 63 to 2,275 in winter. High abundance at T1 and T12 in winter was due to very large catches of the trailtip sea pen, which have been occurring there in large numbers since 2002 (Figure 6-10).

Historically, 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 6-10).

Biomass

In 2008-09, a total of 52.4 kg of EMI were collected in the District's monitoring area. The California sea cucumber (*Parastichopus californicus*) comprised 22 kg (42%) of this biomass and the ridgeback rockshrimp made up 7 kg (14%). The highest biomass values occurred at T3 due to the California sea cucumber and at the deep Stations T10 and T14 due to the ridgeback rockshrimp (Figure 6-9). Outfall Station T1 also had high biomass in winter due to 1 large sheep crab (*Loxorhynchus grandis*) and several California sea cucumbers.

Historically, biomass has ranged from 0.1 to 82 kg by station group since 1985 (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. Overall, there has been no indication of impact at the discharge site, other than the potential increase in sea pens.

Number of Species

A total of 55 EMI taxa were collected during 2008-09 (Tables 6-4 and B-17). Only one species occurred at every station, the ridgeback rock shrimp. Another 10 species, consisting of 7 echinoderms, 2 crustaceans, and 1 anthozoan, were wide ranging and occurred at over 65% of the stations. No seasonal differences were apparent for mean number of species at the 36 m and 55 m stations, though the 137 m stations had approximately half the number of species in winter than summer (Figure 6-9 and Table B-18). The greatest number of species occurred at T3 in both seasons. Outfall Station T1 had the second highest mean number of species among the 55 m stations in both seasons. Annual 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 2008-09 was well within the historical range.

Table 6-4. Summary of epibenthic macroinvertebrates species collected during the summer (July 2008) and winter (January 2009) surveys. Data for each species are expressed as total abundance (Total), percent abundance (%A), frequency of occurrence (%FO), and mean abundance per haul (MAH).

n = 46 hauls

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Species	Total	%A	%FO	MAH
Acanthoptilum sp.	8,265	69	78	197
Lytechinus pictus	1,254	10	67	30
Ophiura luetkenii	621	5	78	15
Thesea sp.	506	4	89	12
Sicyonia ingentis	493	4	100	12
Hamatoscalpellum californicum	433	4	89	10
Astropecten verrilli	89	1	78	2
Luidia foliolata	83	1	89	2
Ophiothrix spiculata	53	<1	67	1
Parastichopus californicus	43	<1	67	1
Pleurobranchaea californica	19	<1	44	<1
Amphichondrius granulatus	18	<1	44	<1
Dendronotus frondosus	18	<1	22	<1
Orthopagurus minimus	12	<1	44	<1
Virgularia californica	12	<1	33	<1
Acanthodoris brunnea	9	<1	56	<1
Spatangus californicus	8	<1	11	<1
Stylatula elongata	8	<1	22	<1
Crangon alaskensis	7	<1	44	<1
Sicyonia penicillata	7	<1	67	<1
Pyromaia tuberculata	6	<1	33	<1
Heterogorgia sp.	5	<1	33	<1
Podochela lobifrons	4	<1	11	<1
Loxorhynchus crispatus	3	<1	33	<1
Neocrangon zacae	3	<1	22	<1
Octopus rubescens	3	<1	33	<1
Tunicate	3	<1	22	<1
Aphrodita sp.	2	<1	22	<1
Fusinus barbarensis	2	<1	11	<1
Geitodoris heathi	2	<1	11	<1
Loxorhynchus grandis	2	<1	22	<1
Luidia asthenosoma	2	<1	22	<1
Megasurcula carpenteriana	2	<1	22	<1
Metacarcinus anthonyi	2	<1	11	<1
Paguristes turgidus	2	<1	22	<1
Podochela hemphillii	2	<1	22	<1
Silicea	2	<1	22	<1

Table 6-4 continues.

Table 6-4 continued.

Species	Total	PA	FO	MAH
Romaleon antennarius	2	<1	22	<1
Strongylocentrotus fragilis	2	<1	22	<1
Tritonia diomedea	2	<1	22	<1
Calliostoma turbinum	1	<1	11	<1
Crossata californica	1	<1	11	<1
Dendronotus diversicolor	1	<1	11	<1
Doris montereyensis	1	<1	11	<1
Gorgoniidae	1	<1	11	<1
Hemisquilla californiensis	1	<1	11	<1
Lopholithodes foraminatus	1	<1	11	<1
Neocrangon resima	1	<1	11	<1
Paguristes bakeri	1	<1	11	<1
Paralithodes rathbuni	1	<1	11	<1
Pisaster brevispinus	1	<1	11	<1
Platymera gaudichaudii	1	<1	11	<1
Rossia pacifica	1	<1	11	<1
Virgularia agassizi	1	<1	11	<1
Virgularia sp.	1	<1	11	<1
Total	12,026	100		
Total no. of species	55			

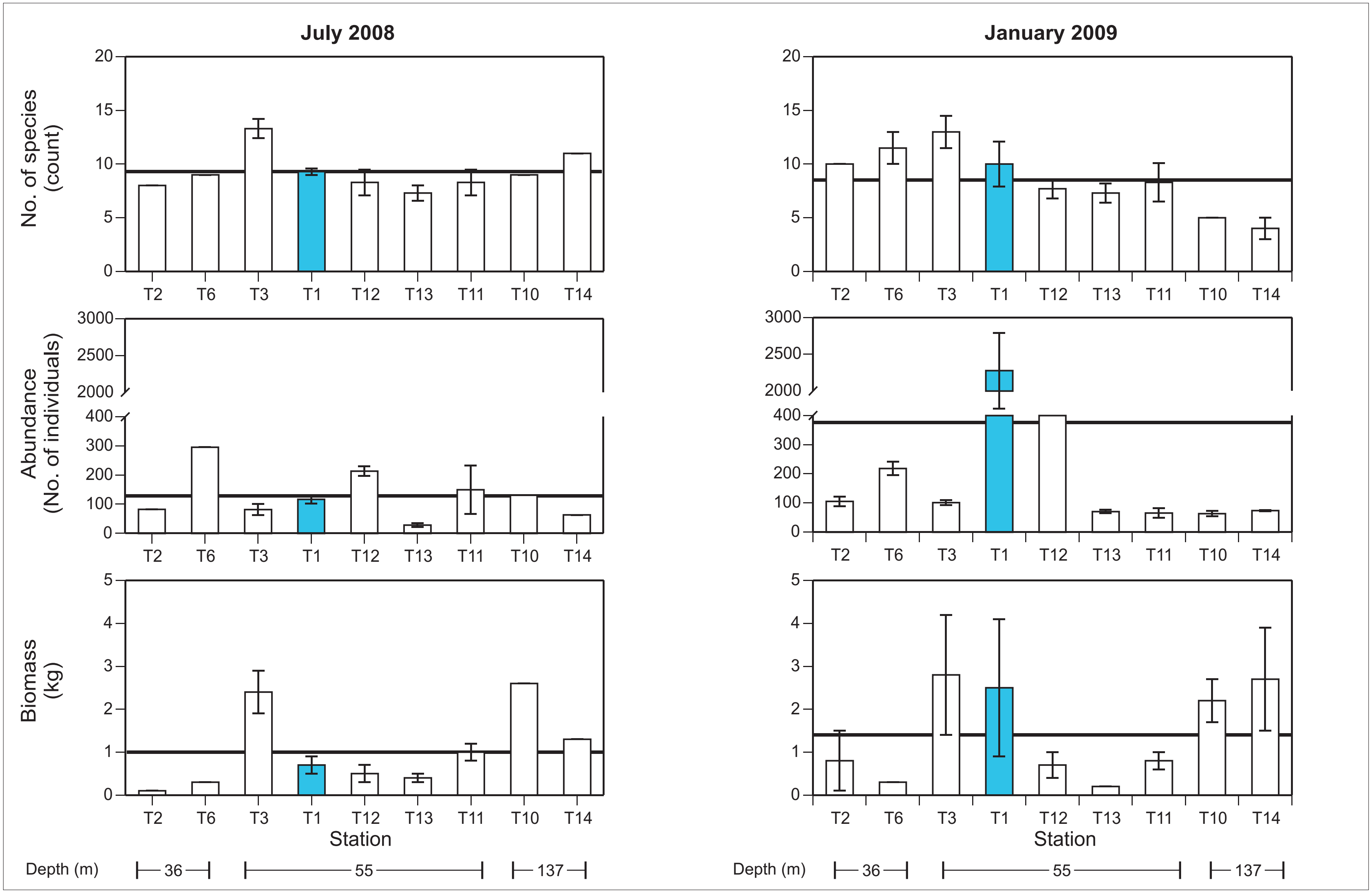

Figure 6-9. **Mean and 95% confidence interval for number of species, number of individuals (abundance), and biomass of epibenthic macroinvertebrates collected during the summer (July 2008) and winter (January 2009) surveys. Only one sample was collected at stations T2, T6, T10, and T14 during the summer of 2008 (see methods).**
Outfall Station T1 indicated in blue. Survey mean indicated by heavy line.

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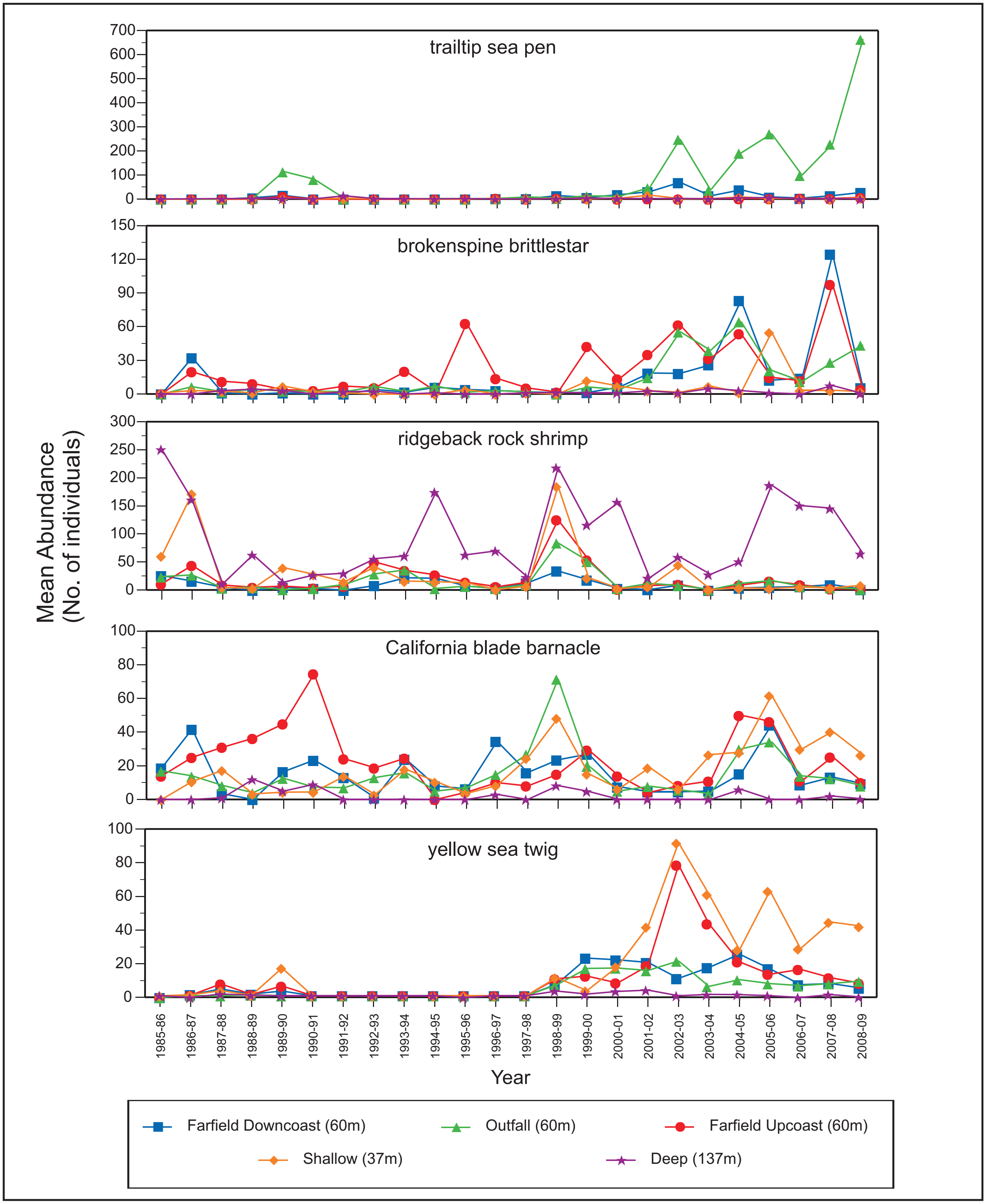

Figure 6-10. **Comparisons of the most abundant epibenthic macroinvertebrates: trailtip sea pen (*Acanthoptilum* sp.), brokenspine brittlestar (*Ophiura luetkenii*), ridgeback rock shrimp (*Sicyonia ingentis*), California blade barnacle (*Hamatoscalpellum californicum*), and yellow sea twig (*Thesea* 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 2009; n=4–6 replicates/station/year.**

Orange County Sanitation District, California.

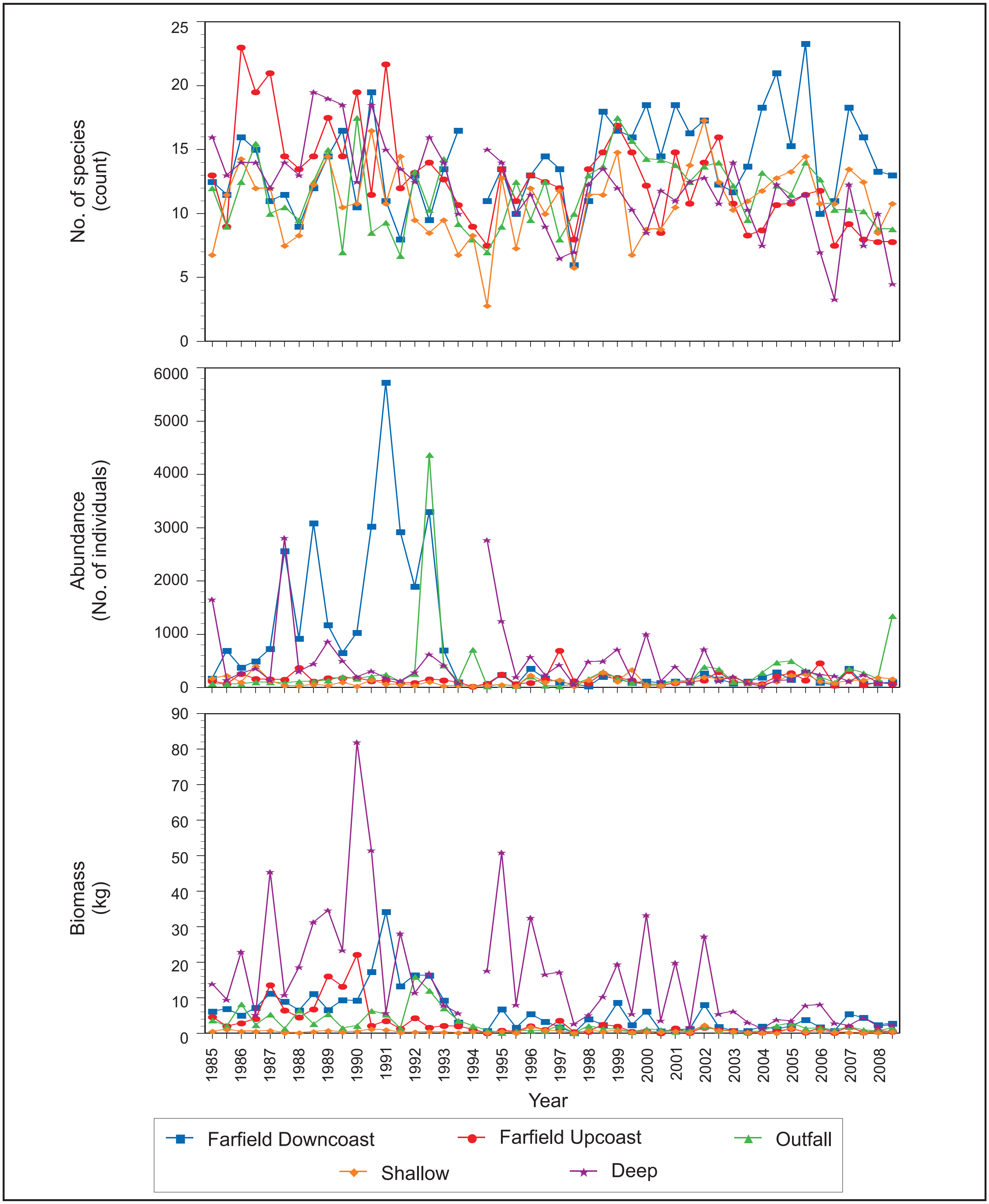

Figure 6-11. Comparison of epibenthic macroinvertebrate parameters by station groups: farfield downcoast (T3), farfield upcoast (T11 and T13), outfall (T1 and T12), shallow (T2 and T6), and deep (T10 and T14). All data for mean number of species, abundance, and biomass by station group are for the period 1985–2009.

Orange County Sanitation District, California.

Diversity

Diversity, as represented by H’, SR, and Dominance, was generally highest at the shallow stations T2 and T6, and the 55 m stations, especially T3 and T13 (Figure 6-12 and Table B-18). Species diversity at outfall Station T1 was comparable to other 55 m stations, except T3 and T13 in summer. In winter, however, T1 had a low mean H’ and Dominance. This was due to the extremely high abundances of the trailtip sea pen caught in winter. Shannon-Wiener diversity is affected by both the number of species and their evenness, hence a large abundance of a single species at 1 location will substantially lower the H’ value.

Regional Comparisons

The District’s summer 2008 EMI data for outfall Station T1 and upcoast reference Station T11 were compared to regional data collected during the 1994 SCBPP, Bight’98, and Bight’03 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). A more detailed summary of the Bight results can be found in OCSD 2008. 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).

Station T1 and T11 data from 2008 were comparable to the Bight data, with means falling within the range of values for the Bight stations. 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 4 years considered for this evaluation (Figure 6-13).

Fish Tissue Contaminants

Muscle and liver contaminant concentrations were measured for hornyhead turbot, English sole, and the whole-body tissue of Pacific sanddabs. Three size classes (lengths) of Pacific Sanddabs were tested: zero (5–8 cm), one (9–13 cm), and two (14–16 cm). 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. A complete list of analytes tested is presented in Appendix A.

Outfall vs. Farfield Stations Comparisons

Hornyhead turbot

The mean standard length of hornyhead turbots was slightly greater at the outfall than the farfield station. This is important 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 than location of capture. Percent lipid was greater, but not significantly different at the farfield station than at the outfall (Table 6-5). In contrast, muscle tissue tDDT levels were two-fold higher in farfield fish than at the outfall, while tPCB

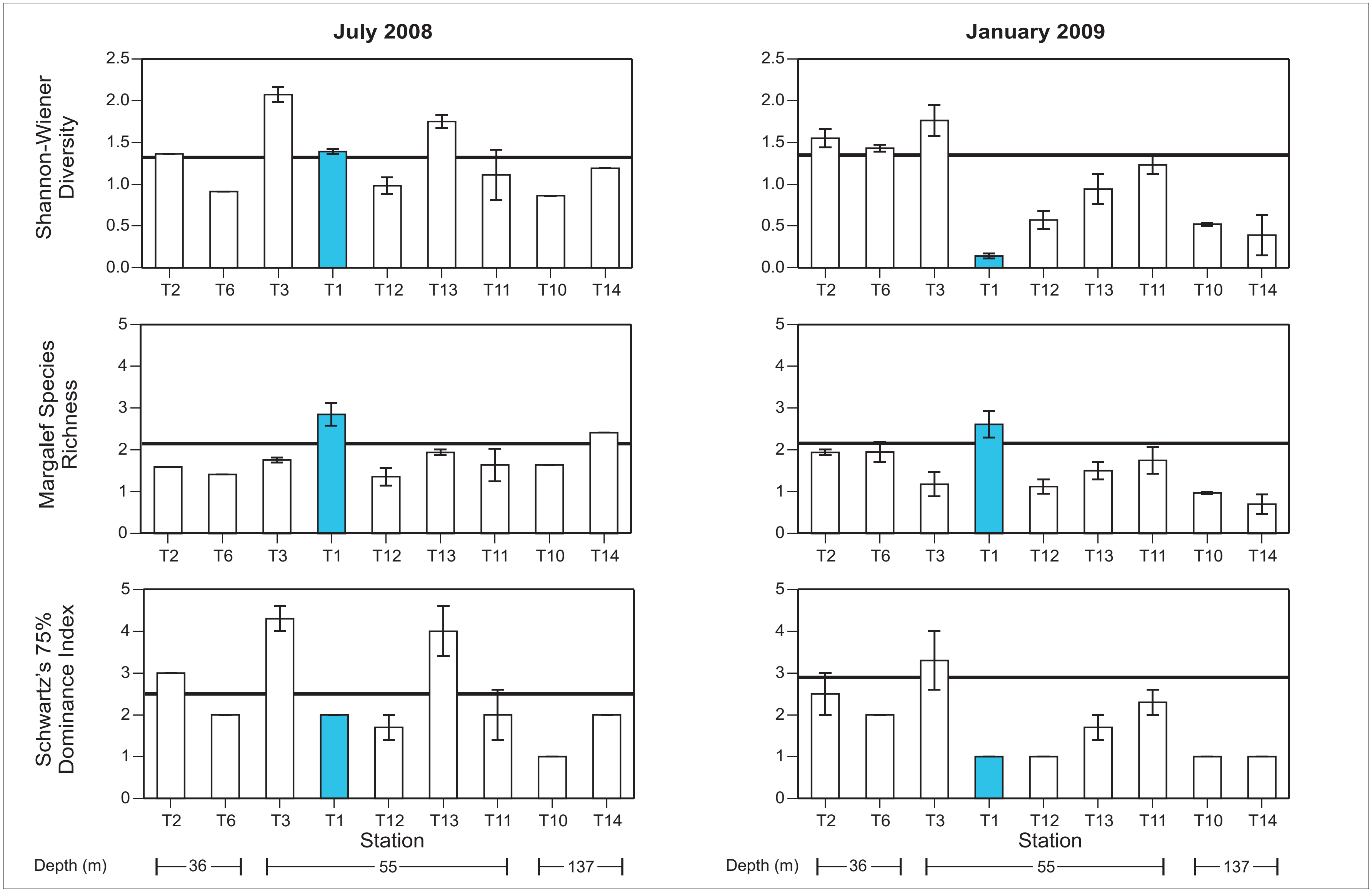

Figure 6-12. **Mean and 95% confidence interval for diversity indices — Shannon-Wiener Diversity Index (H'), Margalef Species Richness (SR), and Schwartz's 75% Dominance Index of epibenthic macroinvertebrates collected during the summer (July 2008) and winter (January 2009) surveys. Only one sample was collected at stations T2, T6, T10, and T14 during the summer of 2008 (see methods).**
Outfall Station T1 indicated in blue. Survey mean indicated by heavy line.

Orange County Sanitation District, California.

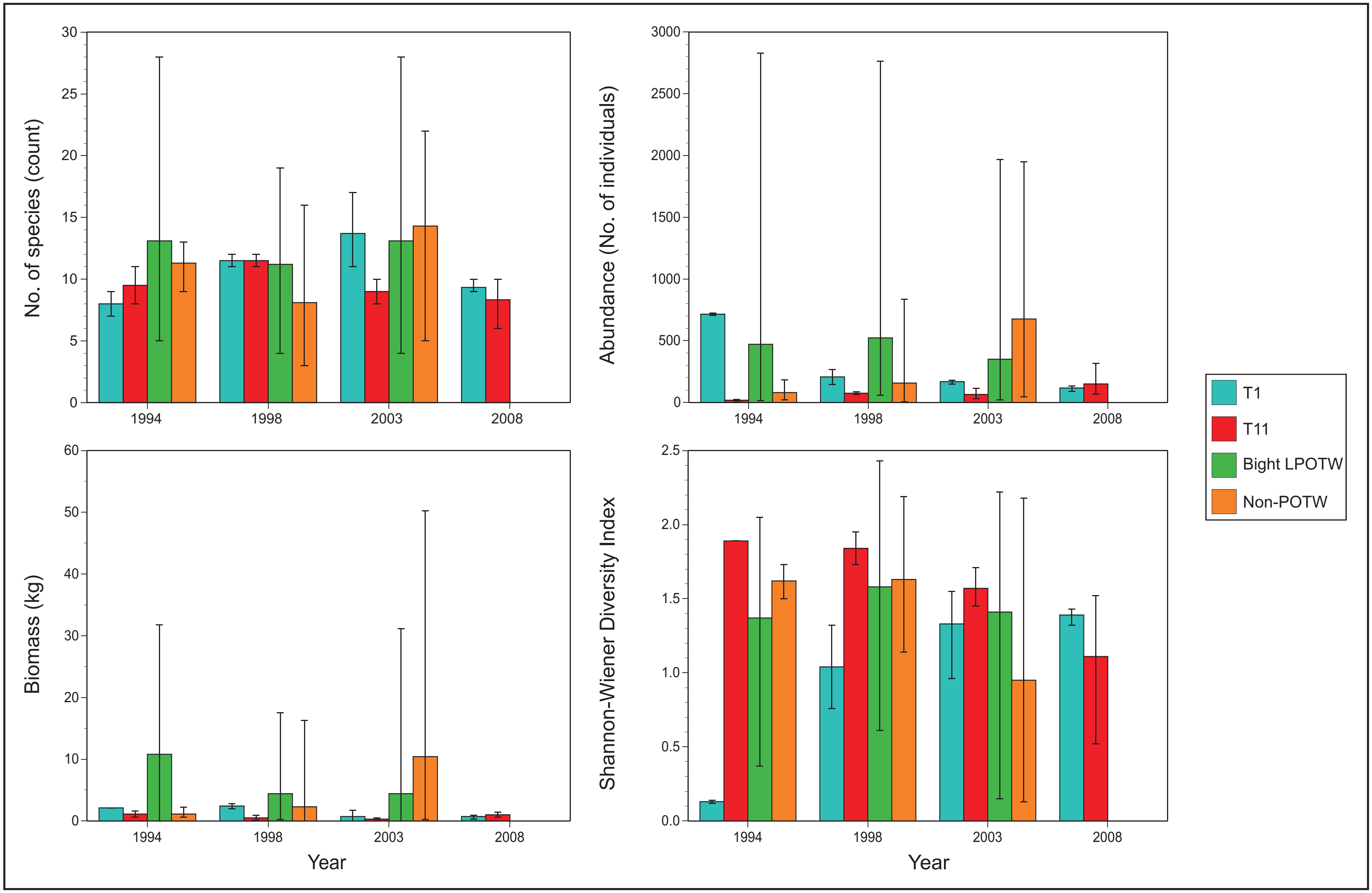

Figure 6-13. **Comparison of epibenthic macroinvertebrate parameters at OCSD Stations T1 and T11 in 1994, 1998, 2003, and 2008 and regional POTW and non-POTW stations from the 1994, 1998, and 2003 regional monitoring surveys. All data for mean number of species, abundance, biomass, and Shannon-Wiener 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

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

Data for total DDT, total PCB, and total other pesticides are lipid-normalized. ND = not detected.

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)	Total Pest (ug/kg)
Hornyhead Turbot	Muscle	Outfall	10	Mean	171	0.114	0.062	134	28	0.44
				Min.	154	ND	0.018	76.7	18.4	ND
				Max	204	0.24	0.108	269	43.3	4.4
		Farfield	10	Mean	164	0.137	0.058	276	113	ND
				Min.	142	ND	0.036	66.2	ND	ND
				Max	179	0.242	0.151	1160	266	ND
	Liver	Outfall	10	Mean	171	6.95	0.172	203	43.6	0.431
				Min.	154	2.1	0.098	87.9	7.86	ND
				Max	204	13.5	0.244	452	96.8	4.31
		Farfield	10	Mean	164	8.65	0.293	312	252	0.215
				Min.	142	3.01	0.068	65.2	8.39	ND
				Max	179	22.7	0.789	1030	2314	2.15
English Sole	Muscle	Outfall	10	Mean	156	0.365	0.05	586	74.4	ND
				Min.	139	ND	0.03	40.2	ND	ND
				Max	183	0.59	0.073	4570	556	ND
		Farfield	10	Mean	160	0.339	0.065	115	7.3	ND
				Min.	124	0.227	0.045	49.6	ND	ND
				Max	195	0.425	0.104	188	11.6	ND
	Liver	Outfall	10	Mean	156	12.3	0.05	205	30.6	0.922
				Min.	139	3.93	0.025	39	8.39	ND
				Max	183	21.8	0.085	974	104	6.12
		Farfield	10	Mean	160	9.05	0.072	296	66.9	ND
				Min.	124	3.5	0.037	95.7	9.8	ND
				Max	195	15	0.154	629	199	ND
Pacific Sanddab	Whole Fish	Outfall	3	Mean	0 (5–8 cm)	0.982	0.018	47.9	15.6	ND
				Min.		0.91	0.016	36.7	2.57	ND
				Max		1.04	0.021	65.1	34.8	ND
		Farfield	3	Mean		0.547	0.038	107	28.8	1.69
				Min.		0.383	0.02	83.4	17.2	ND
				Max		0.726	0.071	152	45.7	5.08
		Outfall	3	Mean	1 (9–13 cm)	1.05	0.034	72.2	15.6	0.685
				Min.		0.946	0.022	58.7	5.12	ND
				Max		1.11	0.049	88.7	31.8	2.06
		Farfield	3	Mean		0.607	0.036	208	34.5	ND
				Min.		0.507	0.021	101	24.7	ND
				Max		0.768	0.057	394	43.8	ND
		Outfall	3	Mean	2 (14–16 cm)	0.791	0.052	139	35.1	1.51
				Min.		0.59	0.045	76.2	4.32	ND
				Max		1.16	0.057	199	52.4	4.54
		Farfield	3	Mean		0.57	0.43	194	39.2	1.59
				Min.		0.427	0.027	142	32.4	ND
				Max		0.732	0.062	279	47.3	4.78

was 4 times higher in farfield collected fish than at the outfall (Figures 6-14 through 6-17). There were no patterns for either total pesticides or mercury. Only 1 fish had measurable muscle pesticide concentrations (outfall = 4.40 ug/kg) and mercury was similar at both sites. Similar to muscle tissue, percent lipid in liver tissue was not significantly different in outfall or farfield fish. Liver tissue tDDT, mercury, and tPCB levels were approximately 50%, 60%, and 600% higher in farfield fish than those collected at the outfall. Total pesticides were two-fold greater at the outfall (0.431 ug/kg) than the farfield site (0.215 ug/kg), however, only 1 fish at each site had measurable levels of pesticides. No significant station differences were found for any analyte with t-tests in hornyhead turbot muscle or liver tissues. This is reflective of the high degree of variability among individual fish at both sites considering the magnitude of differences in the means of tissue contaminants from each station location.

English sole

The mean standard length of English sole was slightly greater at the farfield station than at the outfall. Muscle lipid concentration did not significantly differ between outfall and farfield fish. Muscle tissue tDDT and tPCB levels were 5 and 10 times higher, respectively, in outfall fish than in farfield collected fish (Table 6-5; Figures 6-14 through 6-17). This was primarily due to a single fish with tissue concentrations of tDDT and tPCB of 4570 ug/kg and 556 ug/kg, respectively. When that fish is removed as a statistical outlier, the station means were comparable for both analytes. No fish at either site had measurable muscle pesticide concentrations and mercury was similar at both sites. There were no significant station differences for muscle tissue for any analyte. Liver lipid concentrations were comparable in outfall and farfield fish. Liver tissue tDDT and mercury levels were also comparable at both sites. Total PCB was significantly higher in farfield collected fish (67 ug/kg) than at the outfall (31 ug/kg). Other pesticides were measured in 2 fish from the outfall (mean = 0.922 ug/kg) and were not detected in any of the farfield fish. Other than tPCB, there were no other significant station differences.

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 (Table 6-5; Figures 6-14 through 6-17). Station and size class differences were analyzed using two-way ANOVA. Percent lipid was significantly higher in outfall than farfield fish (0.94% and 0.57%, respectively; $p = 0.001$). Total DDT was significantly higher in farfield station fish than in outfall fish (170 ug/kg and 86 ug/kg, respectively; $p = 0.02$). No other station differences were found. There were no significant differences between size classes for any analyte and no significant interaction between stations and size classes for tDDT.

<u>Long-term Trends</u>

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 low for all analytes, but some have shown high interannual and interspecies variability.

Total DDT

Muscle tissue tDDT has been generally low in all 3 species with occasional periods of increased concentrations (Figure 6-14). There has been no consistent pattern of higher

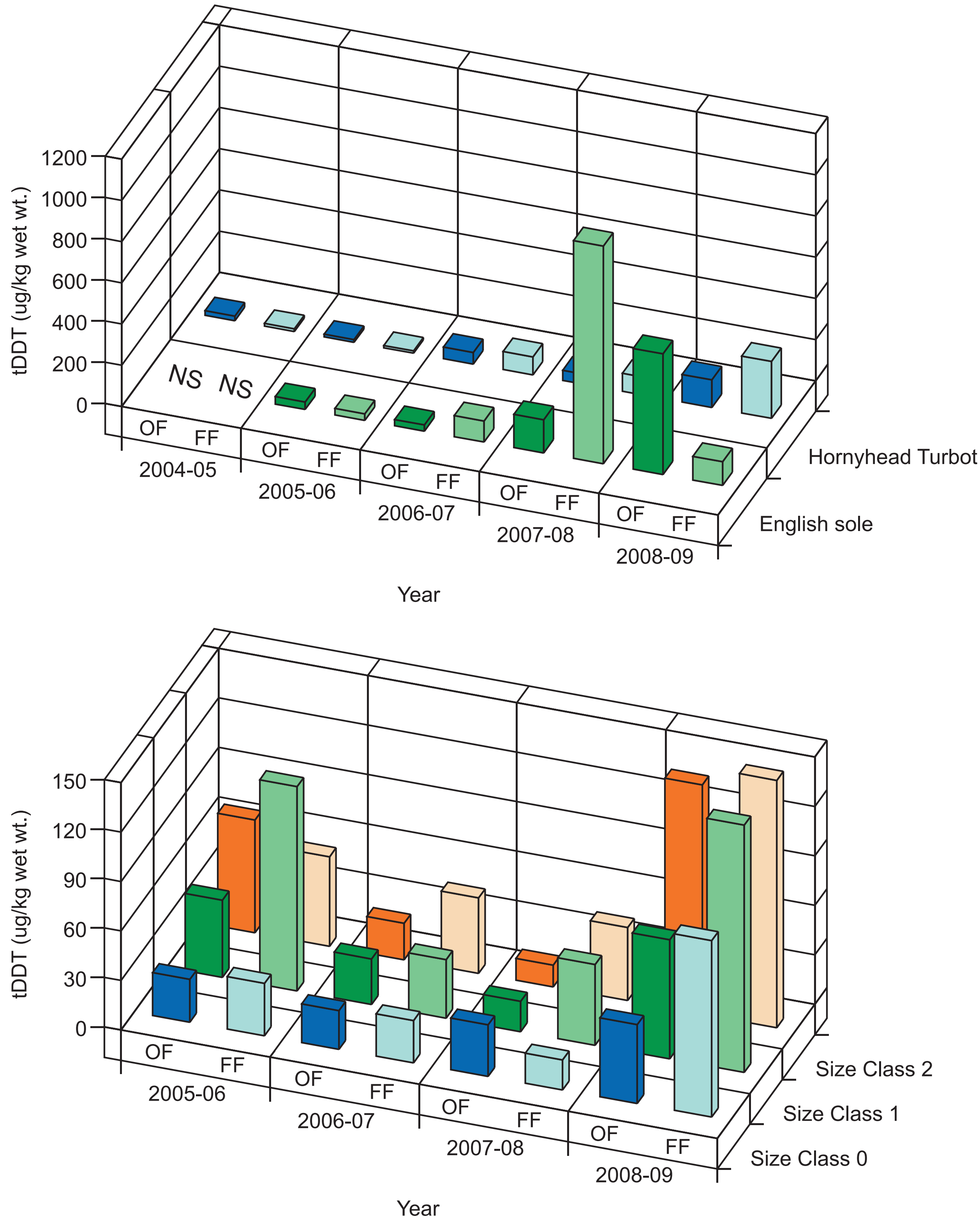

Figure 6-14. **Mean concentrations of total DDT (ug/kg wet weight) in hornyhead turbot (*Pleuronichthys verticalis*) muscle tissue, English sole (*Parophrys vetulus*) muscle tissue, and Pacific sanddab (*Citharichthys sordidus*) whole body tissue for size classes 0 (5–8 cm), 1 (9–13 cm), and 2 (14–16 cm) in July 2008 at outfall (OF) versus farfield (FF) sites.**
Data normalized to % lipids. NS signifies data not collected.

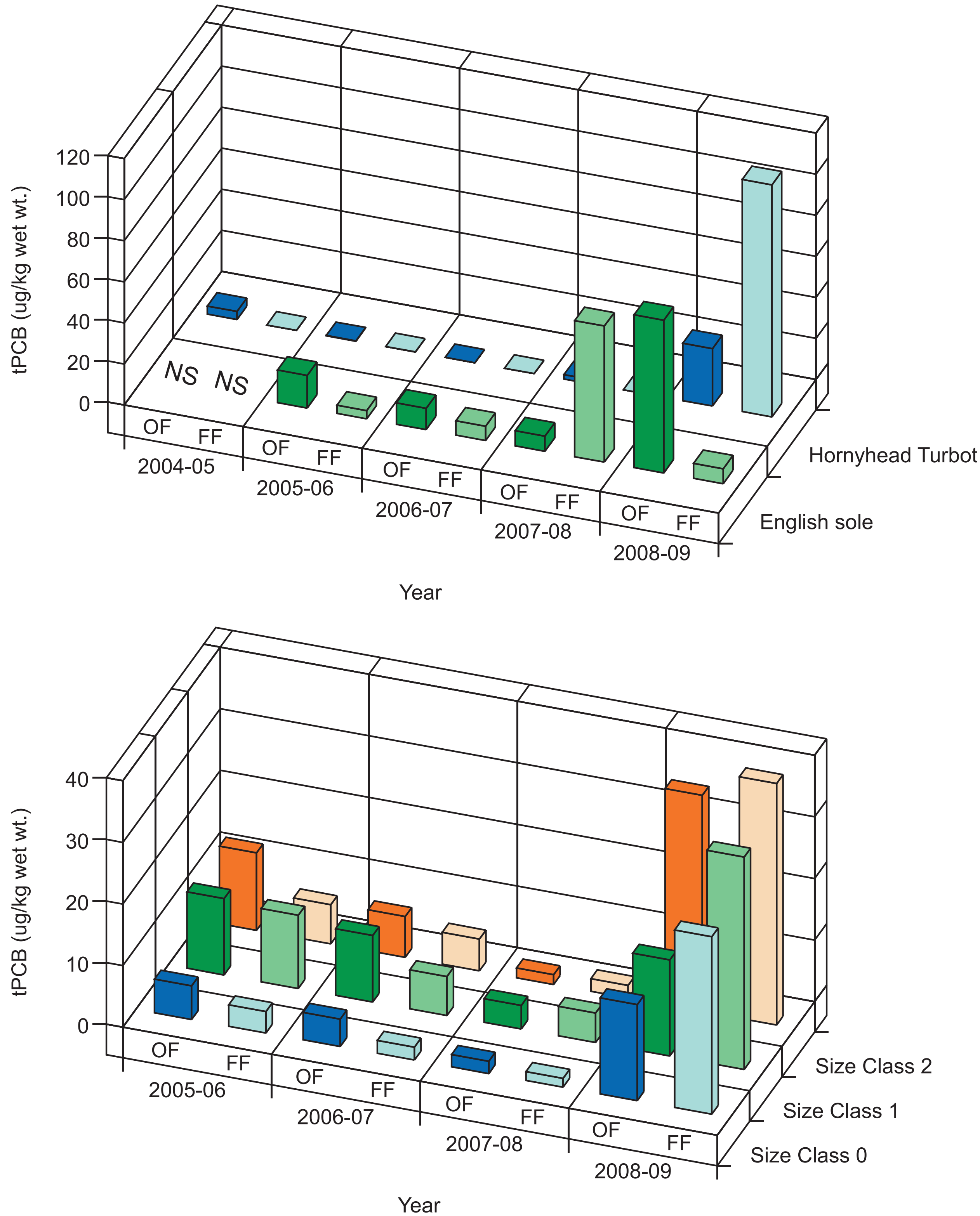

Figure 6-15. **Mean concentrations of total PCB (ug/kg wet weight) in hornyhead turbot (*Pleuronichthys verticalis*) muscle tissue, English sole (*Parophrys vetulus*) muscle tissue, and Pacific sanddab (*Citharichthys sordidus*) whole body tissue for size classes 0 (5–8 cm), 1 (9–13 cm), and 2 (14–16 cm) in July 2008 at outfall (OF) versus farfield (FF) sites.**
Data normalized to % lipids. NS signifies data not collected.

Orange County Sanitation District, California.

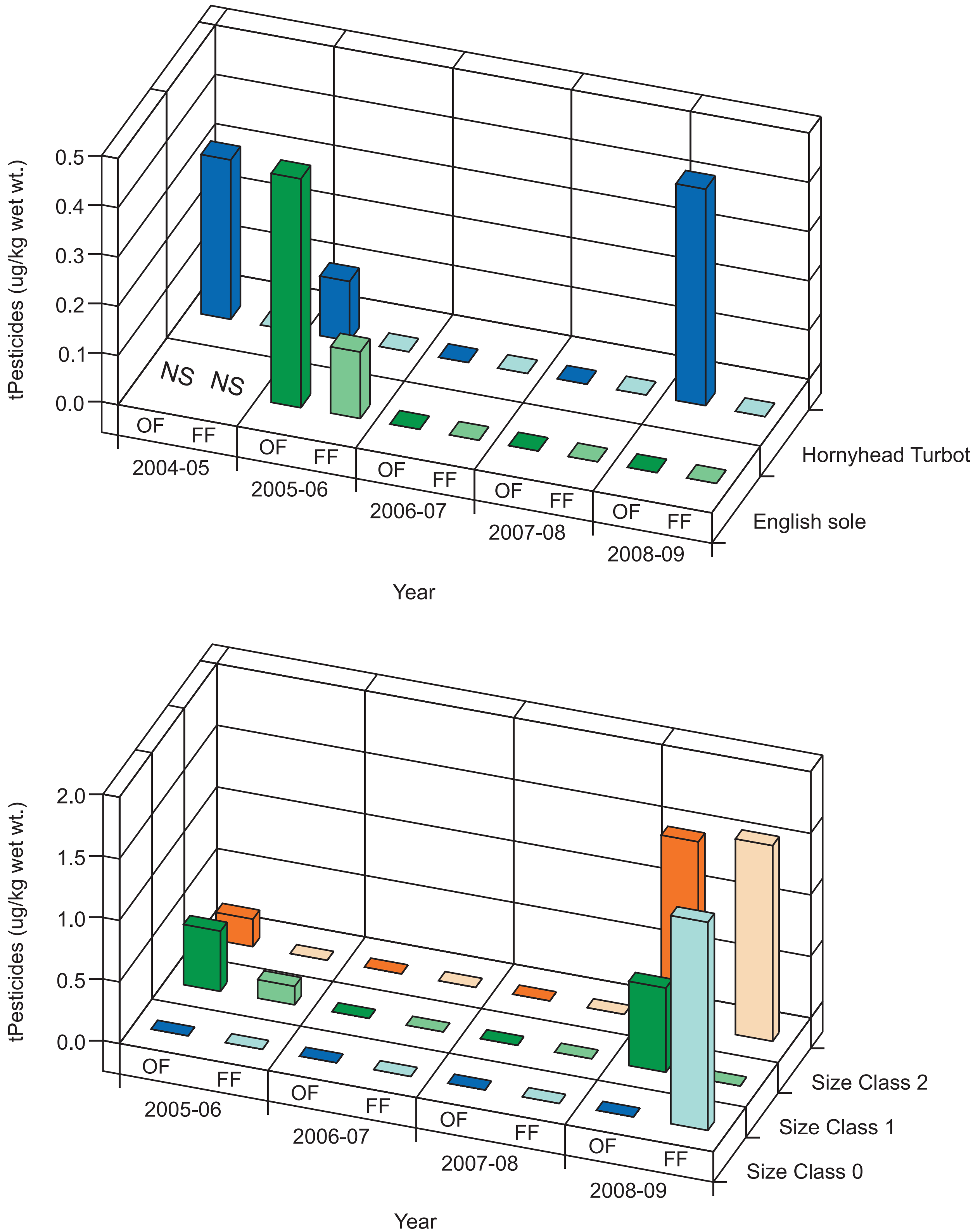

Figure 6-16. **Mean concentrations of total chlorinated pesticides (ug/kg wet weight) in hornyhead turbot (*Pleuronichthys verticalis*) muscle tissue, English sole (*Parophrys vetulus*) muscle tissue, and Pacific sanddab (*Citharichthys sordidus*) whole body tissue for size classes 0 (5–8 cm), 1 (9–13 cm), and 2 (14–16 cm) in July 2008 at outfall (OF) versus farfield (FF) sites.**
Data normalized to % lipids. NS signifies data not collected.

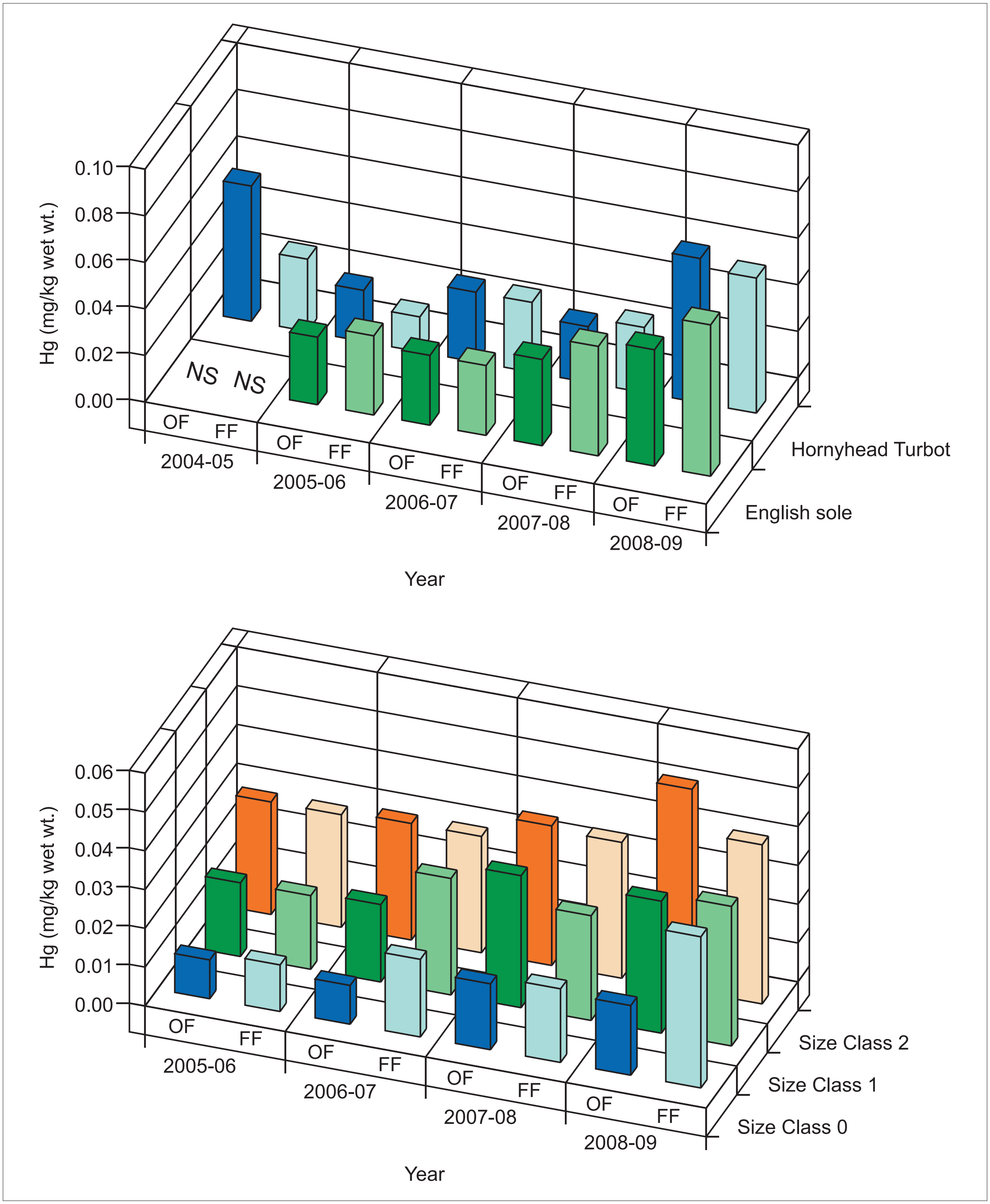

Figure 6-17. Mean concentrations of mercury (mg/kg wet weight) in hornyhead turbot (*Pleuronichthys verticalis*) muscle tissue, English sole (*Parophrys vetulus*) muscle tissue, and Pacific sanddab (*Citharichthys sordidus*) whole body tissue for size classes 0 (5-8 cm), 1 (9-13 cm), and 2 (14-16 cm) in July 2008 at outfall (OF) versus farfield (FF) sites.
Data normalized to % lipids. NS signifies data not collected.

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, though the outfall site was elevated in 2008-09. There were no apparent reasons for the recent increase nor were there 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 occurred in the 2008-09 monitoring year. Like tDDT, long-term trends did not correlate with sediment tPCB concentrations.

Total Chlorinated Pesticides

Fish tissue samples are analyzed for 12 chlorinated pesticides other than DDT. The general trend for total pesticides was similar to tDDT and tPCB with elevated tissue concentrations in 2004-05 and 2005-06 followed by low concentrations in 2006-07 and 2007-08, and then elevated concentrations again in 2008-09 (Figure 6-16). In hornyhead turbot and English sole the concentrations are highest in fish collected from the outfall, while Pacific sanddabs have elevated concentrations from both sites. It should be noted that in all cases the majority of the fish show levels below the detection limit for most analytes and in many cases all analytes are not detected.

Since July 2004, 8 of these 12 pesticide compounds have been measured in fish collected in the monitoring area. 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). All 3 fish species tested had rates of pesticide detection between 13–14% and below 2 parts per billion. This demonstrates that the chlorinated pesticide analytes do not occur in high concentrations in fish in the monitoring area.

Mercury

Mercury tissue concentrations are slightly elevated in all 3 species compared to previous years 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 2008-09 when the Pacific sanddab size class 0 farfield fish had a mean concentration (0.038 mg/kg), approximately twice that of outfall fish (0.018 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. Muscle tissue samples from 4 hornyhead turbots and 1 English sole exceeded the CDHS advisory limit of 100 µg/kg for tPCB. The 4 hornyhead turbot were collected from the farfield station and had muscle tissue concentrations ranging from 181 µg/kg to 471 µg/kg. The English sole was collected at the outfall and had a muscle tissue level of 556 µg/kg.

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.

Regional Comparisons

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 large POTW and non-POTW stations. Total DDT concentrations ranged from ND to 10,462 μg/kg at large POTW sites and 4.2 μg/kg to 1,061 μg/kg at non-POTW locations (Allen *et al.* 2002). In 2008-09, tDDT was detected in all Pacific sanddab composites tested with concentrations ranging from 38 μg/kg (Outfall; Size Class 0) to 200 μg/kg (Farfield; Size Class 1). 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.

The Outfall as an Epicenter for Fish Tissue Contamination

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, Abnormalities and Liver Pathologies

External Parasites and Abnormalities

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 2.1 % (120 occurrences) of Pacific sanddabs. This parasite was found at all the 55 m and 137 m stations in both surveys, except for T11 in summer, but not at either of the 2 shallow Stations T2 and T6. No outfall trend was evident, as only 19 of the 120 P*. cincinnatus* were found at T1, and the 2.1% 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, 12 other abnormalities were found in 2008-09. Five individuals of Dover sole and 1 Pacific sanddab were infected with tumors. Two skeletal deformities occurred, 1 each on a Dover sole and an English sole. Five other parasites were found on 2 vermillion rockfish and 3 California skates (*Raja inornata*).

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.

It should be noted that 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) concluded 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), but demersal fish with large ranges may transport contaminants away from the source (Allen 2006) or be captured away from the primary location of exposure. 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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