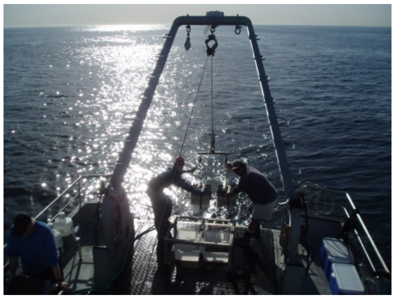
chapter 5

MACROBENTHIC INVERTEBRATE COMMUNITIES



Chapter 5
MACROBENTHIC INVERTEBRATE COMMUNITIES

INTRODUCTION

The District monitors the composition of the macrobenthic invertebrate community (small organisms, such as worms, clams, and burrowing shrimps) that lives on (epifauna) and in (infauna) sediments to assess the possible effects of the wastewater discharge. Infauna are sensitive indicators of environmental change due to their limited mobility and susceptibility to the effects of changes in sediment quality resulting from both natural (e.g., El Niño/La Niña events) and anthropogenic (organic enrichment and chemical contaminants) influences (Pearson and Rosenberg 1978; Diener and Fuller 1995). In accordance with the District's NPDES ocean discharge permit the macrobenthic communities are monitored to determine if the wastewater discharge has degraded the biological community in the monitoring area beyond the zone of initial dilution (ZID), which is the area within 60 m in any direction of the outfall diffuser (See box).

Compliance Criteria Pertaining to Benthic Infaunal Communities Contained in the District's NPDES Ocean Discharge Permit (Order No. R8-2004-0062, Permit No. CAO110604.

Criteria	Description
C.5.a Marine Biological Communities	Marine communities, including vertebrates, invertebrates, and algae shall not be degraded.

The District's outfall pipe sits on the San Pedro Shelf between the Newport and San Gabriel submarine canyons (Figure 5-1). Since natural processes strongly influence infaunal assemblages, outfall effects are discerned from natural influences by comparing invertebrate communities near the outfall to reference sites, areas located away from the outfall.

Long-term analyses have shown that natural features of the environment account for most of the variability in the distribution of infaunal species in the monitoring area, with depth-related factors being the most important (OCSD 1996, 2003). However, there is a distinct assemblage near the outfall that is influenced by the wastewater discharge. Previous monitoring efforts and special studies have shown that impacts from the discharge are generally localized near the outfall and can be characterized as either reef effects related to the outfall structure or as direct and/or indirect effects of the wastewater discharge.

The outfall pipe and the associated ballast rock make one of the largest artificial reefs in southern California. The outfall structure alters current flow and sediment characteristics

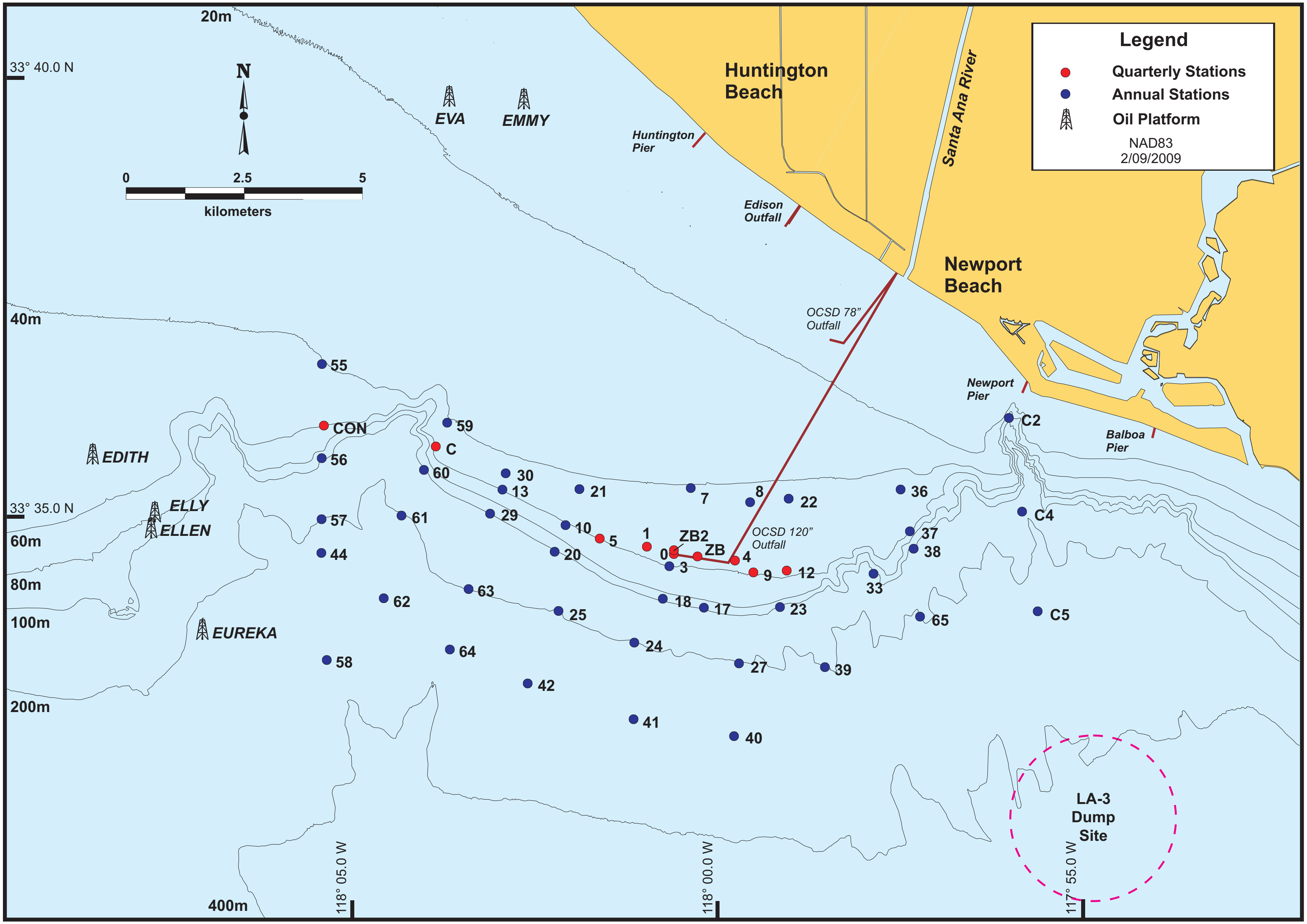


Figure 5-1. Benthic infauna sampling stations for annual and quarterly surveys, 2008-09.

Orange County Sanitation District, California.

near the pipe (e.g., grain size and sediment geochemistry), which in turn influences the structure of the infaunal community. The physical structure of the pipe as well as the predatory fish and invertebrates that it attracts also affect the macrobenthic community in the surrounding area (OCSD 1995, 1996; Diener and Riley 1996; Diener et al. 1997). Release of the treated wastewater produces direct effects, such as organic enrichment that enhances infaunal abundances.

The District has undertaken 3 projects in the last 7 years that have the potential to significantly affect effluent characteristics. The first was the initiation of effluent disinfection by chlorination with hypochlorite bleach followed by de-chlorination with sodium bisulfate, which began in August 2002. Second was the Ground Water Replenishment System (GWRS) water reclamation project that was initiated in January 2008. This has decreased the volume of effluent discharged into the ocean from 237 MGD in 2006-07 to 167 MGD in 2008-09. While the effluent volume has decreased the mass balance of contaminants being discharged is approximately the same, resulting in a more concentrated effluent than before GWRS. Lastly, the District is under a consent decree issued in 2002 to achieve secondary treatment standards by 2012. Presently, effluent quality is near the 30 mg/L secondary treatment levels for total suspended solids (TSS) and biological oxygen demand (BOD). What affect, if any, these treatment changes will have on sediment characteristics and biota are still being assessed and are addressed in this chapter with the information available to date.

METHODS

A 0.1 m^2 modified paired Van Veen sediment grab sampler was used to collect infaunal samples. Three replicate samples were collected quarterly at 10 stations of depths between 55–60 m (referred to herein as the 60 m or outfall-depth sites). An additional 39 “annual” stations, with depths ranging from 40 to 303 m, were sampled in July 2008 (Figure 5-1). The purpose of the quarterly surveys is to determine long-term trends and potential effects along the 60-m depth contour, while the annual survey is primarily to assess the spatial extent of the influence of the effluent discharge. Analysis of the annual survey data included the first replicate sample from the July quarterly stations as well as the 39 annual stations (n=49 stations).

The measures used to assess infaunal community health and function were total number of species, total abundance of individuals, total biomass, Shannon-Wiener Diversity (H’), Margalef Species Richness (SR), Schwartz’ 75% Dominance Index (Dominance), Species Evenness (J’), Infauna Trophic Index (ITI), and Benthic Response Index (BRI). Biomass measurements are sometimes influenced by the occurrence of occasional, large organisms, so they tend to be much more variable than other community measures. For that reason, organisms having large biomass (e.g., sea stars and large molluscs) are removed from the sample calculation. The measures of diversity are based on the number of species and the equitability of their distribution. H”, J’, and Dominance are more sensitive to the distribution of species within a sample, while SR is more sensitive to the number of species. The Infaunal Trophic Index (ITI) is an index developed by Word (1978) and modified in 1980 (Version 2) to provide a measure of infaunal community “health.” ITI values greater than 60 are considered indicative of a “normal” community; 30–60 represent a “changed” community, while values less than 30 indicate a “degraded” community. The

Benthic Response Index (BRI) measures the pollution tolerance of species on an abundance-weighted average basis (Bergen et al. 1998). This measure is scaled such that values below 25 represent reference conditions; 25–34 indicates a marginal deviation from reference conditions, 35–44 indicates a loss of biodiversity, 45–72 indicates a loss of community function, and 73–100 indicates the defaunation or exclusion of most species.

The presence or absence of certain indicator species (pollution sensitive and pollution tolerant) was also determined for each station. Indicator species are those organisms that show strong abundance gradients relative to the wastewater discharge and some can dominate the calculation of community measures (e.g., *Capitella capitata* complex). Patterns of these species are used to assess the spatial and temporal influence of the wastewater discharge in the receiving environment. The presence of the pollution sensitive species tends to indicate the existence of a healthy environment, while the occurrence of the pollution tolerant species may indicate stressed or organically enriched environments. Pollution sensitive species include the red brittle star *Amphiodia urtica* (echinoderm) and amphipod crustaceans from the genera *Ampelisca* and *Rhepoxynius*. The pollution tolerant species include *Capitella capitata* species complex (polychaete) and *Euphilomedes carcharodonta* (ostracod crustacean). The bivalve mollusk *Parvilucina tenuisculpta* was included in the discussion of pollution tolerant species in previous reports. It is excluded from this report due to its low abundance throughout the monitoring area being absent from most stations with a high abundance of only 6 individuals.

Spatial trends for the July 2008 annual station data were assessed graphically by infaunal community measure contour maps and statistically by cluster analysis and non-metric multidimensional scaling (MDS) techniques using the PRIMER v6 statistical software package. Depth-related gradients and relationships between chemical compounds and physical sediment characteristics were assessed using Pearson Product Moment Correlation with the Minitab® Statistical Software package. Temporal trends were assessed graphically. Data was transformed where appropriate. Statistical significance was set at $p \leq 0.05$.

A qualitative assessment of trends over time in the various community measures at the quarterly stations was performed. Trends are presented graphically using grouped data to increase the sample size at each station and decrease the variability of each data point on the graph. Each measure is represented as a line graph, which shows the inter-annual variability, and as a best-fit line to show the overall direction (increasing/decreasing) of changes. The quarterly stations were divided into five stations groups based on their proximity to the outfall diffuser: farfield upcoast (FFU = Stations C and CON); nearfield upcoast (NFU = Stations 1 and 5); nearfield downcoast (NFD = Station 9 and 12); within ZID upcoast (WZU = Stations 0 and ZB2); and within ZID downcoast (WZD = Station 4 and ZB).

A more complete summary of methods for the analyses and the indices used in this chapter are presented in Appendix A.

RESULTS AND DISCUSSION

Overall, infaunal community data showed little ecological impact in the vicinity of the outfall beyond the ZID. There are other areas where communities appear to be stressed, such as specific sites within the submarine canyons and slope and basin areas. However, these do not appear to be related to the effluent discharge.

Taxa and Abundance

The benthic infaunal organisms are classified into five "major taxa" for ease of comparison: polychaeta (worms), mollusca (snails, clams, etc.), crustacea (shrimps, crabs, etc.), echinodermata (sea stars, sea urchins, sea cucumbers), and minor phyla (e.g., cnidaria, nemertea, echiura, etc., Table 5-1). In the 2008-09 monitoring year a total of 688 taxa comprising 58,212 individuals were collected representing an increase of 86 taxa and a decrease of 9,671 individuals from the 2007-08 monitoring year. The number of species and/or the number of individuals of a major taxonomic group was largely related to depth and proximity to the outfall. For example, the mean number of crustacean taxa and abundance generally decreased with increased station depth and there were fewer taxa and individuals at stations within the ZID. However, the polychaeta had the greatest number of taxa and individuals between 91–100 m. Similar to crustaceans, the mean number of polychaete taxa along the 60-m contour was lowest at within-ZID stations, but in contrast to the crustaceans the mean number of individuals was higher at these stations. This was due to the high abundances of Capitellid species, particularly *Capitella capitata* complex.

Community Indicators

<u>Number of species</u>
The number of species collected across all 49 stations in July 2008 ranged from 17 at slope Station 44, located in the San Gabriel Canyon, to 142 at mid-shelf Station 37, and generally decreased with increasing depth (Table 5-2; Figure 5-2). Regression analysis showed a significant relationship between station depth and the number of species (R^2=0.77). Similarly, the mean number of species was lower at the 60-m stations within the ZID relative to those outside the ZID (82 and 98, respectively). The number of species was negatively correlated with sediment tLAB concentrations (R=-0.34) suggesting a small influence from discharged particulates, particularly at sites within the ZID (see Chapter 4).

This same pattern also was present during the quarterly sampling. Quarterly non-ZID station mean number of species ranged from 92 to 105, while within-ZID sites ranged from 71 to 93 (Table 5-3). Overall, however, all quarterly stations exceeded the Bight'03 large POTW and mid-shelf means, suggesting little impact of the discharge on species diversity (Table 5-3).

<u>Abundance</u>
Station abundances during the annual survey ranged from 28 at slope Station 44 to 758 at outer shelf Station 29 and were generally distributed according to depth (Table 5-2; Figure 5-2). There was a significant relationship between station depth and total abundance (R^2=0.62). Abundances were highest at outer shelf stations due to high abundances of

Table 5-1. Major taxonomic groups by station depth and location within or outside the zone of initial dilution (ZID). Values represent the mean and (range) of values for stations within a depth range.
Depth range 56–60 m; Z = within ZID stations; N = Non-ZID stations.

Orange County Sanitation District, California.

Community Measure	Depth (m)	Crustacea	Echinodermata	Misc. Phyla	Mollusca	Polychaeta
Number of Species	Shallow shelf (40–46)	26 (17–35)	5 (3–8)	10 (2–16)	12 (6–18)	60 (36–74)
	Mid-shelf ZID (56–60)	18 (5–26)	2 (0–5)	7 (1–15)	13 (3–21)	43 (18–64)
	Mid-shelf non-ZID (56–60)	22 (8–33)	6 (2–10)	7 (2–17)	14 (2–21)	49 (18–64)
	Outer shelf (91–100)	12 (5–20)	5 (4–6)	6 (2–10)	15 (11–17)	66 (48–80)
	Slope (187–241)	9 (4–21)	2 (0–4)	2 (0–5)	9 (2–16)	24 (9–31)
	Basin (296–300)	8 (3–11)	1 (0–3)	1 (0–2)	6 (2–8)	15 (10–22)
Abundance of Individuals	Shallow shelf (40–46)	106 (49–151)	42 (4–88)	16 (2–23)	24 (8–41)	237 (74–344)
	Mid-shelf ZID (56–60)	55 (24–121)	3 (0–15)	27 (6–56)	39 (8–77)	289 (110–729)
	Mid-shelf non-ZID (56–60)	78 (16–188)	37 (2–130)	14 (3–36)	37 (8–79)	196 (73–642)
	Outer shelf (91–100)	49 (15–128)	138 (30–310)	11 (2–16)	40 (30–72)	341 (258–415)
	Slope (187–241)	19 (5–62)	3 (0–5)	2 (0–5)	23 (2–38)	101 (18–223)
	Basin (296–300)	11 (3–18)	2 (0–4)	1 (0–3)	14 (5–32)	45 (18–90)

Table 5-2. Summary of infaunal community measures for all stations, July 2008 annual survey sorted by depth.

* Mean of 3 replicates reported for quarterly stations.

Orange County Sanitation District, California.

Station	Depth (m)	Total Number of Species	Total Abundance	Total Biomass (g)	Shannon-Wiener Diversity (H')	Margalef Species Richness (SR)	Schwartz' 75% Dominance Index	Species Evenness (J')	Infaunal Trophic Index (ITI)	Benthic Response Index (BRI)
Shallow Shelf (40 – 46 meters)										
7	41	129	440	4.05	4.46	21.0	51	0.92	75	20
8	44	68	164	1.12	3.81	13.1	28	0.90	77	16
21	44	87	364	4.96	3.25	14.6	26	0.83	73	19
22	45	130	507	5.68	4.22	20.7	42	0.87	86	16
30	46	135	619	9.17	4.07	20.9	38	0.83	80	16
36	45	108	381	5.64	3.97	18.0	32	0.85	93	10
55	40	107	434	1.18	4.04	17.5	34	0.86	88	16
59	40	130	477	1.80	4.26	20.9	44	0.88	76	17
Average		**122**	**484**	**4.69**	**4.11**	**19.6**	**38**	**0.86**	**85**	**15**
Mid-Shelf Within-ZID (56 – 60 meters)										
0 *	56	82	564	3.97	3.00	12.8	15	0.66	21	35
4 *	56	83	291	2.13	3.79	14.6	27	0.86	63	23
ZB *	56	71	298	2.52	3.52	12.3	21	0.83	42	33
ZB2 *	56	93	490	3.10	3.49	14.9	22	0.77	27	31
Average		**82**	**411**	**2.93**	**3.45**	**13.7**	**21.3**	**0.78**	**38**	**31**
Mid-Shelf Non-ZID (56 – 60 meters)										
1 *	56	105	440	3.99	3.94	17.2	31	0.85	64	22
3	60	118	624	3.45	3.82	18.3	27	0.80	63	22
5 *	59	99	420	4.92	3.86	16.3	28	0.84	81	15
9 *	59	92	315	3.96	3.88	15.9	32	0.86	69	20
10	60	96	455	6.55	3.91	15.5	28	0.86	87	14
12 *	58	97	290	3.65	4.04	16.9	37	0.89	73	16
13	59	93	419	4.91	3.86	15.4	27	0.85	90	14
37	56	142	473	4.10	4.43	22.9	52	0.89	71	17
C *	56	95	354	5.99	3.88	16.1	31	0.85	87	15
C2	56	44	707	9.27	2.29	6.55	5	0.61	55	44
CON *	59	93	276	3.54	3.98	16.4	36	0.88	90	12
Average		**98**	**434**	**4.94**	**3.81**	**16.1**	**30.4**	**0.83**	**76**	**19**
Outer Shelf (91–-100 meters)										
17	91	94	460	4.57	3.65	15.2	22	0.80	80	15
18	91	108	514	6.35	3.79	17.1	25	0.81	83	14
20	100	113	644	7.87	3.75	17.3	27	0.79	84	17
23	100	91	433	3.20	3.85	14.8	26	0.85	73	20
29	100	108	758	10.5	3.48	16.1	21	0.74	88	17
33	100	101	542	3.24	3.86	15.9	26	0.84	74	23
38	100	101	746	12.5	3.51	15.1	20	0.76	87	16
56	100	107	513	4.74	3.87	17.0	31	0.83	77	20
60	100	112	590	4.56	3.82	17.4	28	0.81	80	18
Average		**104**	**578**	**6.39**	**3.73**	**16.2**	**25**	**0.80**	**81**	**18**

Table 5-2 Continues.

Table 5-2 Continued.										
Station	**Depth (m)**	**Total Number of Species**	**Total Abundance**	**Total Biomass (g)**	**Shannon-Wiener Diversity (H')**	**Margalef Species Richness (SR)**	**Schwartz' 75% Dominance Index**	**Species Evenness (J')**	**Infaunal Trophic Index (ITI)**	**Benthic Response Index (BRI)**
Slope (187 – 241 meters)										
24	200	49	85	0.930	3.67	10.8	28	0.94	77	16
25	200	48	113	3.11	3.51	9.94	21	0.91	79	28
27	200	48	128	2.64	3.45	9.69	20	0.89	74	19
39	200	60	333	1.43	2.87	10.2	11	0.70	81	14
44	241	17	28	0.639	2.58	4.80	10	0.91	75	27
57	200	50	110	2.92	2.58	10.4	23	0.92	74	24
61	200	45	83	4.07	3.59	9.96	24	0.94	64	21
63	200	51	129	1.43	3.36	10.3	20	0.85	66	20
65	200	50	252	2.74	2.58	8.86	10	0.66	65	18
C4	187	46	224	7.77	2.75	8.32	9	0.72	69	31
Average		**46.4**	**149**	**2.77**	**3.09**	**9.33**	**18**	**0.84**	**72**	**22**
Basin (296 – 300 meters)										
40	303	31	64	0.739	3.10	7.21	15	0.90	57	19
41	303	34	76	1.28	3.19	7.62	15	0.90	82	24
42	303	34	79	1.87	2.99	7.55	14	0.85	70	22
58	300	34	64	2.46	3.27	7.94	18	0.93	77	27
62	300	23	37	0.696	2.97	6.09	14	0.95	45	25
64	300	32	98	2.12	2.81	6.76	11	0.81	57	19
C5	296	28	99	4.91	2.63	5.88	9	0.79	66	36
Average		**30.9**	**73.9**	**2.01**	**2.99**	**7.01**	**14**	**0.88**	**65**	**25**

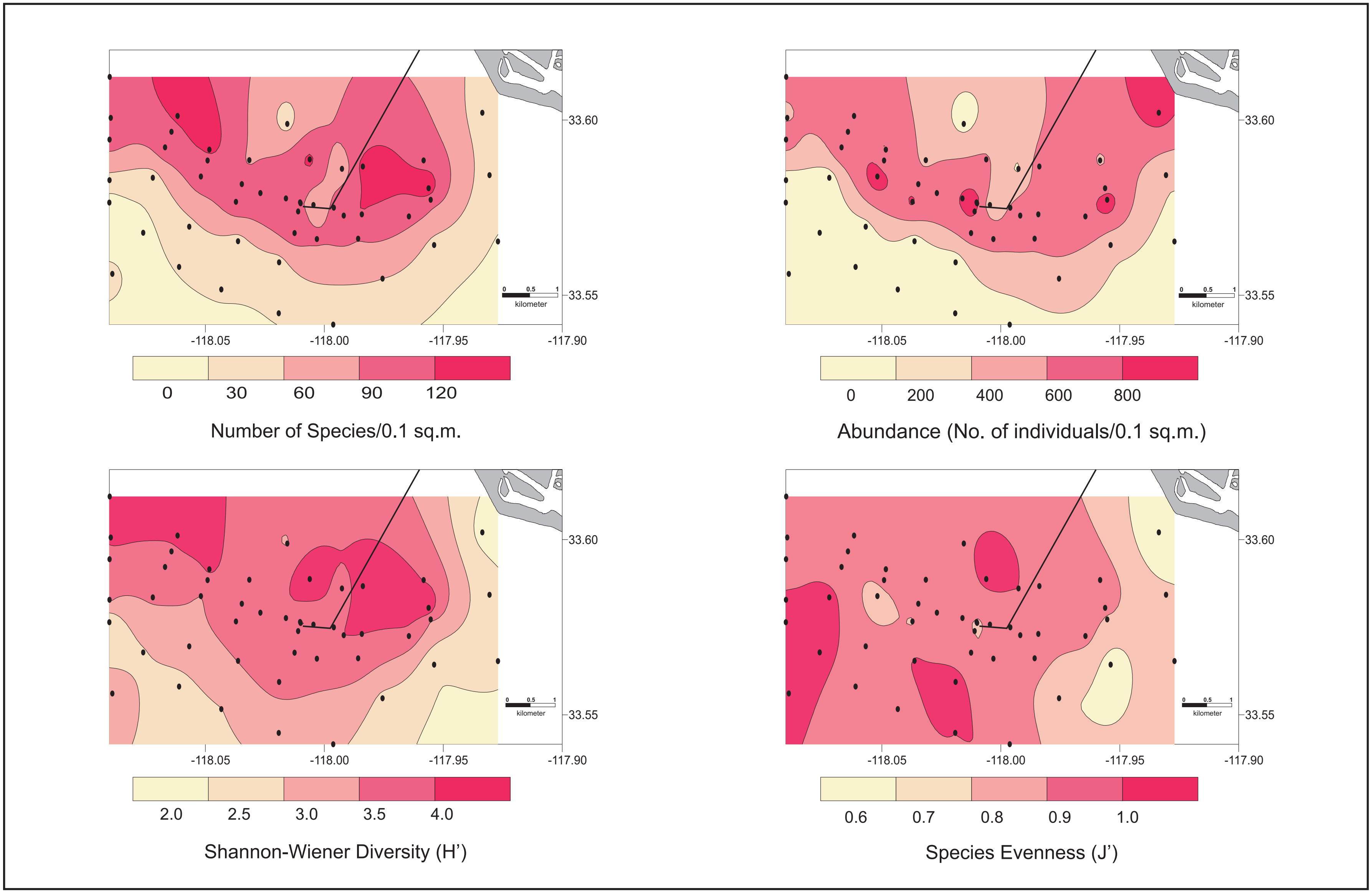


Figure 5-2. **Spatial distributions of number of species, abundance, Shannon-Wiener diversity (H'), and species evenness (J') during July 2008.**

Orange County Sanitation District, California.

Table 5-3. Station means for community measures and diversity indices for quarterly 60 m stations in 2008-09 (n=12) compared to regional and historical values.

Orange County Sanitation District, California.

Station	Station Location Relative to the Outfall	Number of Species	Total Abundance	Total Biomass (g)	Shannon-Wiener Diversity (H')	Margalef Species Richness (SR)	Schwartz' 75% Dominance Index	Evenness (J')	Infaunal Trophic Index (ITI)	Benthic Response Index (BRI)
Within-ZID Stations										
0	WZU	82	564	3.97	3.00	12.8	15	0.66	21	35
ZB2	WZU	93	490	3.10	3.49	14.9	22	0.77	27	31
4	WZD	83	291	2.13	3.79	14.6	27	0.86	63	23
ZB	WZD	71	298	2.52	3.52	12.3	21	0.83	42	33
Mean		**82**	**411**	**2.93**	**3.45**	**13.7**	**21**	**0.78**	**38**	**31**
Non-ZID Stations										
1	NFU	105	440	3.99	3.94	17.2	31	0.85	64	22
5	NFU	99	420	4.92	3.86	16.3	28	0.84	81	15
9	NFD	92	315	3.96	3.88	15.9	32	0.86	69	20
12	NFD	97	290	3.65	4.04	16.9	37	0.89	73	16
C	FFU	95	354	5.99	3.88	16.1	31	0.85	87	15
CON	FFU	93	276	3.54	3.98	16.4	36	0.88	90	12
Mean		**97**	**349**	**4.34**	**3.93**	**16.5**	**33**	**0.86**	**77**	**17**
Regional Reference Values										
Bight'03 *	LPOTW	90	396	NC	3.68	NC	29	0.81	NC	17
Bight'03 *	Mid-shelf-non-POTW	76	321	NC	3.60	NC	26	0.83	NC	14
1985–2008	OCSD Quarterly Station Min.–Max.	57–158	213–1,591	0.56–19.3	2.64–4.14	9.92–19.5	9.08–41.3	0.62–0.91	8.34–92.9	9.17–39.8

WZU = Within ZID Upcoast; WZD = Within ZID Downcoast; NFU = Nearfield Upcoast; NFD = Nearfield Downcoast; FFU = Farfield Upcoast; ZID = Zone of Initial Dilution.
NC = Not Calculated
* Ranasinghe et al. 2006

echinoderms and polychaetes (Table 5-1). Mean abundances at the 60-m stations were comparable between ZID and non-ZID stations at 411 and 434, respectively.

However, the quarterly sampling showed differences between within-ZID and non-ZID stations. Quarterly non-ZID station mean abundances ranged from 276 to 440, while ZID sites ranged from 291 to 564 (Table 5-3; Figure 5-3). The higher within-ZID abundance was due primarily to increased abundances of polychaetes. All quarterly stations were within the historical range of values and non-ZID stations were comparable to or exceeded the Bight'03 large POTW and mid-shelf means.

Biomass

Biomass at the annual stations ranged from 0.64 g at slope Station 44 to 12.5 g at outer shelf Station 38 (Table 5-2). Mean biomass showed a similar distribution as abundance being highest at the outer shelf stations. The high biomass in this station group was due largely to high abundances of the red brittle star *Amphiodia urtica* and spionid polychaetes, particularly *Spiophanes berkeleyorum*. There was a very small, but significant relationship of biomass to station depth (R^2=0.16).

Mean biomass was generally at the quarterly ZID stations relative to the non-ZID stations, which ranged from 3.54 to 5.99 (Table 5-3). All biomass measurements were within the historical range for the District's quarterly stations.

Diversity Indices

Shannon-Wiener Diversity (H'), Margalef Species Richness (SR), and Schwartz' 75% Dominance (Dominance)

The annual survey results showed that community diversity was influenced more by station depth than by the effluent discharge. H', SR, and Dominance all showed a similar pattern of higher values at the shallow- and mid-shelf stations with values generally decreasing with increasing depth (Table 5-2; Figure 5-2). Regression analysis of diversity measures vs. station depth showed moderate to strong relationships for H', SR, and Dominance with R^2 values of 0.50, 0.70, and 0.43, respectively. Correlation analysis showed small inverse relationships of tLAB to H' (R=-0.32) and Dominance (R=-0.36) indicating a minor outfall influence.

The quarterly non-ZID station means for the three indices were in the mid to upper end of the range of historical values and some exceeded Bight'03 regional means for both large POTW and mid-shelf non-POTW areas. Within ZID station values fell in the lower half of the long-term range and were lower, but generally comparable to Bight'03 POTW and non-POTW areas (Table 5-3).

Evenness (J')

Converse to H', SR, and Dominance indices, which are sensitive to the number of species in a sample, J' is more sensitive to the equitable distribution of species in a sample and shows a much different spatial pattern. J' scores showed a U-shaped trend with changes in depth. J' scores were highest in the shallow and deep groups and lowest in the outer shelf m group (Table 5-2; Figure 5-2). There was no difference in mean J' scores between

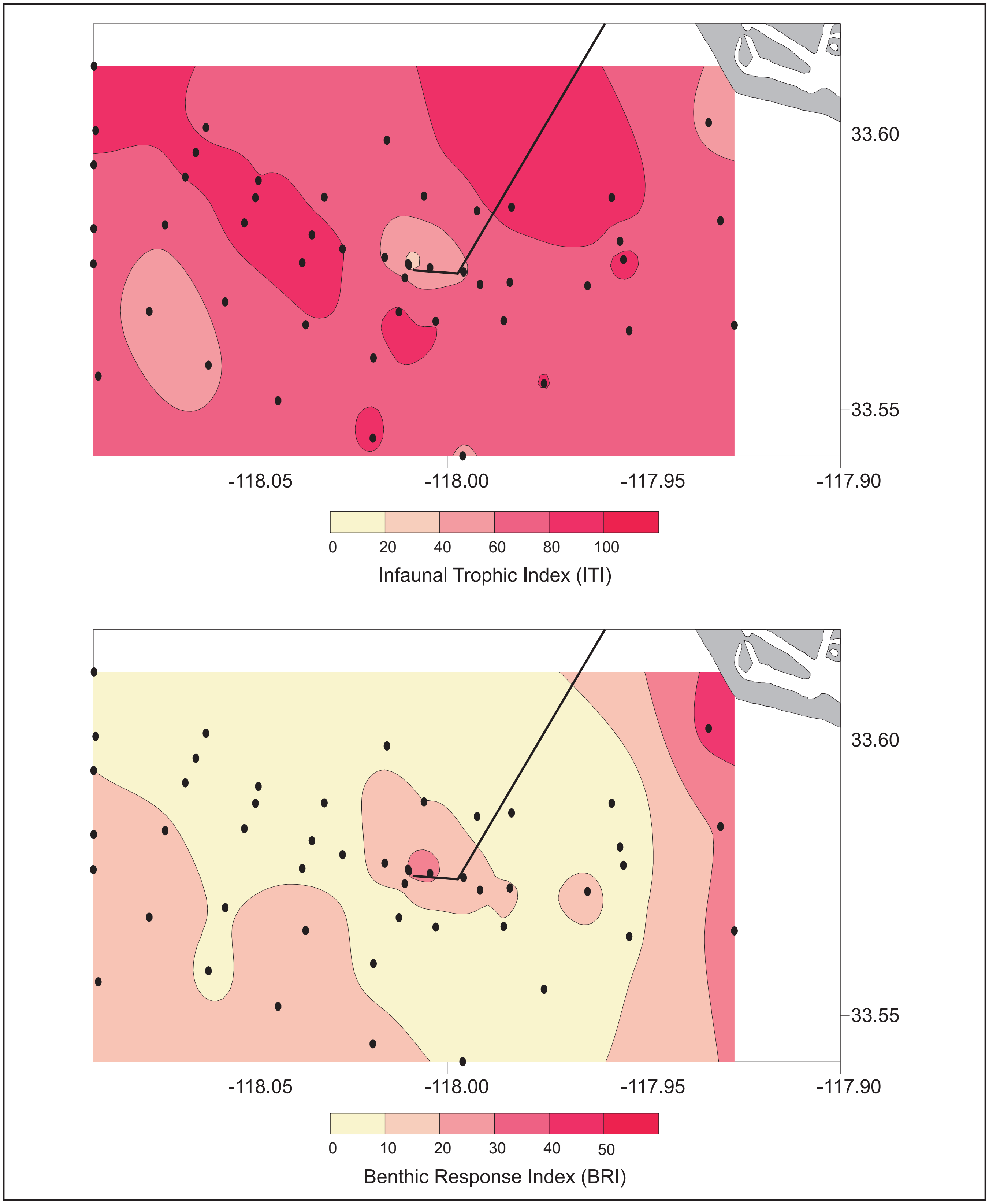


Figure 5-3. Spatial distributions of infaunal trophic index (ITI) and benthic response index (BRI) during July 2008.

Orange County Sanitation District, California.

ZID and non-ZID stations in the 56–60 m station group. Regression analysis showed no relationship between species evenness and station depth.

Species evenness at the quarterly non-ZID stations fell within a narrow range (0.84 to 0.89). All values fell within the long-term range and were greater than both Bight'03 large POTW and mid-shelf non-POTW area means (Table 5-3).

Infaunal Trophic Index and Benthic Response Index

Infaunal Trophic Index (ITI)

In July 2008, Infaunal Trophic Index (ITI) scores ranged from 21 at Station 0 to 93 at Station 36 (Table 5-2). The majority of ITI scores at stations outside the ZID indicated a normal community with the exception of Stations 40, 62, 64 and C2, which had scores indicating a changed community. Stations 40, 62 and 64 are located in the basin and C2 is located at the head of the Newport Canyon (Figure 5-1). Station C2 characterizes differently from the other 60 m shelf stations, including ZID stations, in sediment characteristics (See Chapter 4 Sediment Geochemistry) and infaunal communities (see cluster/MDS analysis later in this chapter). In general, values were lower near the ZID and increased with distance from the outfall (Figure 5-3). Regression analysis showed no relationship of ITI scores to station depth, but there was a good negative correlation of ITI scores and sediment tLAB (R=-0.60).

Quarterly mean ITI scores at non-ZID stations ranged from 64 at Station 1 to 90 at Station CON (Table 5-3). All ITI scores fell within the long-term range of values and indicated normal infaunal communities are present at all stations (Table 5-3).

Benthic Response Index (BRI)

Benthic Response Index (BRI) scores in the July annual survey ranged from 10 at Station 36 to 44 at Station C2 (Table 5-2). With the exception of the within-ZID stations, BRI scores were fairly uniform on the San Pedro Shelf, increasing slightly with station depth and decreasing with distance from the outfall (Figure 5-3). All San Pedro Shelf shallow and outfall-depth stations beyond the ZID had BRI scores indicating reference conditions. Several stations along the slope and basin had BRI scores indicating marginal deviation from reference conditions, while the score at Station C2 indicated a loss of biodiversity. Regression analysis showed no relationship between BRI Scores and station depth. There is a good correlation between BRI scores and sediment tLAB (R = 0.59).

Mean BRI scores at quarterly non-ZID stations ranged from 12 at Station CON to 22 at Station 1 (Table 5-3). All BRI scores were within the long-term range of values, comparable to Bight'03 means, and indicated reference conditions at all stations (Table 5-3).

Temporal (long-term) Trend Analysis

Long-term trends for all community measures were relatively unchanged from the 2007-08 monitoring period (OCSD 2008; Figure 5-4). Community measures in 2008-09 were within the range of long-term variability seen in the 60 m stations.

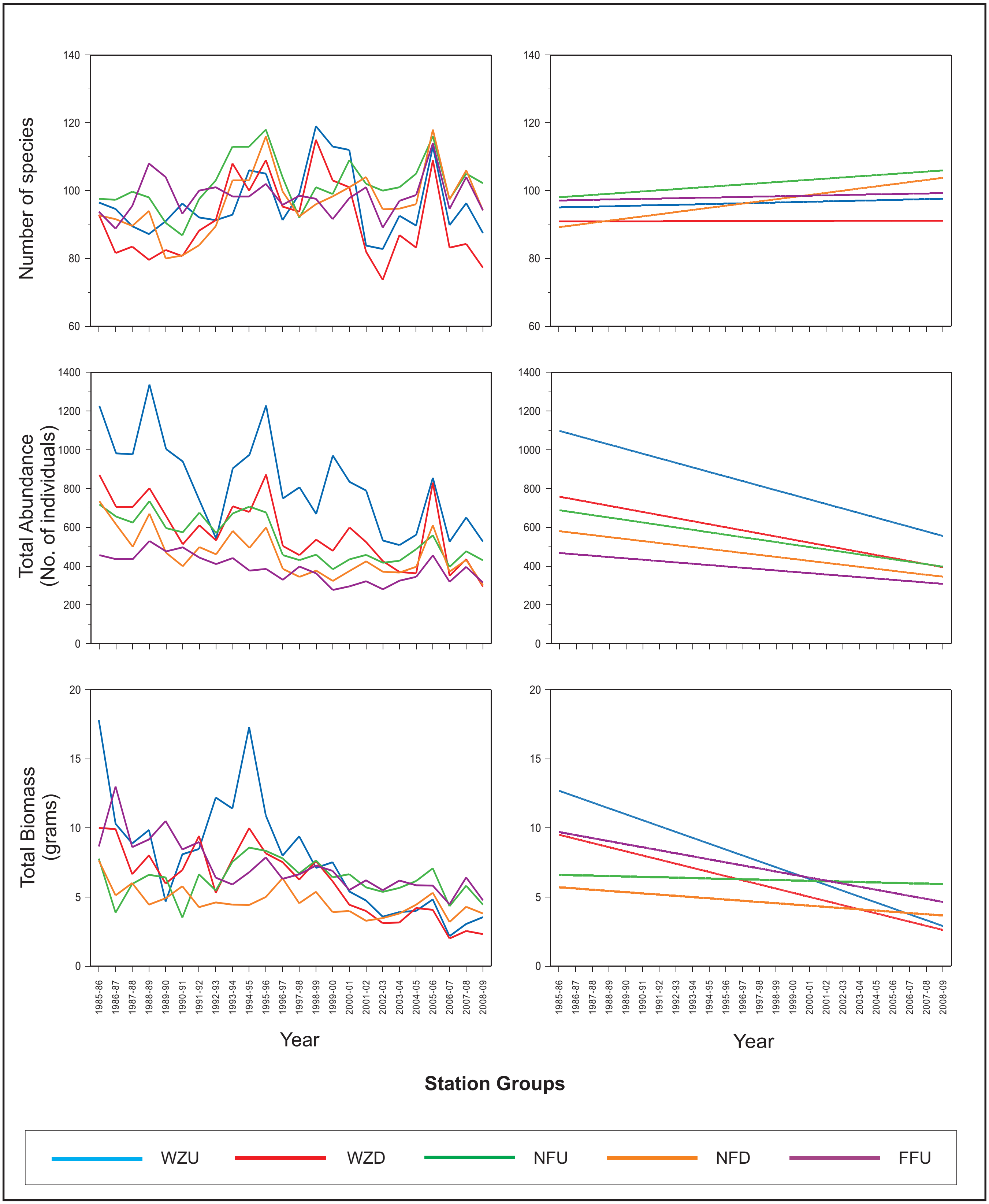


Figure 5-5. **Annual mean values for benthic infauna parameters for the period 1985–2009: No. of species, abundance, biomass, Shannon-Wiener diversity (H'), Margalef species richness (SR), Schwartz's 75% dominance, species evenness (J'), infaunal trophic index (ITI), and benthic response index (BRI).**

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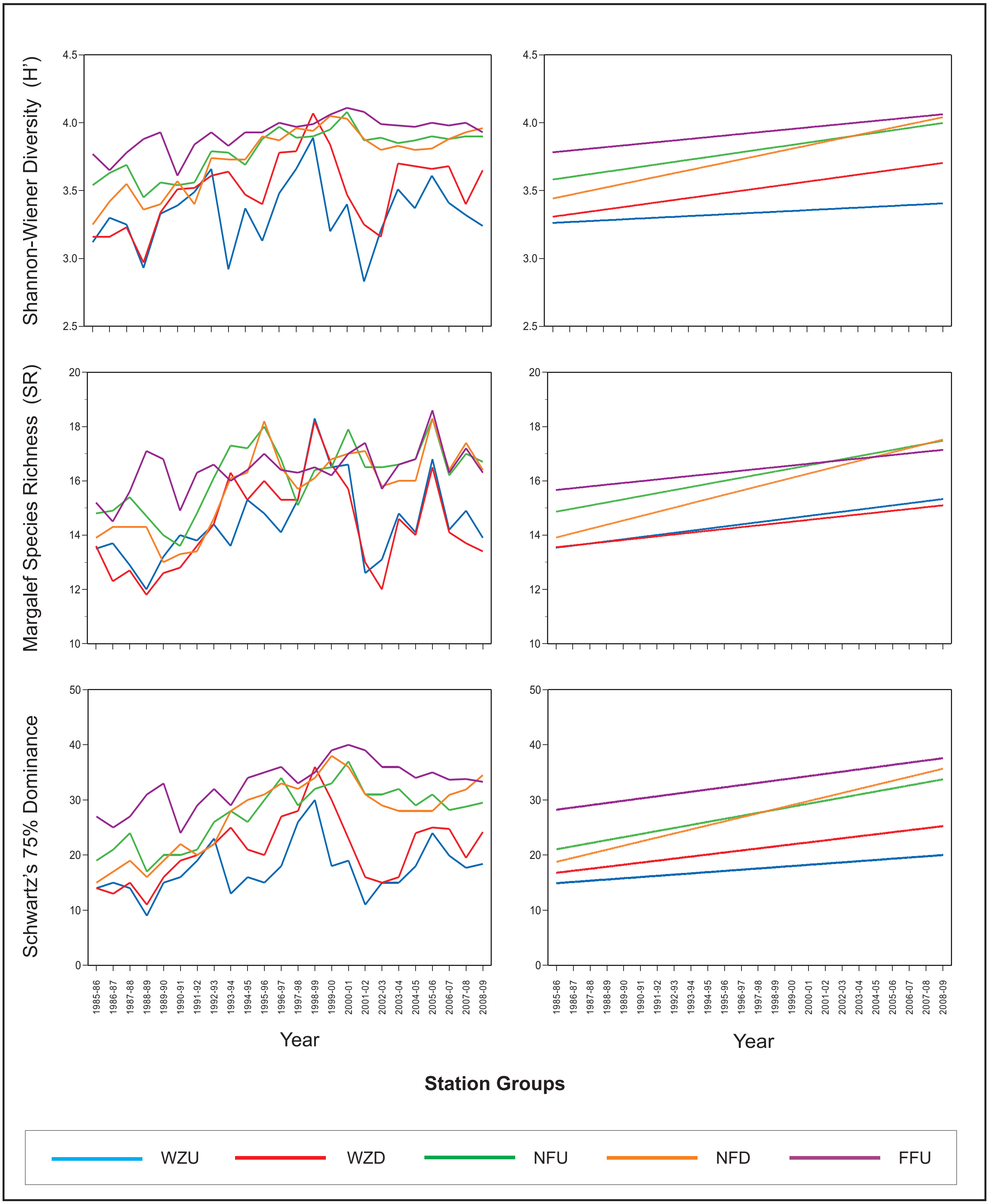

Figure 5-5 continued.

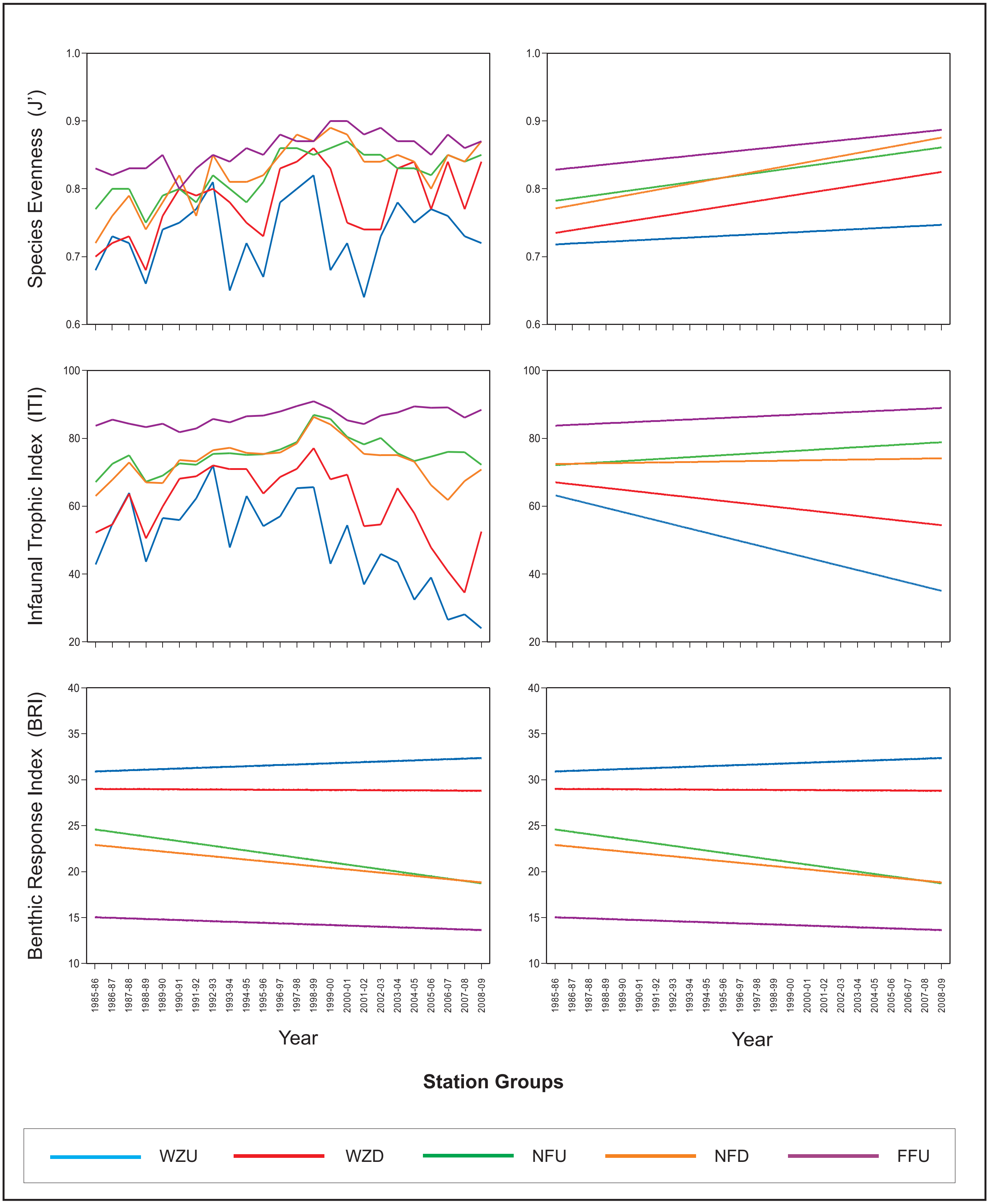

Figure 5-5 continued.

The various measures of community diversity, such as Shannon-Wiener Diversity, Margalef Species Richness, Species Evenness, and Schwartz' 75% Dominance are increasing over time in all station groups. By contrast, total abundance and total biomass are decreasing over time in all station groups indicating area-wide influences on these parameters. The number of species and abundance of individuals were down from last year in all station groups indicating an area-wide influence. The number of species is increasing over time at NFU (Stations 1 and 5) and NFD (Stations 9 and 12) station groups and show no change over time at the within-ZID and farfield station groups. ITI scores are increasing over time in the non-ZID station groups and indicate normal infaunal communities are present beyond the ZID. In contrast, the decreasing ITI scores within the ZID suggest either changed (WZD) or degraded (WZU) communities exist in these areas. Since 1999, ITI scores have been decreasing at within-ZID Stations 0 and ZB2 (WZU) indicating declining conditions. Conversely, ITI scores at within-ZID Stations 4 and ZB (WZD) have been increasing indicating improving conditions at these stations. The predominate sub-thermocline current flow is upcoast (see Chapter 3) and the WZU stations receive more direct effluent particulate deposition than the WZD stations, which may partially explain this disparity in conditions. BRI scores show similar patterns to ITI, although reversed since the two have inverse scales. Unlike ITI analyses, BRI scores generally indicate only a marginal deviation from reference condition at stations within the ZID rather than the degree of degradation of infaunal communities indicated by the ITI. In 2008-09, BRI scores changed very little at the within-ZID stations groups from 2007-08, increasing slightly at Stations 0 and ZB2 (WZU) and decreasing slightly at Station 4 and ZB (WZD).

Indicator Species

<u>Pollution Tolerant Species</u>

Euphilomedes carcharodonta
E. carcharodonta abundances distribution during the annual survey were highest in the areas just offshore and upcoast of the outfall diffuser (Figure 5-5). The distribution of *E. carcharodonta* was partially related to depth ($R^2 = 0.23$), but was not related to sediment tLAB concentrations indicating no relationship with the District's effluent discharge.

Capitella capitata
The July annual survey, as in previous years, included high abundances of *C. capitata* at within-ZID stations only where they were a major factor in the low ITI and high BRI scores at these stations. *C. capitata* was only present sporadically at stations outside the ZID (Figure 5-5) and abundances were not significantly related to station depth. Abundances were significantly correlated with tLAB concentrations (R=0.65), however, this result is driven by high abundances within the ZID. When ZID stations are removed from the analysis, there is no significant correlation.

<u>Pollution Sensitive Species</u>

Amphiodia urtica
In July 2008, *A. urtica* distribution was influenced by depth gradients (R^2=0.15), declining at the slope and basin depths, shallow areas, and near the outfall, while increasing with distance from the outfall (Figure 5-5). There was also a small but significant correlation to tLAB (R=-0.30), suggesting a minor effluent discharge influence.

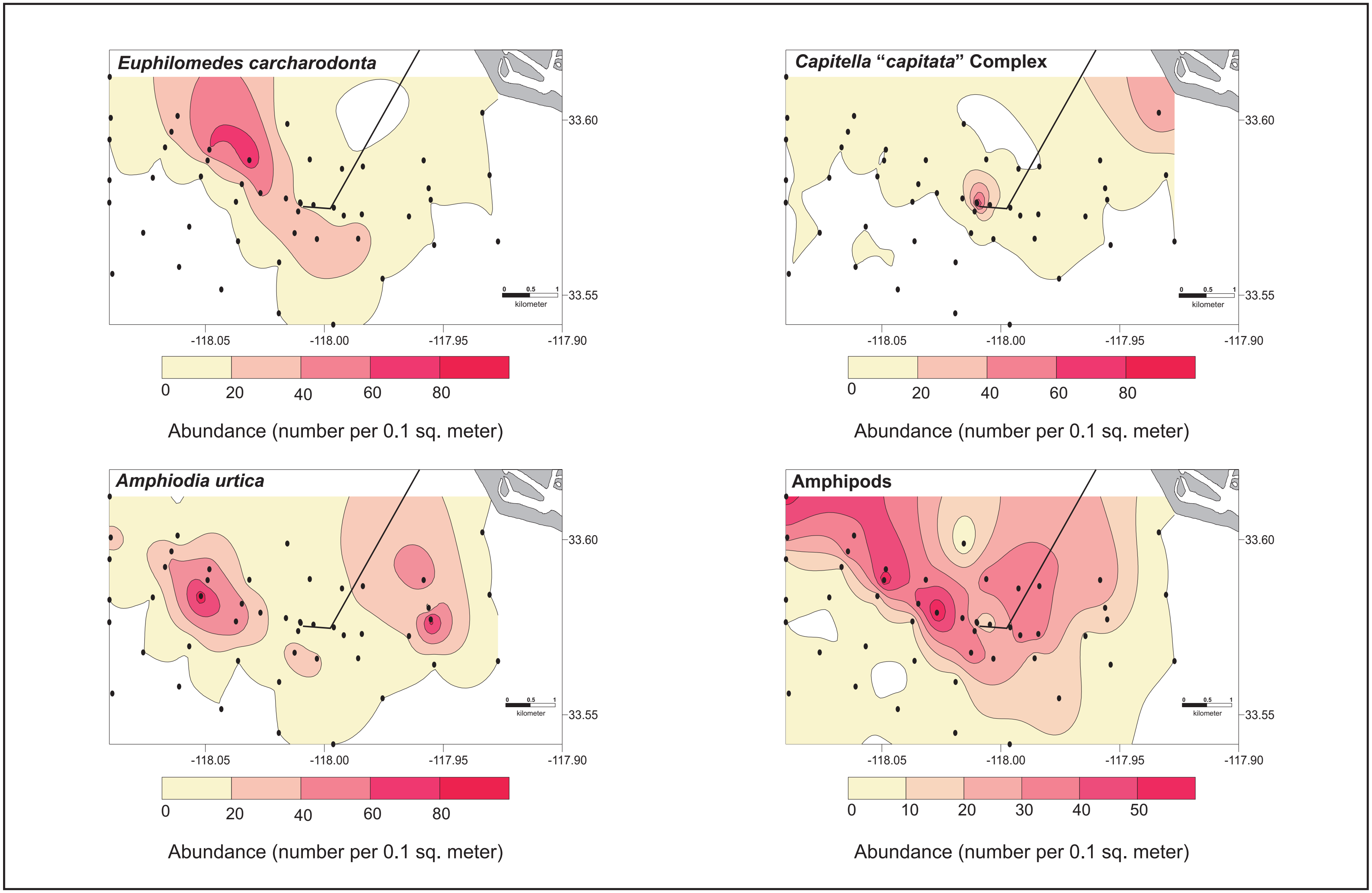

Figure 5-5. **Spatial distribution of abundance of *Euphilomedes carcharodonta*, *Capitella "capitata"* complex, *Amphiodia urtica,* and selected amphipods during July 2008.**

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Amphipods
The July annual survey showed abundances of Rhepoxynid and Ampelsicid amphipods were lowest in the canyons and slope areas, while they were highest on the San Pedro Shelf upcoast and inshore of the outfall pipe (Figure 5-5). Regression analysis showed that amphipod abundance significantly decreased with increasing depth (R^2=0.54). Correlation analysis showed a moderate inverse relationship between amphipod abundance and sediment tLAB concentrations (R=-0.40) suggesting that both depth and the effluent discharge may be affecting amphipod distribution.

Spatial Analysis

Cluster Analysis
Cluster analysis on the July 2008 abundance data identified 7 major station clusters (Figure 5-6). The station clusters generally follow depth contours and are similar to those reported in previous years (Figure 5-7). These station groups were corroborated through non-metric multidimensional scaling (MDS) using 4^{th} root transformed data and Bray-Curtis similarity as the resemblance matrix (Figure 5-8). The output stress was low (2D = 0.10; 3D = 0.08) indicating good ordination.

Station Cluster 1 (SC1) consists of only Station 44, which located in the San Gabriel Canyon at 241 m. SC1 is dominated by polychaetes (9 of 17 taxa, Table 5-4), which makes up 64% of the abundance of individuals. Three polychaete species (*Paradiopatra parva*, *Aglaomorphus erectans*, and *Onuphis iridescens*) comprise 50% of the abundance. A. erectans is unique to this station.

Table 5-4. Percent of abundance by taxa for cluster analysis station groups.

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Station Group	Percent of Abundance				
	Crustacea	Echinodermata	Mollusca	Minor Phyla	Polychaeta
1	18	11	7	0	64
2	0	0	22	0	78
3	12	8	26	3	51
4	18	8	22	10	33
5	8	10	15	3	64
6	22	6	5	12	55
7	6	1	3	4	86

Station Cluster 2 (SC2) consists of Stations 62 and C5. Station 62 is located along the slope of the San Gabriel Canyon at a depth of 241 m and Station C5 is located in the Newport Canyon at 300 m depth. SC2 is characterized by only 8 species and small abundances. Polychaetes account for 6 of 8 species and 78% of the abundance (Table 5-4). Three polychaetes (*Paraprionospio alata*, *Chloeia pinnata*, and *O. iridescens*) make up 50% of the total abundance. The polychaete *Leitoscopolos* sp A is found only in SC2.

Station Cluster 3 (SC3) consists of 8 stations and 2 sub-clusters located along the slope area. Sub-cluster A consists of the southern 3 stations (27, 39, and 65), and sub-cluster B of the northern group (24, 25, 57, 61, and 63). SC3 has 42 species, with 12 comprising

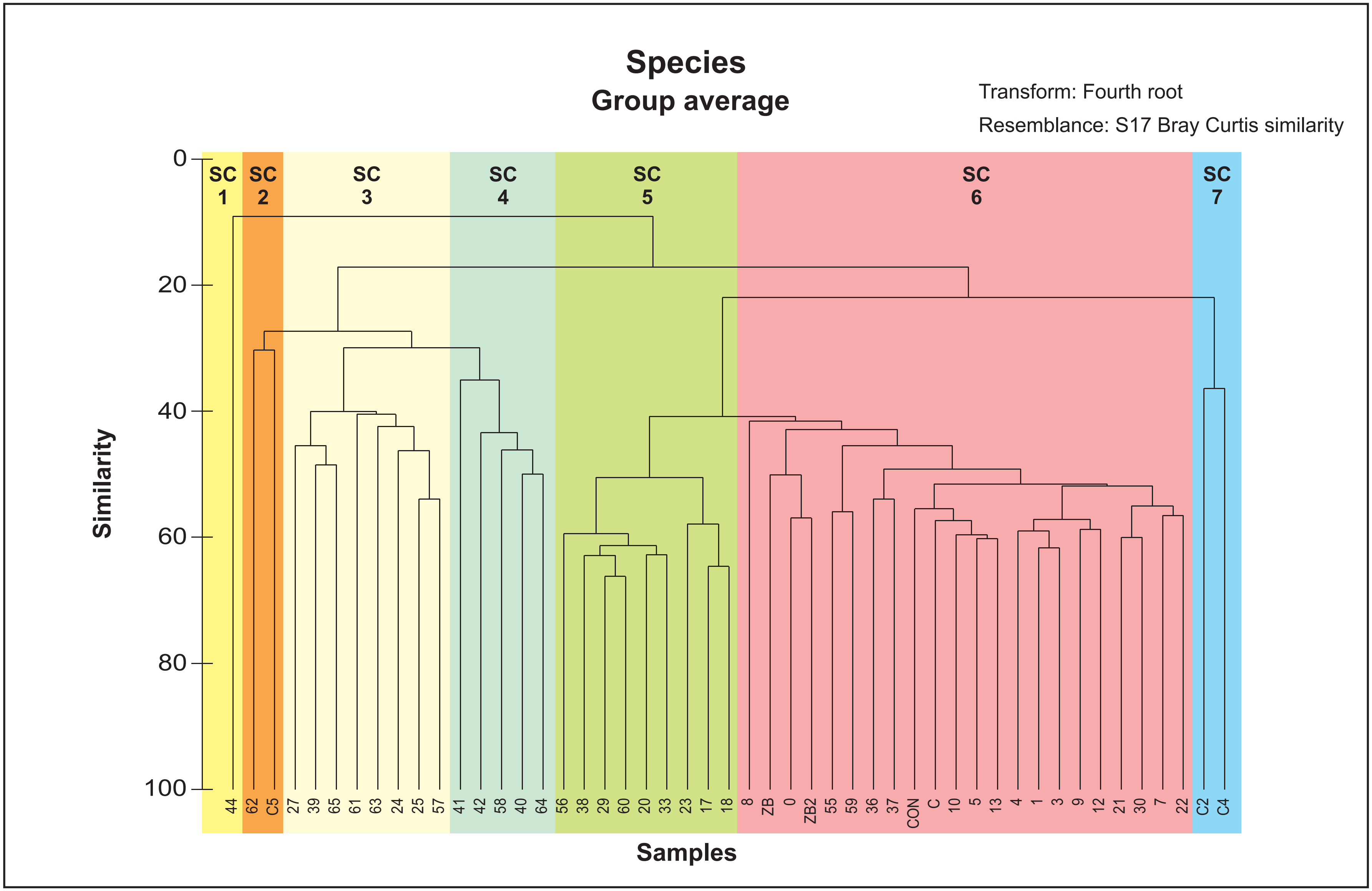

Figure 5-6. **Summary of cluster analysis and relationships among stations and infaunal species groups for July 2008.**

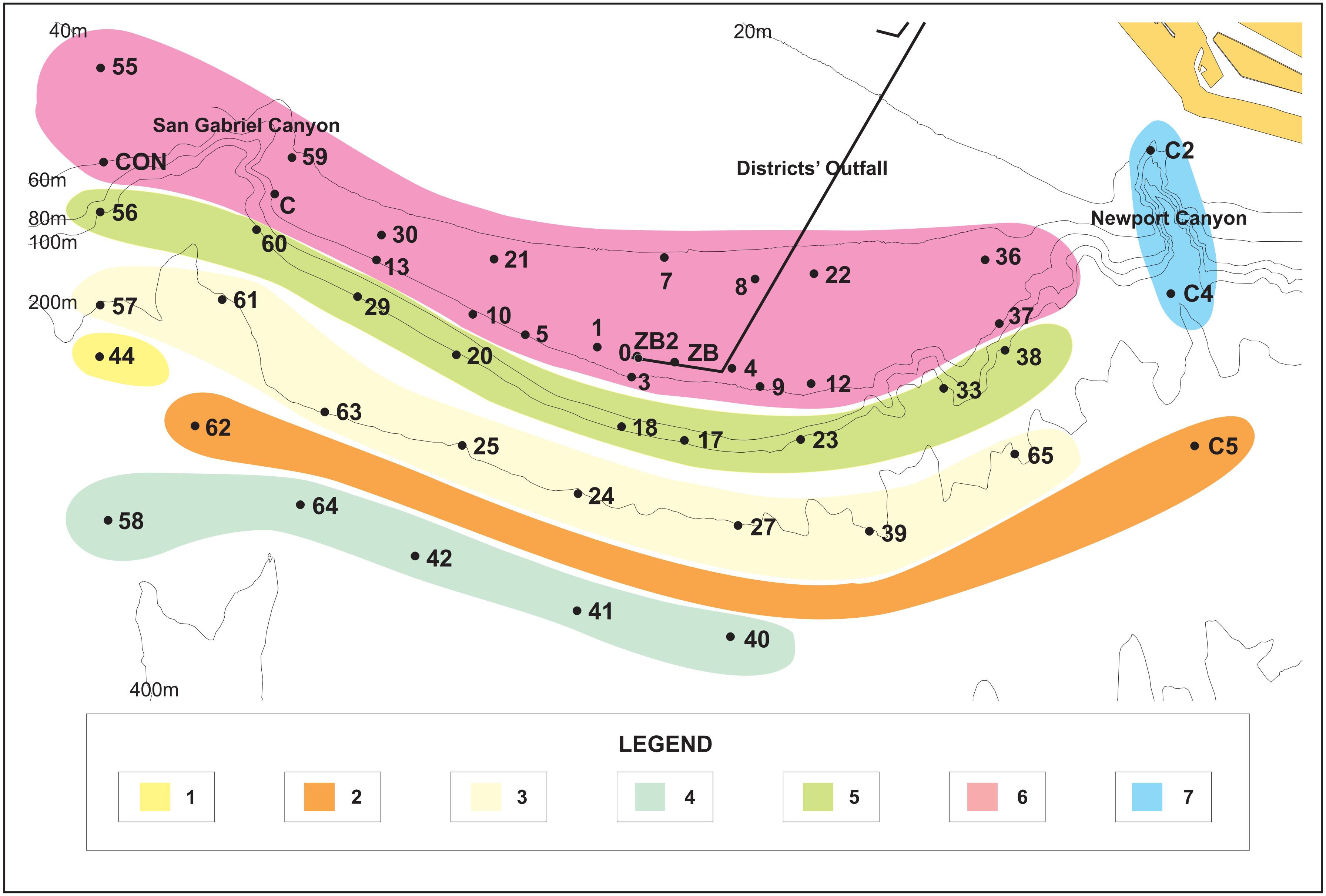

Figure 5-7. **Map of station groups from cluster analysis for July 2008.**

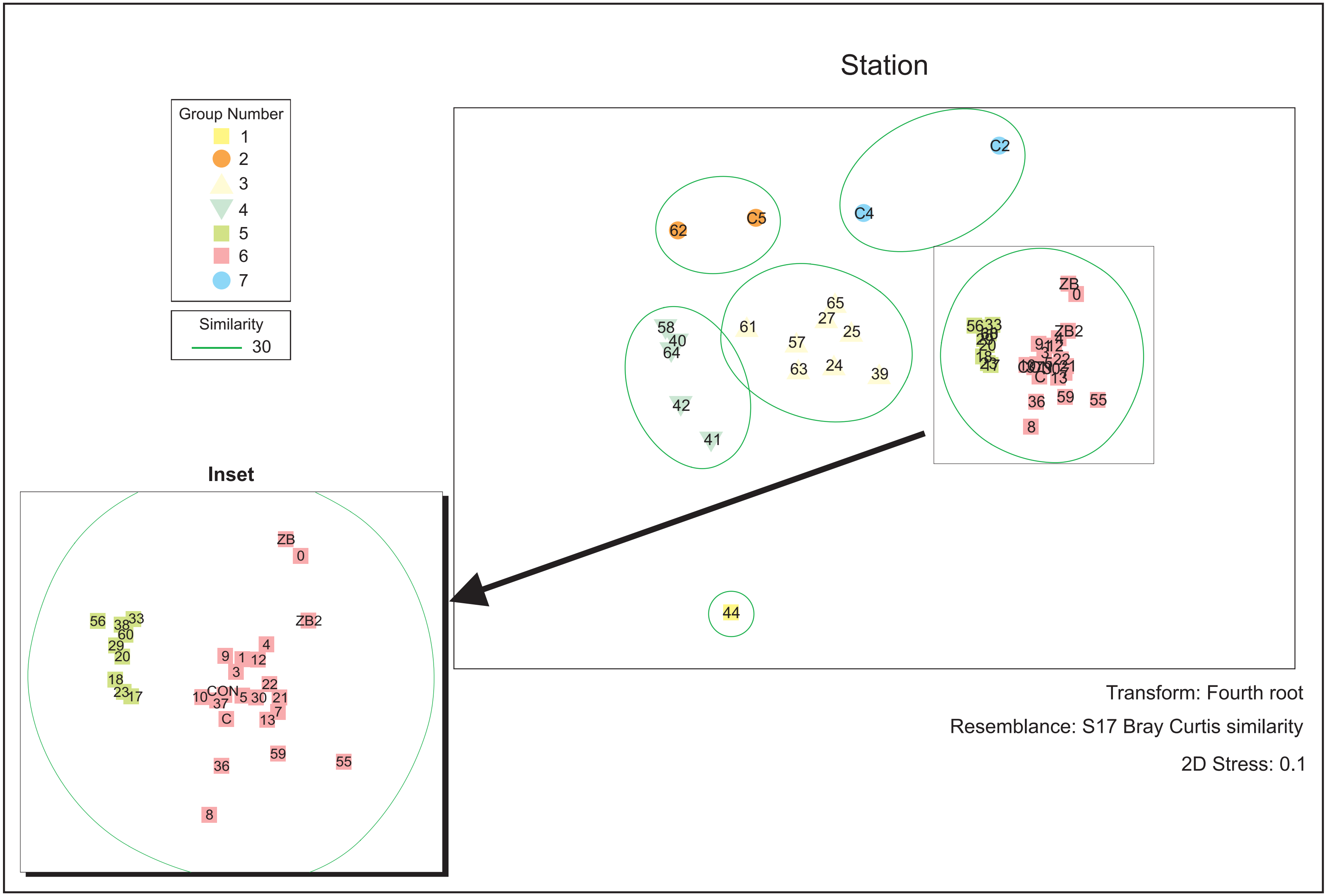

Figure 5-8. Non-metric multi-dimensional scaling (MDS) station plot with cluster analysis overlay. Station symbols correspond to cluster analysis station groupings (group numbers).

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50% of the individuals. Polychaetes make up 49% of the abundance. The top 5 numerically dominate species were the polychaetes *Spiophanes kimballi*, *P. alata*, *Tellina carpenteri, Glycera nana*, and *Scoletema tetraura* complex. Species unique to SC3 are *Ampharete acutifrons*, *Brada pluribranchiata*, *Cyclocardia gouldi*, *Heterophoxus affinis*, *Laonice nuchala*, and *Malmgreniella scriptoria*.

Station Cluster 4 (SC4) consists of 5 stations located at approximately 300 m in the basin offshore of the San Pedro Shelf. Polychaetes, mollusks, and crustaceans comprise 33%, 22%, and 18% of the abundance, respectively. The polychaetes *Aphelochaeta monilaris*, *S. kimballi*, and *P. alata* account for 25% of all individuals. Species characteristic of SC4 include the echinoid echinoderms *Brissopsis pacifica* and *Brisaster townsendi*, 2 crustaceans *Ampelisca unsocalae* and *Diastylis pellucida*, and the polychaete *Prionospio ehlersi*.

Station Cluster 5 (SC5) consists of 9 stations and 3 sub-clusters located along the outer shelf area at depths ranging from 91–100 m. Sub-cluster A includes Station 56 only, which is located at the upcoast end of the monitoring area. Sub-cluster B is comprised of Stations 20, 29, 33, 38, and 60. The stations in sub-cluster B are divided with Stations 20, 29, and 60 located upcoast and Stations 33 and 38 downcoast of the outfall. Sub-cluster C is made up of Stations 17, 18, and 23, which are more centrally located near the outfall diffuser. SC5 has 86 species, with 25 accounting for 50% of the individuals. Polychaetes dominate SC5 abundance (62%) followed by mollusks (12%) and echinoderms (8%). The top 5 numerically abundant species are the brittlestar *A. urtica and the polychaetes Spiophanes berkeleyorum*, *S. kimballi*, *Lumbrineris cruzesis*, and *Aphelochaeta glandaria* “complex”.

Station Cluster 6 (SC6) consists of 22 shallow and mid-shelf stations comprising 4 sub-clusters. Sub-cluster A contains of only Station 8, which is located inshore of the diffuser along the outfall pipe; sub-cluster B contains the within-ZID Stations 0, ZB, and ZB2; sub-cluster C has only Stations 55 and 59 located inshore at the upcoast end of the monitoring area; and sub-cluster D includes the remaining mid-shelf stations (1, 3, 4, 5, 7, 9, 10, 12, 13, 21, 22, 30, 36, 37, C, and CON). SC6 consists of 292 species, 51 of which are found only in this station cluster, while 28 species, 17 of which are polychaetes, comprise 50% of the population. Sub-cluster A has 68 species and is dominated by polychaetes and crustaceans. Sub-cluster B (the within-ZID sub-cluster) is comprised of 55 species with polychaetes accounting for 58% of the abundance. This sub-cluster contains the indicator species *C. capitata* and several other species that are associated with stressed environments, including the polychaete *Dorvillea* sp. and the mollusk *Solemya reidi*. Sub-cluster C is also dominated by polychaetes (63%), but lacks the indicator species found in sub-cluster B. Sub-cluster D is also dominated by polychaetes (51%), but also has the highest population of echinoderms (7%) of the 4 sub-clusters, including the indicator species *A. urtica*.

Station Cluster 7 (SC7) consists of Newport Canyon Stations C2 and C4 and is characterized by few species (16) and high abundances of polychaetes (75% of individuals). The 5 most abundant species, all polychaetes, make up 40% of the population of this cluster. The species are *P. alata*, *Cossura* sp A, *Heteromastus filobranchus*, *G. nana*, and *Praxillella pacifica*. Species unique to SC7 are the crustacean *Pinnixia occidentalis* and the polychaetes *Cossura* sp A, *H. filobranchus*, *Lepidasthenia berkeleyae*, and *Podarkeopsis glabrus*.

Overall, depth and sediment-related factors appear to be the most significant in determining infaunal distribution and abundance throughout the monitoring area. The within-ZID stations clustered with the larger shelf group, with 3 of the 4 within-ZID stations forming only a sub-cluster (sub-cluster B). This analysis supports the general finding that the effects of the wastewater discharge are primarily localized near the outfall and are causing only minimal effects to the infaunal community in the District's monitoring area.

CONCLUSIONS

Invertebrate communities outside the ZID appeared normal and most could be characterized as being of reference condition. Similar to previous years, the 2008-09 monitoring results showed some localized outfall effects within the ZID and at several stations close to the outfall. However, then on-ZID stations show only marginal deviation from reference condition per the ITI and BRI. Overall, the infaunal community in the monitoring area appears healthy and permit criteria regarding sediment quality were met (See Chapter 2). These results support the conclusion that outfall impacts are limited to those stations closest to the discharge and the receiving environment is not being degraded as a result of District operations.

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