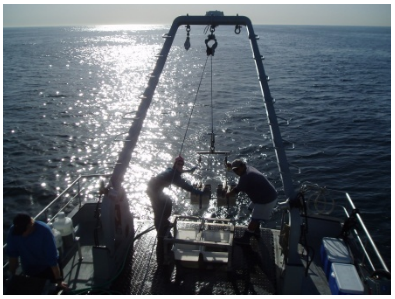
chapter 5

MACROBENTHIC INVERTEBRATE COMMUNITIES



Chapter 5
MACROBENTHIC INVERTEBRATE COMMUNITIES

INTRODUCTION

The District monitors the composition of the macrobenthic infaunal invertebrate community (small organisms, such as worms, clams, and burrowing shrimps) that lives in ocean 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., depth, grain size, and geochemistry) and anthropogenic (e.g., organic enrichment and chemical contaminants) influences (Pearson and Rosenberg 1978). 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). The ZID is the area within 60 m in any direction of the outfall diffuser (See box).

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 located away from the outfall.

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 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 tends to enhance infaunal abundances.

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.

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 (e.g., OCSD 2007–2011). 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.

Since 2005, infaunal community structure at the point of discharge has changed to the point of being classified as degraded. Changes in benthic assemblages are now being observed beyond the zone of initial dilution (ZID), though not to the point of degradation. As a result, the District is conducting an investigation into these changes. Efforts include: (1) a sediment mapping study; (2) a redistribution and increased density of sampling sites near the discharge in July 2011 and January 2012 in order to assess the spatial extent of these changes; (3) statistical correlation analyses of treatment plant operations and environmental monitoring data to identify potential causes (i.e., polymer and bleach usage, final effluent flow rates); (4) the potential effect of wastewater reclamation (e.g., decreased final effluent volume and reverse osmosis reject stream constituents); and (5) the formation of chlorination by-products from effluent disinfection. Results to date are discussed throughout this chapter where appropriate.

The District has undertaken three treatment process changes in the last 9 years that have altered 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, the District is under a consent decree issued in 2002 to achieve secondary treatment standards by 2012. This effort has involved significant construction and changes in treatment processes that have resulted in effluent quality that is below the 30 mg/L secondary treatment levels for total suspended solids (TSS) and biological oxygen demand (BOD). Lastly, the Ground Water Replenishment System (GWRS) water reclamation project was initiated in January 2008. This project has decreased the volume of effluent discharged into the ocean from 237 MGD in 2006-07 to 139 MGD in 2011-12. What effects these treatment changes have had or might have on the surrounding biota are still being assessed. Additional details of these changes in treatment and plant processes are provided in Chapter 1.

METHODS

The District's 2004 NPDES ocean discharge permit required that single samples be collected quarterly at 10 stations along the 60-meter (m) contour (outfall depth) and annually in summer at an additional 39 stations that range in depth from 40 to 303 m (see OCSD 2012 Figure 4-1). However, for 2011-12, the District received regulatory approval to conduct modified semiannual benthic sampling in summer (July/August 2011) and winter (January 2012) at 9 semi-annual stations, 39 annual stations and 21 additional new stations (Figure 5-1). A 0.1 m² modified paired Van Veen sediment grab sampler was used to collect single replicate infaunal samples. The purpose of the semi-annual surveys was to determine long-term trends and potential effects along the 60 m depth contour, while the annual and 29 new stations survey was primarily to assess the spatial extent of the influence of the effluent discharge. The new stations were included this year as part of

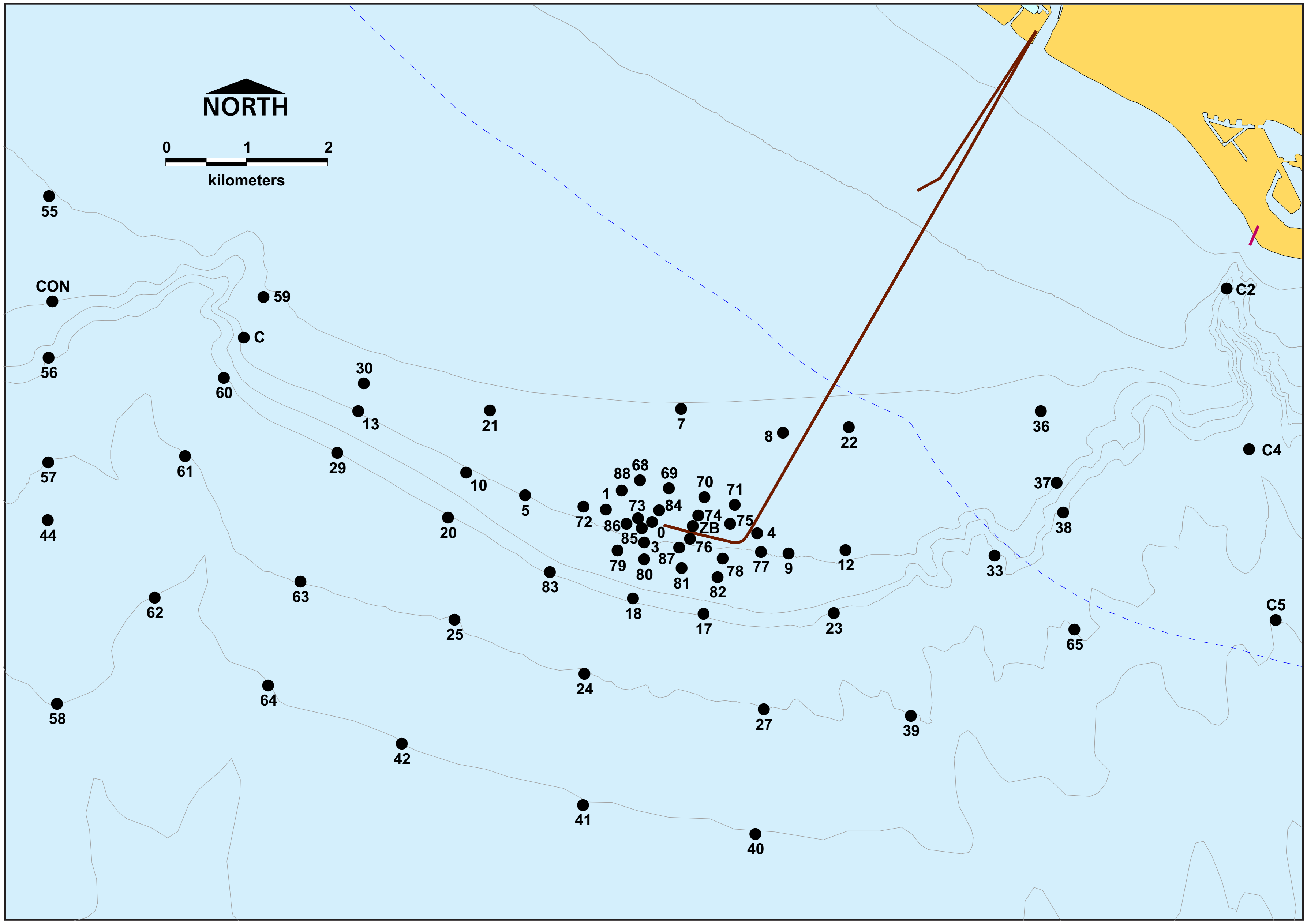


Figure 5-1. Benthic infaunal sampling stations for semi-annual surveys, 2011-12.

Orange County Sanitation District, California.

the investigation into changes in the benthic community near the outfall (see Chapter 7). Analysis of the summer survey data included the semi-annual stations survey as well as the annual and new stations (n=68 stations).

Six measures are used to assess infaunal community health and function: (1) total number of species; (2) total abundance of individuals; (3) Shannon-Wiener Diversity (H'); (4) Swartz 75% Dominance Index (SDI); (5) Infaunal Trophic Index (ITI); and (6) Benthic Response Index (BRI). Shannon-Wiener Diversity was calculated using $\log_e$ (Zar 1999). SDI was calculated as the minimum number of species with combined abundance equal to 75% of the individuals in the sample (Swartz 1978). H' and SDI are based on the number of species and the equitability of their distribution.

The Infaunal Trophic Index (ITI) is an index developed by Word (1978; 1990) to provide a measure of infaunal community "health" based on a species' mode of feeding (e.g., primarily suspension vs. deposit feeder). 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 inversely to ITI with low values (<25) representing reference conditions and high values (>72) representing the defaunation or exclusion of most species; The intermediate value range of 25–34 indicates a marginal deviation from reference conditions, 35–44 indicates a loss of biodiversity, and 45–72 indicates a loss of community function. The BRI was used to determine compliance with NPDES permit conditions. It is a commonly used southern California benchmark for infaunal community structure and was developed with the input of regulators.

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* Lyman 1860 (echinoderm) and select amphipod crustacean species from the genera *Ampelisca* and *Rhepoxynius*. The pollution tolerant species include *C. capitata* Complex (polychaete) and *Euphilomedes carcharodonta* Smith 1952 (ostracod crustacean).

Spatial patterns for the July 2011 and January 2012 annual station data were assessed graphically by benthic infaunal character or species using geographic data maps created using MapInfo v11.5 (Mapinfo 2012). PRIMER v6 (Plymouth Routines in Multivariate Ecological Research) multivariate statistical software was used to examine the spatial patterns of infaunal invertebrate communities in the monitoring area. 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). Clarke and Warwick (2001) warn that clustering is less useful and may be misleading where there is a strong environmental forcing, such as depth. Data were truncated to include only the shallow- and mid-shelf stations since depth is a strong environmental factor in delineating species clusters (OCSD 2010). Prior to the calculation of the Bray-Curtis indices, the data were 4th-root transformed in order to down-weight the highly abundant species and incorporate the importance of the less common species (Clarke and Warwick 2001). The SIMPER ("similarity percentages") routine was also used to determine inter- and intra-group species differences.

Relationships of species and community metrics with sediment concentrations of the sewage marker total linear alkylbenzenes (tLAB), percent fine sediments, percent total organic carbon (TOC), and dissolved sulfides were assessed using Pearson Product Moment Correlation with the Minitab® Statistical Software package. Regression analysis was used to measure relationships to station depth. Data was transformed where appropriate. Statistical significance was set at $p \leq 0.05$.

Temporal trends were evaluated graphically at the semi-annual stations. Each community measure was represented as a line graph to show the inter-annual variability. The semi-annual stations were divided into two station groups: within-ZID (0, 4, and ZB) and non-ZID stations (1, 5, 9, 12, C, and CON). Twenty of the 29 semi-annual stations were added this year, so there is no historic data for temporal trends at these new sites. The ZID and non-ZID stations represent those that have been sampled quarterly since 1985.

Infaunal organisms are classified into five "major taxa" for ease of comparison between stations and depth strata: Polychaeta (worms), Mollusca (snails, clams, etc.), Crustacea (shrimps, crabs, etc.), Echinodermata (sea stars, sea urchins, sea cucumbers), and minor phyla (Cnidaria, Nemertea, Echiura, etc.).

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

The following is a summary of the Summer 2011 and Winter 2012 surveys. The primary focus of this chapter is on the Summer 2011 survey data. The Winter 2012 data is presented but is not discussed in detail except where the difference between the summer and winter data is noteworthy.

RESULTS AND DISCUSSION

Taxa and Abundance

A total of 615 taxa comprising 41,538 individuals were collected in the 2011-12 monitoring year. This represents a comparable number of taxa with the previous year (618). However, there was a large decrease in the number of individuals from the 58,800 individuals collected in 2010-11. The number of individuals this year is the lowest in monitoring program history (1985–present). Further, the number of stations sampled was 138 compared to 139 in 2010-11 and 159 from 1998 through 2009. From 1998 through 2011, the total number of individuals ranged from 48,541 (2007-08) to 107,451 (2005-06) with a mean of 66,200. This occurred primarily in the polychaete and mollusk taxonomic groups. For example, shallow-shelf, mid-shelf within-ZID, and outer-shelf station means decreased, respectively, by 252, 61, and 103 individuals per station. The number of species and/or the number of individuals within a major taxonomic group was largely related to depth, with proximity to the outfall having less of an effect (Table 5-1). For example, the mean number of crustacean species and individuals generally decreased with increased station depth, but was comparable at within-ZID and non-ZID mid-shelf stations.

Community Indicators

Results and spatial trends from the July 2011 annual survey are discussed broadly in terms of station depth zones (e.g., shallow-shelf, mid-shelf within-ZID, etc.) with discussion of specific stations as appropriate. Correlations of community measures to sediment physical (grain size/percent fines) and chemical (tLAB, percent TOC, and dissolved sulfides) parameters were made only on shallow- and mid-shelf stations to eliminate depth-related factors.

Number of species

The number of species collected across all 68 stations in July 2011 was greatest at shallow-shelf, mid-shelf non-ZID, and outer-shelf stations and generally decreased with increasing depth (Tables 5-2 and 5-3; Figure 5-2). The mean number of species was lower at the 60 m within-ZID stations (76) relative to mid-shelf non-ZID stations (94). The number of species at stations located outside of the ZID on the middle shelf ranged from 70–121; this excludes Newport Submarine Canyon Station C2 (48 species), which is located near the Newport Pier and is not influenced by the outfall discharge. Mid-shelf non-ZID station values were comparable to or greater than the regional monitoring mid-shelf non-POTW (MSN-POTW; Publically Owned Treatment Works) mean of 76 species. All stations, except C2, were within the OCSD historical mid-shelf non-ZID range of 65–142 species. Unlike recent years (OCSD 2009, 2010, 2011) correlation analysis showed no relationship between the number of species and tLAB indicating no measureable influence from discharged wastewater particulates.

Abundance

Abundances of benthic invertebrates in the July 2011 survey followed the same general pattern as for number of species. Abundances were greatest at shallow-shelf, mid-shelf non-ZID, and outer-shelf stations and decreased with increasing depth (Tables 5-2 and 5-3; Figure 5-3). Contrary to recent years, abundances at within-ZID stations were comparable to mid-shelf non-ZID stations. This was due largely to the absence of large numbers of the polychaete *C. capitata* Complex that had been present primarily at Station 0. In July 2010, Station 0 had 1,280 *C. capitata* Complex compared to only 42 in July 2011. Mid-shelf non-ZID station abundances were generally comparable to or greater than the regional MSN-POTW mean of 321 individuals. All station abundances were within the OCSD historical mid-shelf non-ZID range of 163–1055 individuals.

Correlation analysis showed no relationship of the total abundance of individuals to sediment tLAB suggesting no significant outfall influence on infaunal community structure.

Diversity Indices

Four diversity (H' and SR) and species equitability (J' and 75% SDI) indices were calculated. All results are reported in tables and figures, but due to the high correlation of results only Shannon-Wiener Diversity (H') and Schwartz' 75% Dominance Index (SDI) are discussed.

Table 5-1. Major taxonomic groups by station depth and location within or outside the zone of initial dilution (ZID) in July 2011. Values represent the mean and (range) of values for stations within a depth range.

Orange County Sanitation District, California.

Community Measure	Depth (m)	Crustacea	Echinodermata	Misc. Phyla	Mollusca	Polychaeta
Number of Species	Shallow shelf (40–46)	30 (25–34)	5 (4–6)	10 (4–14)	12 (7–15)	52 (47–61)
	Mid-shelf ZID (56–58)	21 (13–26)	2 (1–4)	8 (6–9)	14 (11–16)	32 (28–35)
	Mid-shelf non-ZID (52–65)	26 (3–39)	3 (1–7)	6 (2–10)	15 (8–28)	44 (27–62)
	Outer shelf (91–100)	16 (8–25)	3 (1–5)	6 (3–10)	15 (10–23)	52 (29–75)
	Slope (187–241)	6 (1–20)	1 (0–2)	2 (0–4)	11 (5–17)	25 (9–32)
	Basin (296–303)	4 (1–7)	2 (0–4)	1 (0–5)	8 (6–12)	14 (11–20)
Abundance of Individuals	Shallow shelf (40–46)	138 (93–202)	31 (17–59)	16 (6–23)	25 (11–37)	219 (131–431)
	Mid-shelf ZID (56–58)	59 (29–111)	4 (1–8)	14 (11–16)	39 (29–51)	189 (136–243)
	Mid-shelf non-ZID (52–65)	90 (4–212)	10 (1–37)	17 (6–48)	35 (15–84)	219 (143–319)
	Outer shelf (91–100)	42 (23–78)	39 (17–76)	11 (5–18)	55 (17–207)	236 (74–323)
	Slope (187–241)	19 (1–107)	3 (0–6)	3 (0–5)	38 (13–82)	77 (16–148)
	Basin (296–303)	8 (2–21)	2 (0–5)	2 (0–7)	31 (15–52)	38 (23–54)

ZID = Zone of Initial Dilution

Table 5-2. Summary of infaunal community measures for all stations during the Summer 2011 survey, sorted by depth.

Orange County Sanitation District, California.

Station	Depth (m)	Total Number of Species	Total Abundance	Shannon-Wiener Diversity (H')	Margalef Species Richness (d)	Schwartz' 75% Dominance Index	Species Evenness (J')	Infaunal Trophic Index (ITI)	Benthic Response Index (BRI)
Shallow Shelf (40 – 46 meters)									
7	41	112	333	4.06	16.85	35	0.86	85	17
8	44	104	349	3.91	15.37	32	0.85	83	20
21	44	111	435	3.71	15.84	28	0.79	81	15
22	45	124	503	4.09	17.53	34	0.85	80	15
30	46	112	496	3.85	15.48	27	0.82	76	15
36	45	110	332	3.99	15.93	33	0.86	89	16
55	40	112	615	2.82	13.95	11	0.61	85	18
59	40	91	372	3.78	12.93	26	0.85	85	16
	Mean	**110**	**429**	**3.78**	**15.5**	**28**	**0.81**	**83**	**17**
Mid-Shelf Within-ZID (56 – 58 meters)									
0 *	56	61	212	2.82	9.08	11	0.69	23	36
4 *	56	89	397	3.03	12.47	14	0.68	77	19
76 *	58	84	268	2.95	11.98	14	0.67	69	24
ZB *	56	70	343	3.16	9.81	14	0.75	70	28
	Mean	**76**	**305**	**2.99**	**10.84**	**13**	**0.70**	**60**	**27**
Mid-Shelf Non-ZID (52 – 65 meters)									
1*	56	119	479	3.60	15.85	20	0.76	68	23
3*	60	91	406	3.51	13.35	17	0.77	65	22
5*	59	121	471	3.92	16.73	31	0.83	81	13
9*	59	88	350	2.97	12.21	14	0.67	80	16
10	60	98	372	3.98	13.95	32	0.88	85	12
12*	58	89	271	3.03	12.93	19	0.68	82	18
13	59	93	278	4.04	14.50	35	0.90	89	12
37	56	115	290	4.02	17.17	34	0.85	80	18
68*	52	94	378	3.42	12.75	19	0.77	80	19
69*	52	85	420	3.39	12.77	17	0.77	86	18
70*	52	100	304	3.66	13.91	22	0.81	81	19
71*	52	84	334	2.96	11.16	12	0.68	76	23
72*	55	117	402	3.61	16.22	28	0.77	75	20
73*	55	72	244	3.30	10.76	16	0.78	52	32
74*	57	102	460	3.60	13.87	22	0.79	70	23
75*	60	75	314	3.07	10.10	13	0.73	71	27
77*	60	89	339	3.22	12.78	15	0.72	74	17
78*	63	94	454	2.90	12.35	12	0.64	75	19
79*	65	104	366	3.81	15.21	28	0.82	82	17
80*	65	106	492	3.39	14.35	20	0.73	84	15
81*	65	89	270	3.37	13.16	19	0.76	78	19
82*	65	85	282	2.68	12.10	12	0.61	75	17
84*	54	70	289	3.04	9.32	12	0.73	83	32
85*	57	95	629	3.55	12.56	18	0.79	65	27
86*	57	100	436	3.45	13.68	16	0.76	68	26
87*	60	79	268	2.98	10.97	15	0.70	40	23
88*	57	107	373	3.54	14.38	25	0.77	78	20
C*	56	111	327	3.99	15.95	34	0.86	83	16
C2	56	48	391	2.11	5.90	6	0.56	65	45
CON*	59	104	449	3.85	15.20	26	0.83	82	15
	Mean	**94**	**371**	**3.40**	**13.21**	**20**	**0.76**	**75**	**21**

Table 5-2 Continues.

Table 5-2 Continued.

Station	Depth (m)	Total Number of Species	Total Abundance	Shannon-Wiener Diversity (H’)	Margalef Species Richness (d)	Schwartz’ 75% Dominance Index	Species Evenness (J’)	Infaunal Trophic Index (ITI)	Benthic Response Index (BRI)
Outer Shelf (91–100 meters)									
17	91	87	294	3.64	12.52	25	0.83	84	14
18	91	65	172	3.49	10.73	22	0.84	87	13
20	100	94	330	3.28	13.05	15	0.73	82	18
23	100	104	458	3.45	14.18	18	0.75	85	15
29	100	83	370	3.38	11.83	18	0.77	84	19
33	100	83	452	3.15	11.54	15	0.71	77	19
38	100	118	577	3.55	15.76	20	0.75	77	19
56	100	97	361	3.46	13.21	16	0.77	80	19
60	100	87	321	3.24	12.65	18	0.73	83	15
83	100	104	490	3.78	14.74	23	0.81	86	13
	Mean	**92**	**383**	**3.44**	**13.0**	**19**	**0.77**	**82**	**16**
Slope (187–241 meters)									
24	200	45	125	2.74	7.65	11	0.71	69	26
25	200	50	149	2.76	7.91	9	0.71	67	22
27	200	51	170	2.81	7.90	10	0.72	70	20
39	200	69	348	2.46	9.23	5	0.59	78	19
44	241	17	32	2.38	3.65	6	0.86	33	26
57	200	39	73	3.20	7.93	15	0.87	70	20
61	200	43	101	3.18	7.75	15	0.85	52	23
63	200	46	87	2.63	7.53	9	0.70	73	21
65	200	50	137	3.04	8.25	12	0.78	65	23
C4	187	46	167	2.92	7.42	10	0.77	60	31
	Mean	**46**	**139**	**2.81**	**7.5**	**10**	**0.75**	**64**	**23**
Basin (296–303 meters)									
40	303	33	88	2.80	5.73	10	0.81	54	27
41	303	29	74	2.30	5.26	6	0.69	51	27
42	303	30	72	2.94	6.15	12	0.85	58	27
58	300	33	91	2.63	5.98	8	0.77	56	22
62	300	22	56	2.76	5.06	11	0.91	42	31
64	300	32	78	3.15	6.43	14	0.93	74	27
C5	296	29	105	2.17	4.83	6	0.66	74	34
	Mean	**30**	**81**	**2.68**	**5.6**	**10**	**0.80**	**58**	**28**
Regional Reference Values									
Bight’03 LPOTW*		90	396	3.68	NC	29	NC	NC	17
Bight’03 MSN-POTW*		76	321	3.60	NC	26	NC	NC	14
OCSD ZID-Station Min.–Max. 1998-2010		40–137	184–2686	0.78–4.19	4.69–19.50	1–41	0.19–0.91	1–84	20–43
OCSD Non-ZID Station Min.–Max. 1998-2010		65–142	163–1055	2.99–4.31	11.29–21.12	11–46	0.68–0.93	42–94	9–30

ZID = Zone of Initial Dilution, LOPTW = Large POTW, MSN-POTW = Mid-shelf non-POTW, NC = Not calculated.
*Semiannual Station

Table 5-3. Summary of infaunal community measures for all stations during the Winter 2011 survey, sorted by depth.

Orange County Sanitation District, California.

Station	Depth (m)	Total Number of Species	Total Abundance	Shannon-Wiener Diversity (H')	Margalef Species Richness (d)	Schwartz' 75% Dominance Index	Species Evenness (J')	Infaunal Trophic Index (ITI)	Benthic Response Index (BRI)
Shallow Shelf (40 – 46 meters)									
7	41	112	377	4.05	16.59	33	0.86	87	19
8	44	106	320	4.02	16.04	33	0.87	87	21
21	44	82	255	3.78	13.03	27	0.86	80	18
22	45	111	406	3.99	15.59	33	0.86	86	17
30	46	93	394	3.75	13.28	30	0.84	85	16
36	45	85	276	3.69	12.78	25	0.84	92	17
55	40	73	321	2.77	9.98	12	0.66	92	16
59	40	95	544	3.39	12.93	21	0.76	85	14
	Mean	**95**	**362**	**3.68**	**13.8**	**27**	**0.82**	**87**	**17**
Mid-Shelf Within-ZID (56 – 58 meters)									
0 *	56	56	141	2.93	8.97	13	0.74	59	25
4 *	56	87	243	3.64	12.76	24	0.83	69	23
76 *	58	81	393	2.93	10.92	9	0.67	69	27
ZB *	56	89	392	3.45	12.14	17	0.78	75	26
	Mean	**78**	**292**	**3.24**	**11.2**	**16**	**0.76**	**68**	**25**
Mid-Shelf Non-ZID (52 – 65 meters)									
1*	56	95	320	3.57	13.42	21	0.79	77	21
3*	60	107	492	3.24	14.42	16	0.70	72	25
5*	59	101	338	3.96	14.57	31	0.87	83	15
9*	59	84	240	3.58	12.68	22	0.81	81	17
10	60	76	245	3.71	11.72	24	0.87	84	14
12*	58	93	249	3.90	14.00	32	0.87	81	20
13	59	108	342	4.18	16.11	36	0.90	87	14
37	56	112	384	3.99	16.02	35	0.85	75	22
68*	52	92	324	3.51	13.08	20	0.79	82	19
69*	52	100	324	3.70	13.65	25	0.82	79	21
70*	52	89	280	3.57	13.55	20	0.80	81	21
71*	52	87	366	3.19	11.95	14	0.72	80	23
72*	55	82	321	3.71	11.93	22	0.85	79	19
73*	55	65	237	3.02	8.62	12	0.75	70	27
74*	57	78	333	3.05	10.80	13	0.71	74	22
75*	60	72	269	3.33	10.16	17	0.79	70	30
77*	60	83	290	3.20	12.01	17	0.73	81	20
78*	63	90	496	3.09	11.89	13	0.69	77	22
79*	65	97	421	3.21	12.93	16	0.71	80	19
80*	65	67	190	3.25	11.29	16	0.77	77	17
81*	65	95	318	3.64	13.87	23	0.81	75	21
82*	65	94	308	3.56	13.65	23	0.79	77	19
84*	54	106	595	3.39	13.94	16	0.74	84	26
85*	57	81	410	3.10	10.77	12	0.72	67	27
86*	57	83	373	3.19	11.56	13	0.73	67	26
87*	60	75	290	2.93	10.74	12	0.68	66	22
88*	57	97	376	3.53	13.00	22	0.79	82	21
C*	56	96	387	3.90	14.13	28	0.86	69	16
C2	56	45	257	2.18	6.22	6	0.59	69	46
CON*	59	98	263	4.16	14.97	37	0.92	86	16
	Mean	**88**	**335**	**3.45**	**12.6**	**20**	**0.78**	**77**	**22**

Table 5-3 Continues.

Table 5-3 Continued.

Station	Depth (m)	Total Number of Species	Total Abundance	Shannon-Wiener Diversity (H')	Margalef Species Richness (d)	Schwartz' 75% Dominance Index	Species Evenness (J')	Infaunal Trophic Index (ITI)	Benthic Response Index (BRI)
				Outer Shelf (91–100 meters)					
17	91	98	460	3.78	14.37	24	0.82	81	17
18	91	97	354	3.86	14.47	28	0.84	84	12
20	100	88	355	3.59	12.87	19	0.80	84	18
23	100	92	368	3.65	13.44	22	0.81	86	21
29	100	86	383	3.25	12.42	16	0.73	80	18
33	100	84	290	3.33	12.64	19	0.75	76	24
38	100	105	614	3.67	15.31	23	0.78	79	21
56	100	90	304	3.74	13.52	22	0.83	79	20
60	100	85	312	3.64	12.70	22	0.82	81	19
83	100	90	368	3.60	12.58	21	0.81	84	14
	Mean	**92**	**381**	**3.61**	**13.4**	**22**	**0.80**	**81**	**19**
				Slope (187–241 meters)					
24	200	55	128	2.49	8.70	9	0.62	76	18
25	200	41	97	2.77	6.98	9	0.75	75	20
27	200	66	197	2.90	10.34	12	0.69	74	17
39	200	51	219	2.88	8.00	10	0.73	78	12
44	241	23	46	2.50	5.05	8	0.79	67	25
57	200	26	62	2.87	5.14	11	0.88	73	24
61	200	35	96	2.73	6.07	8	0.77	70	23
63	200	54	117	3.11	9.34	16	0.78	72	22
65	200	64	564	1.17	7.79	1	0.29	67	18
C4	187	44	143	2.76	7.28	8	0.73	72	28
	Mean	**46**	**167**	**2.62**	**7.5**	**9**	**0.70**	**72**	**21**
				Basin (296–303 meters)					
40	303	27	66	2.18	5.19	6	0.65	65	25
41	303	34	60	3.13	6.65	14	0.89	62	25
42	303	27	65	2.55	4.89	9	0.80	70	20
58	300	25	48	2.92	5.53	11	0.90	70	19
62	300	14	34	2.17	3.08	6	0.84	67	20
64	300	20	67	2.58	3.83	9	0.88	60	31
C5	296	18	50	2.10	3.51	6	0.73	74	34
	Mean	**24**	**56**	**2.52**	**4.7**	**9**	**0.81**	**67**	**25**
				Regional Reference Values					
Bight'03 LPOTW*	90	396	NC	3.68	NC	29	NC	NC	17
Bight'03 MSN-POTW*	76	321	NC	3.60	NC	26	NC	NC	14
OCSD ZID-Station Min.–Max. 1998-2010		40–137	184–2686	0.78–4.19	4.69–19.50	1–41	0.19–0.91	1–84	20–43
OCSD Non-ZID Station Min.–Max. 1998-2010		65–142	163–1055	2.99–4.31	11.29–21.12	11–46	0.68–0.93	42–94	9–30

ZID = Zone of Initial Dilution, LOPTW = Large POTW, MSN-POTW = Mid-shelf non-POTW, NC = Not calculated.
*Semiannual Station

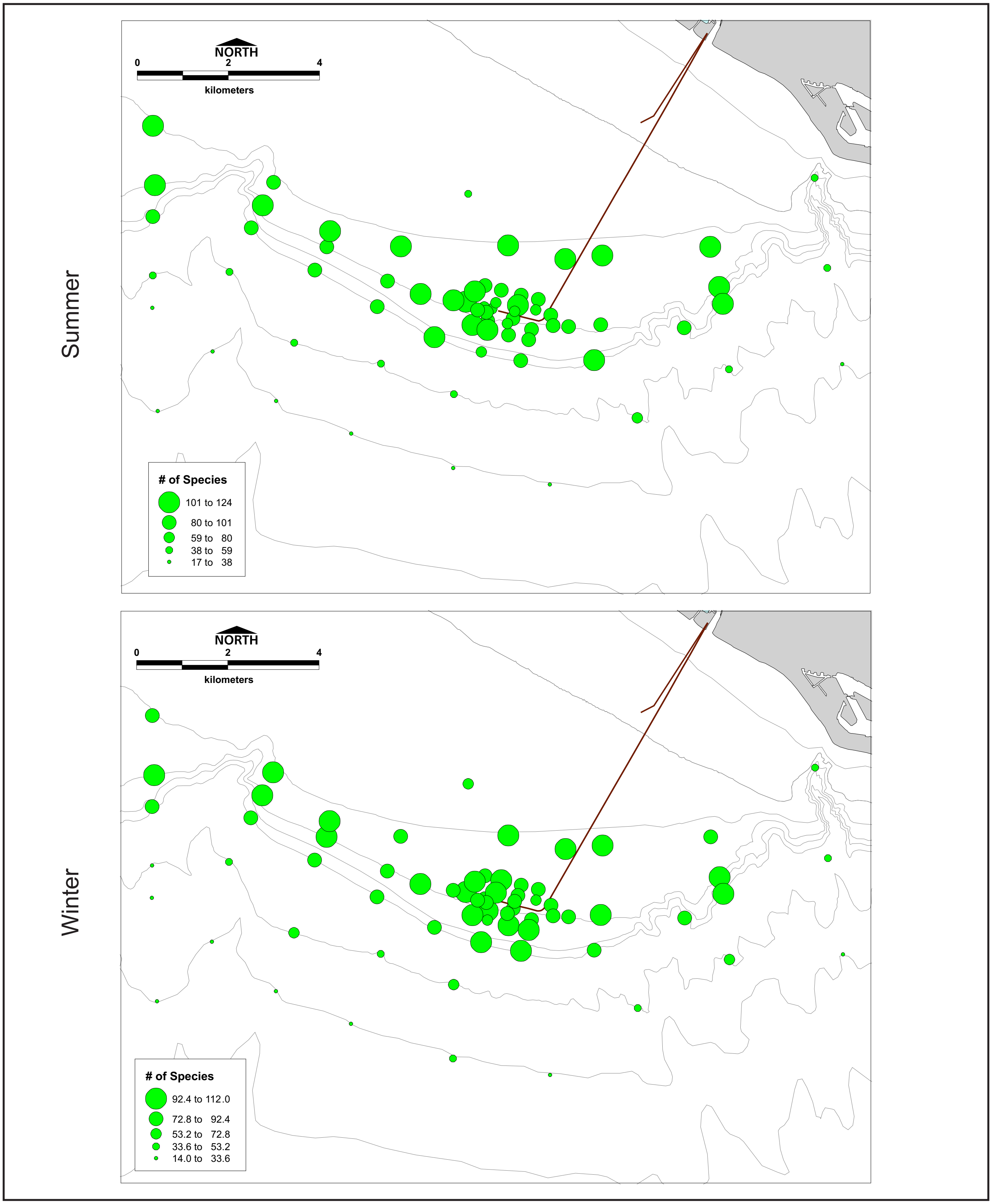


Figure 5-2. **Spatial trend bubble plots of number of species for summer 2011 (top) and winter 2012 (bottom).**

Orange County Sanitation District, California.

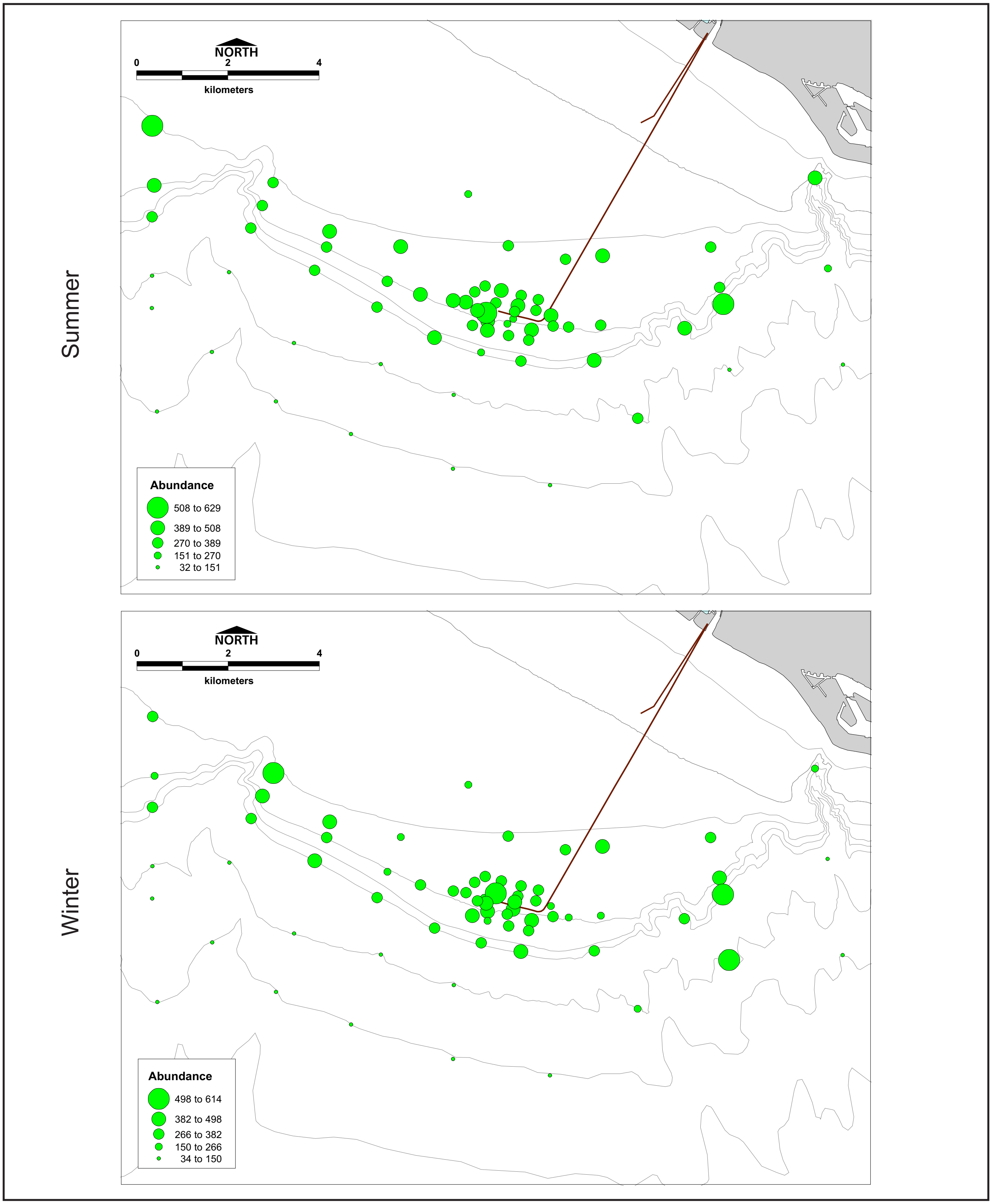


Figure 5-3. **Spatial trend bubble plots of abundance for summer 2011 (top) and winter 2012 (bottom).**

Orange County Sanitation District, California.

Shannon-Wiener Diversity (H')

Consistent with previous summer surveys (e.g., OCSD 2011), the summer 2011 survey showed a pattern of higher H' values at the shallow-, non-ZID mid-shelf, and outer-shelf stations with values generally decreasing with increasing depth and proximity to the outfall (Tables 5-2 and 5-3; Figure 5-4). H' values at mid-shelf non-ZID stations were comparable to the regional MSN-POTW mean of 3.60. All station H' values were within the OCSD historical mid-shelf non-ZID range of 0.79–4.19. Correlation analysis showed no relationship of H' to sediment tLAB suggesting no significant outfall influence on infaunal community structure.

Schwartz' 75% Dominance Index (SDI)

SDI scores in the summer 2011 survey were greatest at the shallow-shelf stations and decreased with increased station depth and outfall proximity (Tables 5-2 and 5-3; Figure 5-5). Several stations near the ZID (Stations 3, 9, 71, 73, 75, 78, 82, 84, 86, and 87; mean=14) had SDI values comparable to the within-ZID station mean of 13. This was due primarily to increased abundances of several polychaete species: *Aricidea (Acmira) catherinae* Laubier 1967, *Chaetozone columbiana* Blake 1996, *Chloeia pinnata* Moore 1911, *Mediomastus* sp., *Prionospio (Prionospio) jubata* Blake 1996. All station SDI values were within the OCSD historical range of 1–41. Mid-shelf SDI values were generally lower than the regional MSN-POTW mean of 26. Correlation analysis showed no relationship of SDI to sediment tLAB suggesting no significant outfall influence on infaunal community structure.

Infaunal Trophic Index and Benthic Response Index

Infaunal Trophic Index (ITI)

For the summer 2011 survey mean ITI scores were greatest at shallow-shelf stations and generally decreased with increased station depth and outfall proximity (Table 5-2; Figure 5-6). Scores tend to increase with distance upcoast and inshore from the outfall. Consistent with previous years, ITI scores were low in the San Gabriel and Newport Canyons, in the basin, and near the ZID. Only two mid-shelf non-ZID stations (73 and 87) had ITI scores that indicate a changed (less than normal) condition and no scores indicated degraded conditions. Both stations are located within 500 m of the outfall. Correlation analysis showed no relationship of ITI to sediment tLAB suggesting no significant outfall influence on infaunal community structure.

ITI scores were higher in the winter survey than in summer (Table 5-3). The ITI scores at all mid-shelf non-ZID stations indicated normal populations. Further, the ITI score at within-ZID Station 0 increased from 23 (degraded conditions) in summer to 59 (changed, but near normal conditions) in winter indicating improving conditions. ITI scores at Station 0 in the 2010-11 monitoring year ranged from 1–6 indicating severely degraded conditions. The improvement is likely due to the treatment plant operating at full secondary treatment levels and the approximate 90% decrease in chlorine bleach usage for effluent disinfection.

Benthic Response Index (BRI)

In summer 2011, mean BRI scores were generally lowest at shelf stations and increased with increased station depth and proximity to the outfall (Table 5-2; Figure 5-7). Consistent with previous years, BRI scores at slope, submarine canyon, and basin stations showed a marginal deviation from reference conditions. Mid-shelf non-ZID stations indicated

Figure 5-4. **Spatial trend bubble plots of Shannon-Wiener diversity (H') for summer 2011 (top) and winter 2012 (bottom).**

Orange County Sanitation District, California.

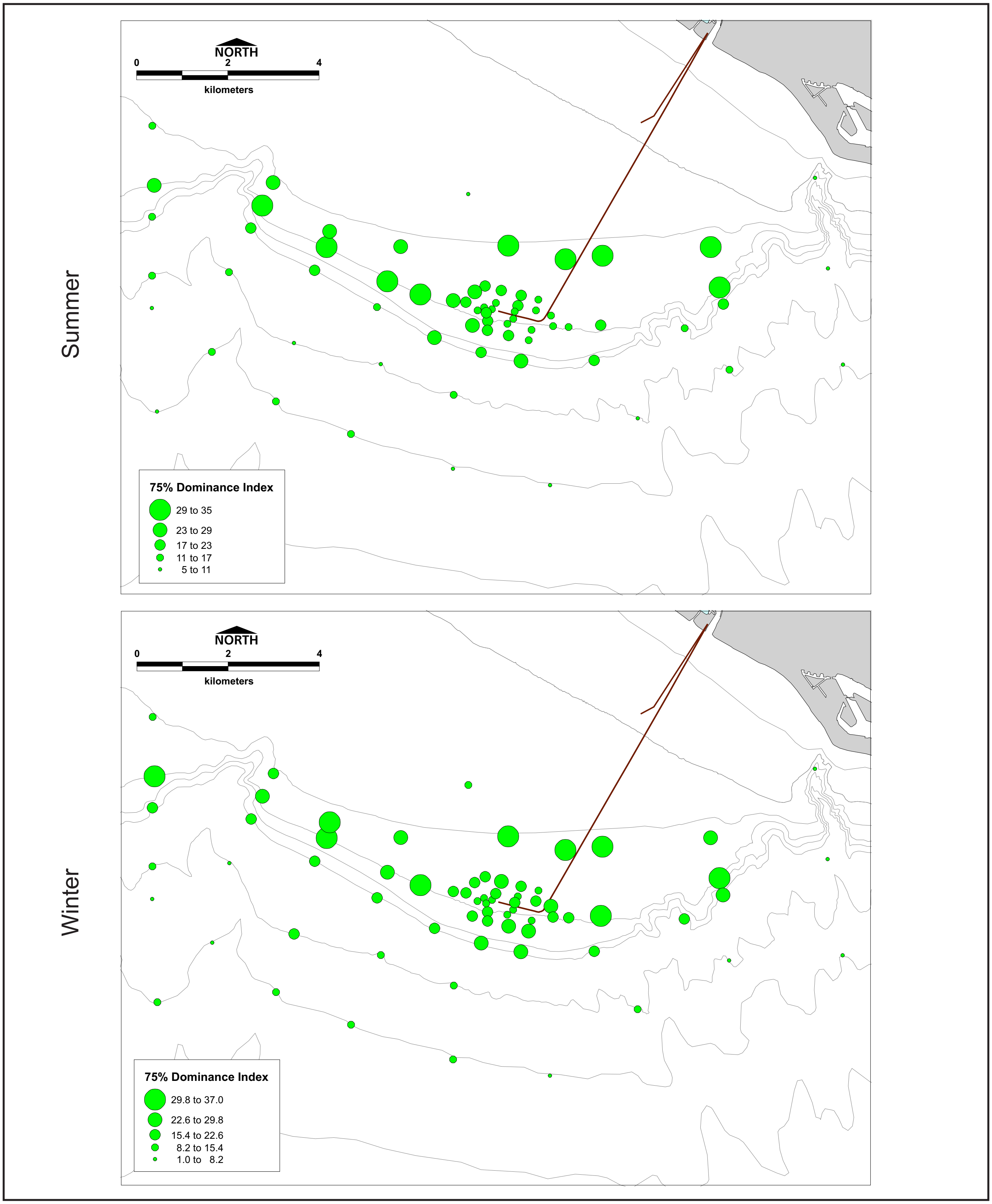


Figure 5-5. **Spatial trend bubble plots of Schwartz's 75% Dominance Index (SDI) for summer 2011 (top) and winter 2012 (bottom).**

Orange County Sanitation District, California.

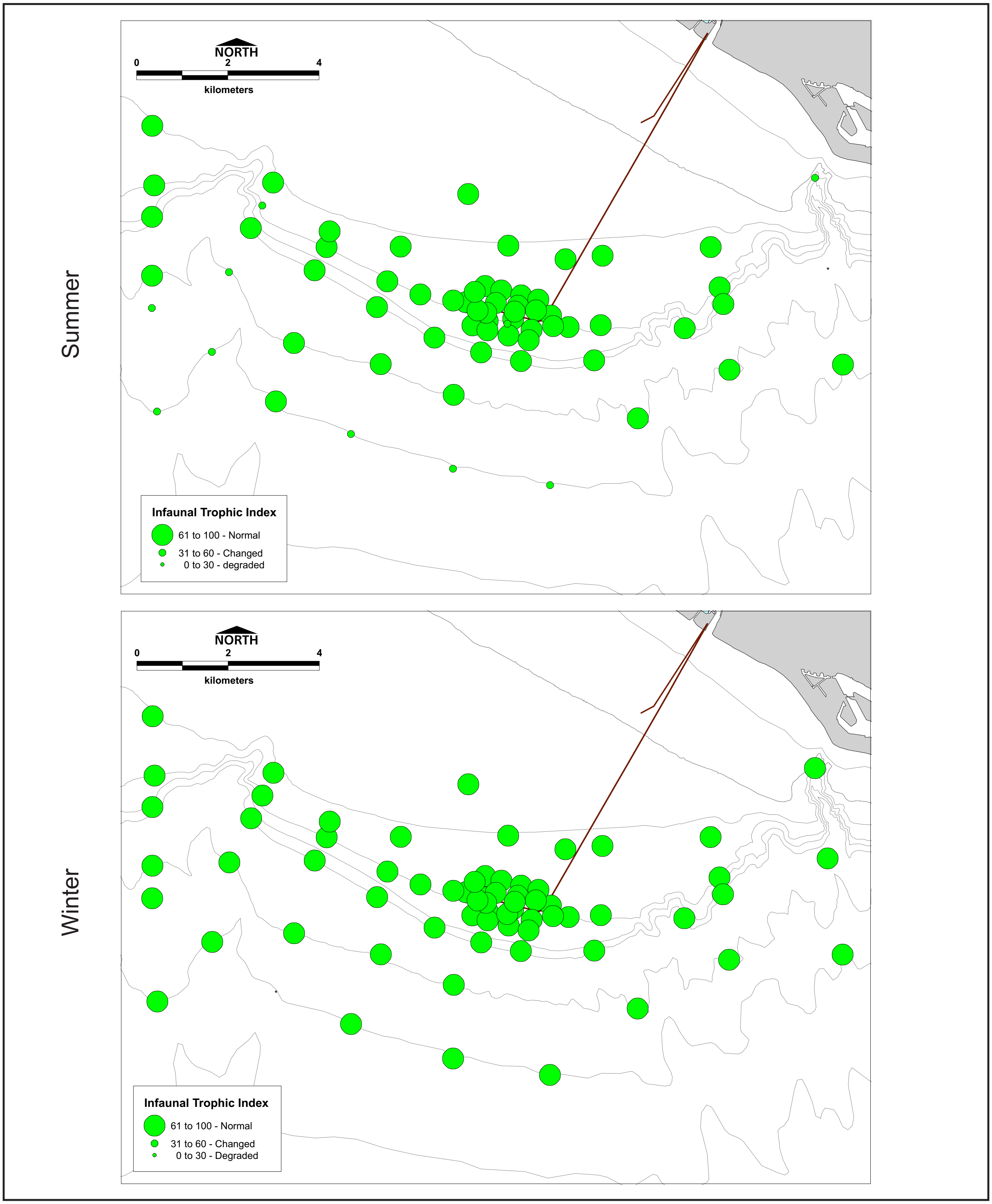


Figure 5-6. **Spatial trend bubble plots of infaunal trophic index (ITI) for summer 2011 (top) and winter 2012 (bottom).**

Orange County Sanitation District, California.

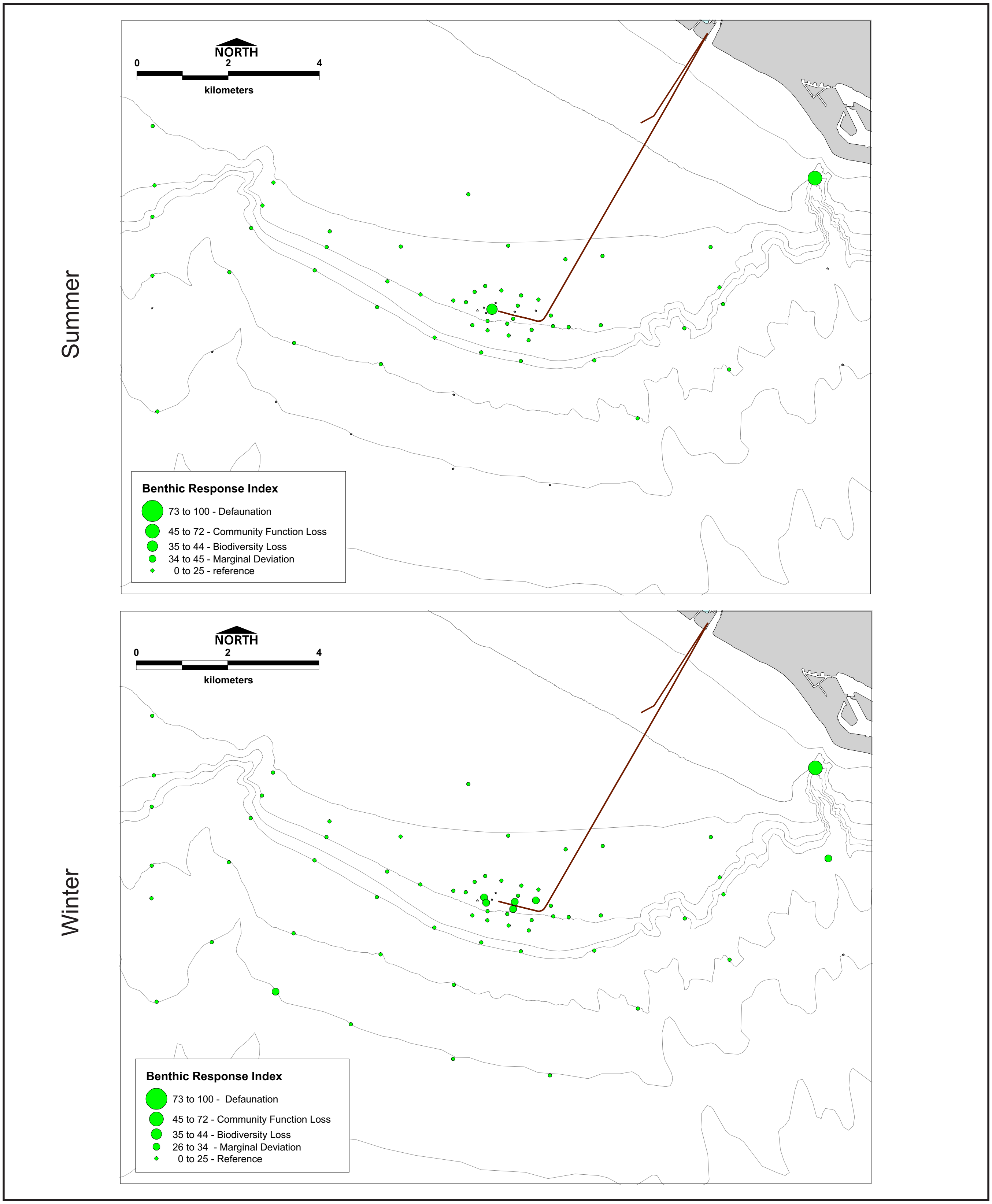


Figure 5-7. **Spatial trend bubble plots of benthic response index (BRI) for summer 2011 (top) and winter 2012 (bottom).**

Orange County Sanitation District, California.

reference conditions at all but six stations. BRI scores at the near-outfall Stations 73, 75, 84, 85, and 86 ranged from 26–32, indicating a marginal deviation from reference conditions, while the BRI score at Station C2 (45) indicated a loss of biodiversity. Station C2 is located at the head of the Newport Canyon and differs from other mid-shelf depth stations in sediment characteristics (e.g., percent fines) and contaminant concentrations (see Chapter 4), which affect species distributions. Correlation analysis showed no relationship of BRI to sediment tLAB suggesting no significant outfall influence on infaunal community structure.

Temporal (long-term) Trend Analysis

Long-term trends for selected outfall depth (60 m) stations are presented in Figure 5-8.

The number of species at non-ZID stations has remained relatively constant, showing expected inter-annual variability. ZID stations exhibit a greater degree of variability and a decline in the number of species. Downcoast Station 4 was less affected than mid-diffuser Station ZB, while upcoast Station 0 showed the greatest decline. There has been a general trend of declining abundances at within-ZID and non-ZID stations. The decline has been greatest at within-ZID stations. H' and SDI showed similar patterns of increase over time at all non-ZID stations; the increase was more pronounced and the variability greater for SDI. Though the data is quite variable at the three within-ZID stations, since 2007 there has been roughly no change for Stations 4 and ZB, and a decrease at Station 0. ITI scores at non-ZID stations were relatively constant over time, though scores at Station 1, closest to the outfall, dropped below that station's historical range during 2009-10. ITI scores at within-ZID stations have been declining since 2004 at Stations 0 and ZB, and to a lesser degree at Station 4. BRI has decreased slightly at all non-ZID stations and ZID-Station 4 indicating improving conditions. Conversely, BRI scores at Stations 0 and ZB decreased slightly from 1985 to 2001, but have since increased through this year with the greatest increases seen from 2009 to 2011. BRI scores decreased at Station 0 this year though there is still an overall increasing trend over time.

Indicator Species

<u>Pollution Tolerant Species</u>

Euphilomedes carcharodonta
Abundances during the summer 2011 survey were highest in the areas just offshore and upcoast of the outfall diffuser (Figure 5-9). Distribution was not related to sediment tLAB concentrations suggesting no relationship with the District's effluent discharge, though *E. carcharodonta* abundances are generally higher near the outfall and in the general direction of effluent plume movement. Since 2008, *E. carcharodonta* abundances have increased slightly at within-ZID stations and non-ZID nearfield upcoast Stations 1, 3, and 5 suggesting changing conditions outside the ZID (Figure 5-10).

Capitella capitata Complex
Abundances of *C. capitata* Complex were greatly reduced this year compared to the last few years (OCSD 2009, 2010, 2011). Within-ZID Station 0 has seen a two-order of magnitude decrease since 2010. Abundances were highest near to and upcoast from the outfall (Figure 5-11). *C. capitata* Complex abundances were not correlated to tLAB

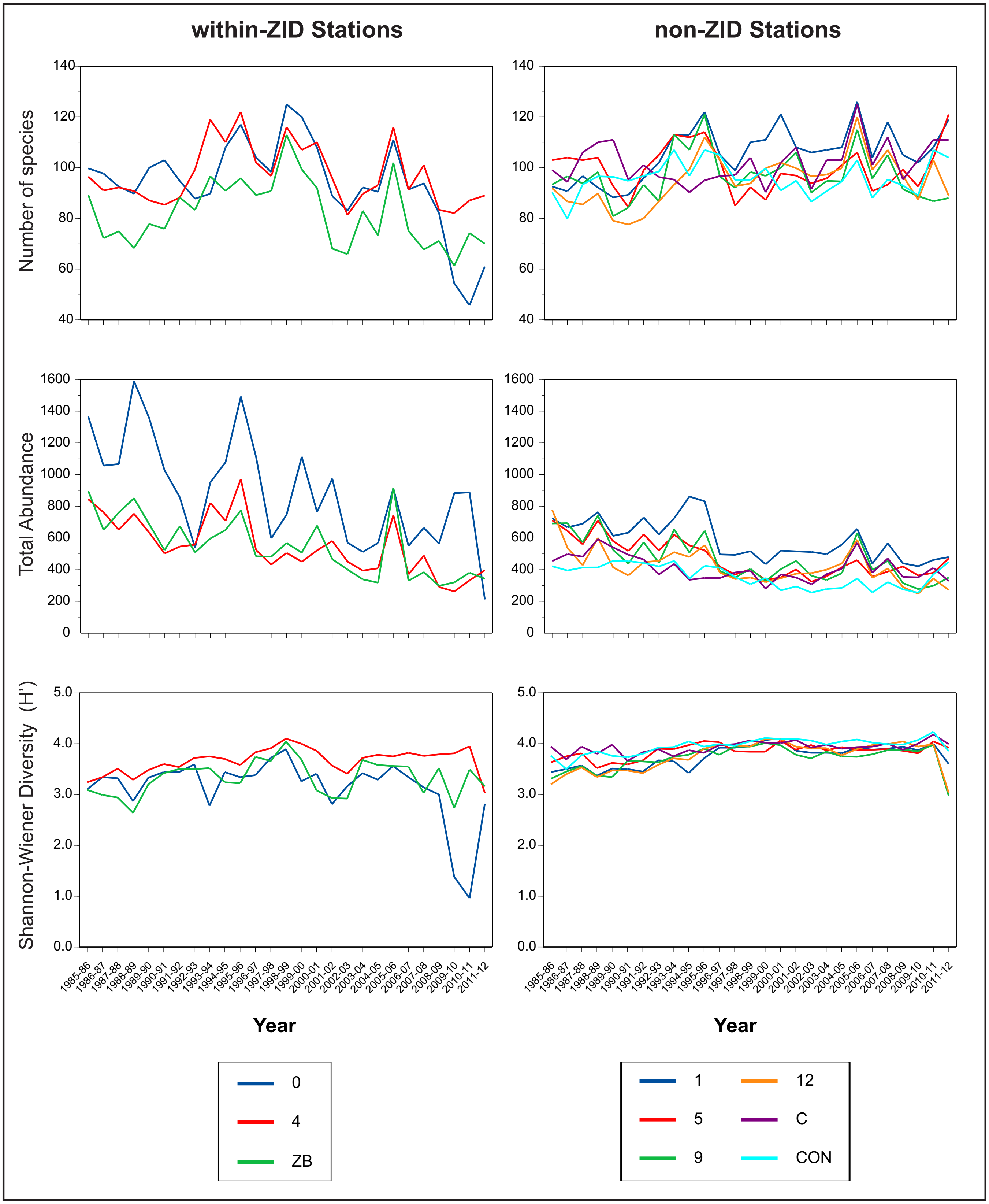


Figure 5-8. Annual mean values for benthic infauna parameters for the period 1985–2012: No. of species, abundance, Shannon-Wiener diversity (H'), Schwartz's 75% dominance, infaunal trophic index (ITI), and benthic response index (BRI).

Orange County Sanitation District, California.

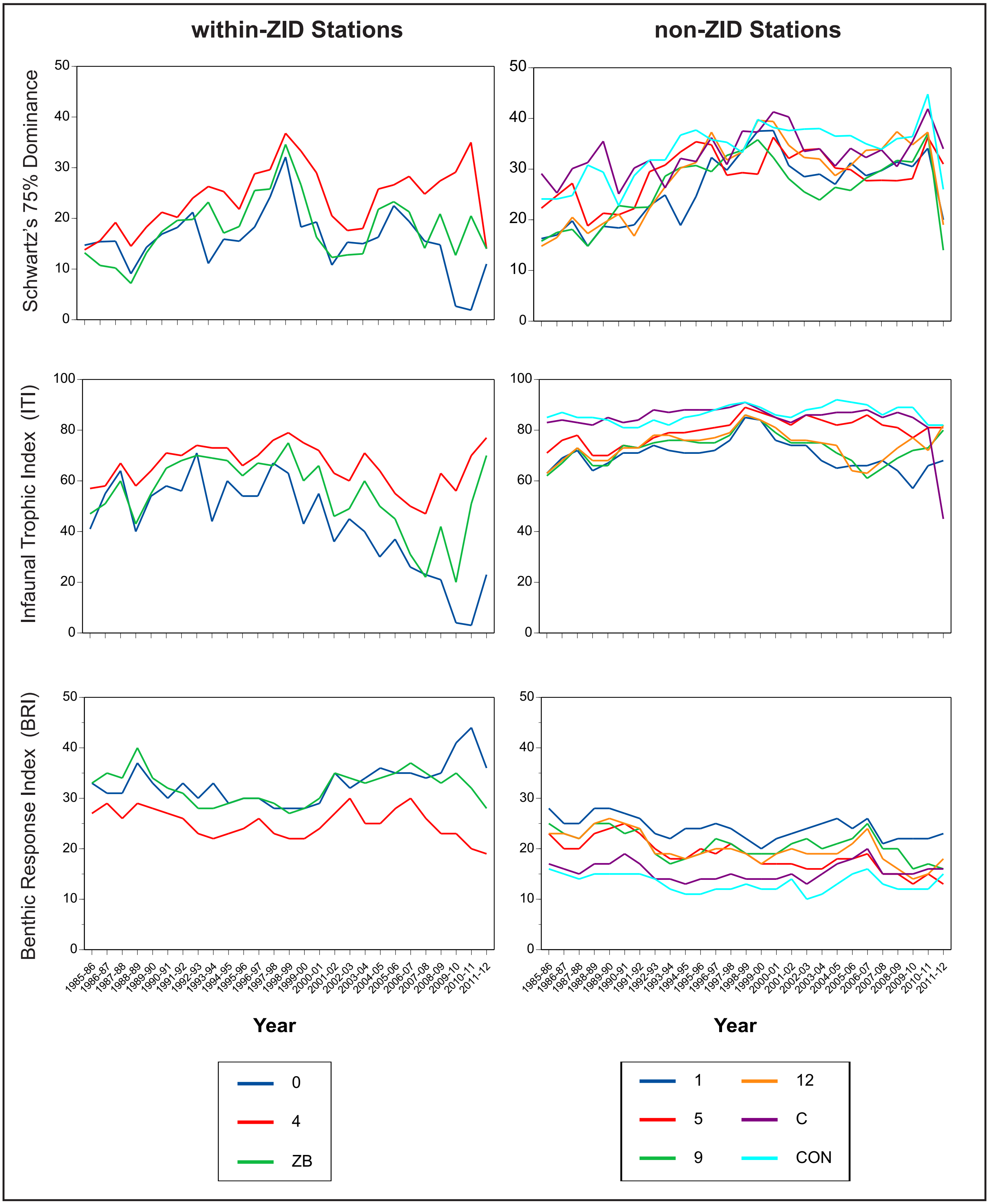


Figure 5-8 continued.

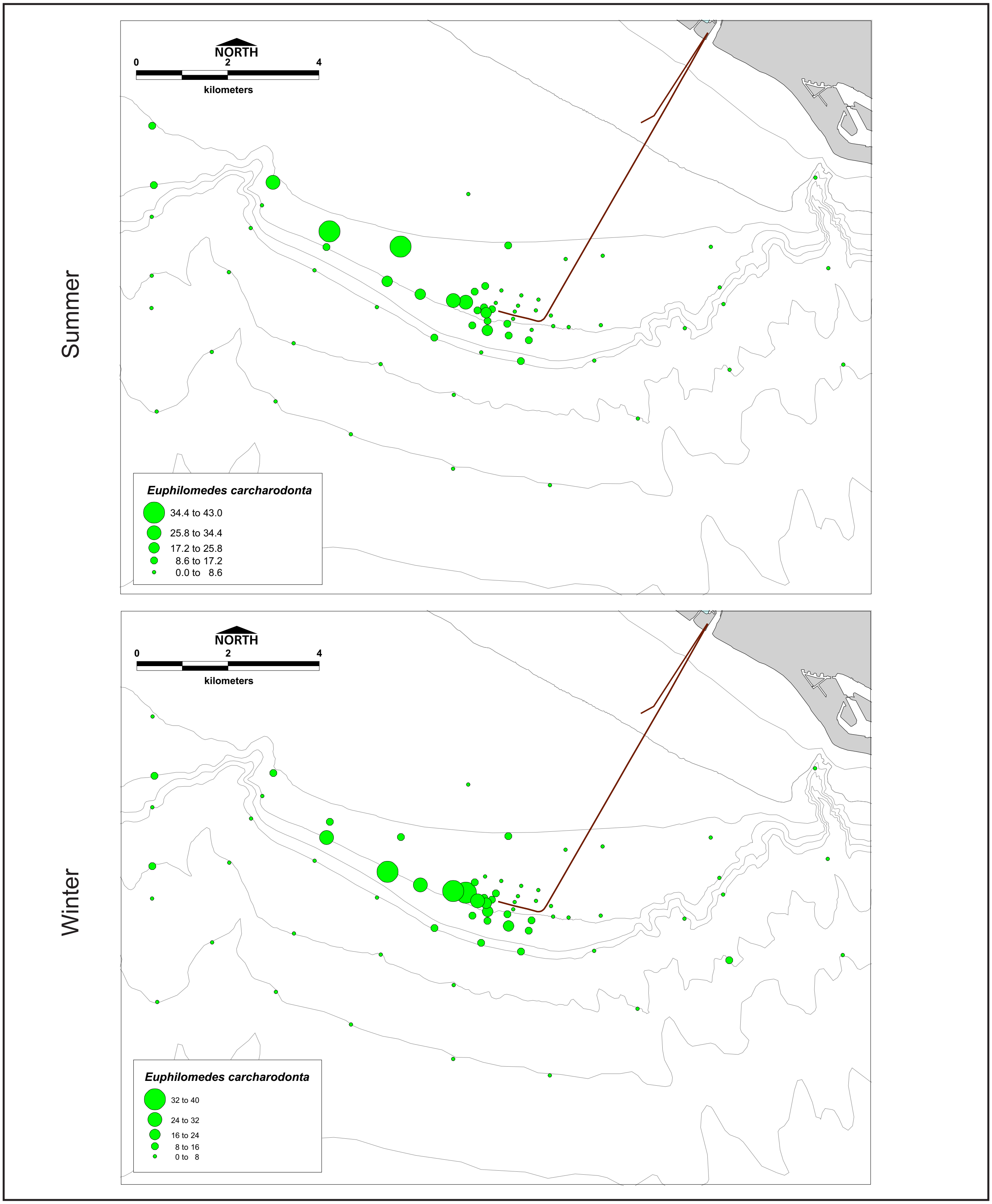


Figure 5-9. Spatial trend bubble plots of *Euphilomedes carcharodonta* abundance for summer 2011 (top) and winter 2012 (bottom).

Orange County Sanitation District, California.

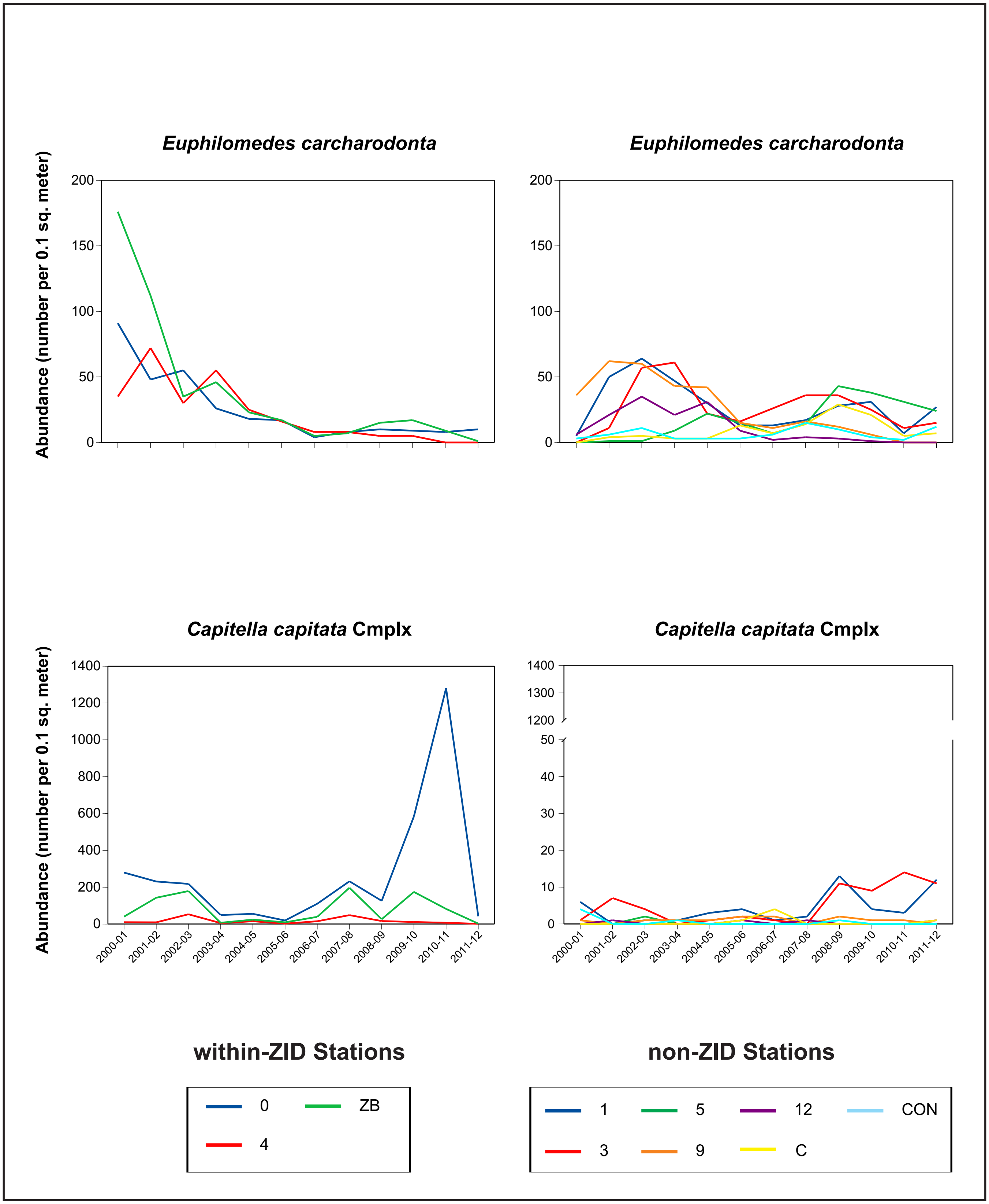


Figure 5-10. Annual mean values of abundance for the period 2000–2011: *Euphilomedes carcharodonta*, *Capitella capitata* Cmplx, *Amphiodia urtica*, and amphipods.

Orange County Sanitation District, California.

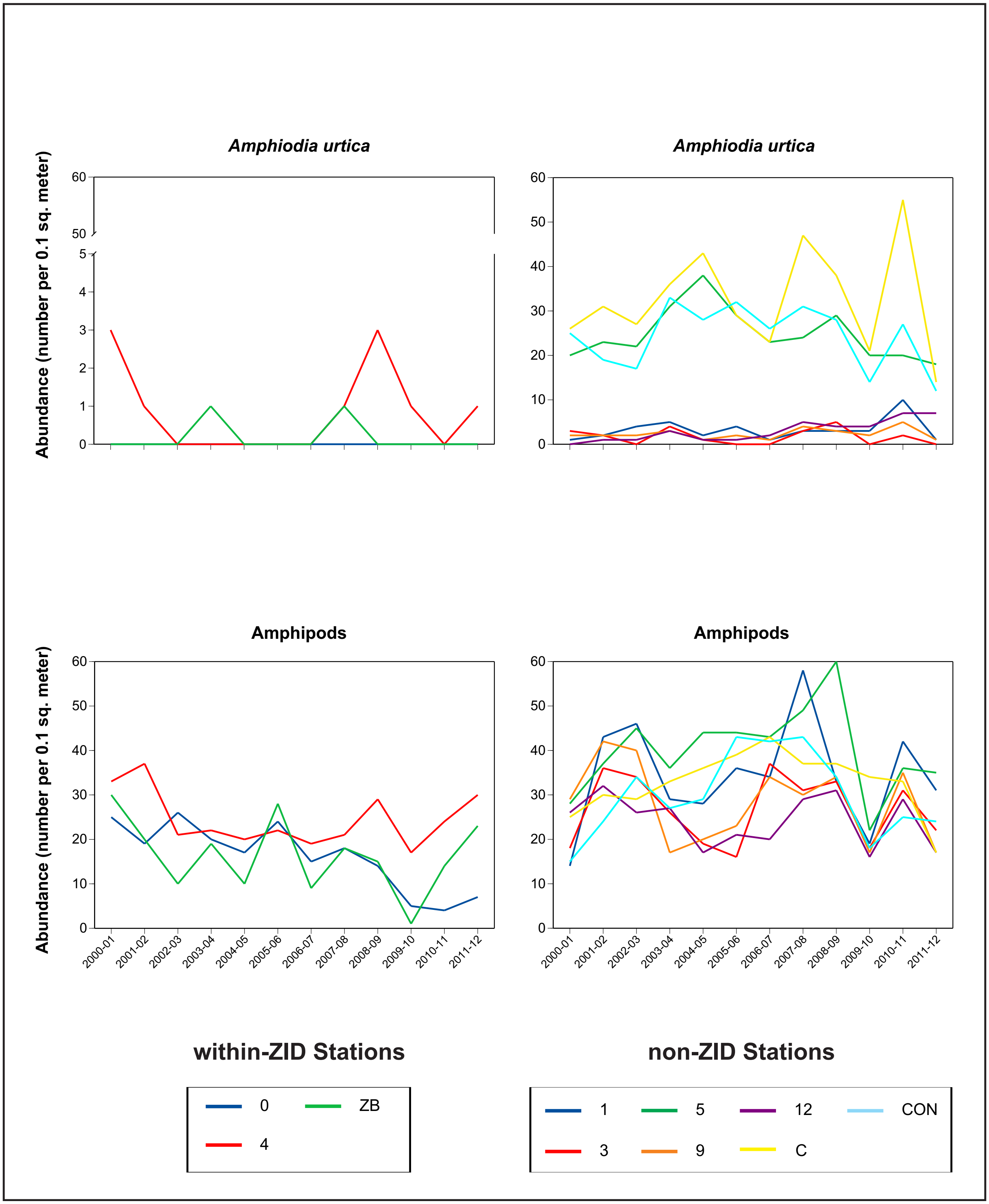


Figure 5-10 continued.

Orange County Sanitation District, California.

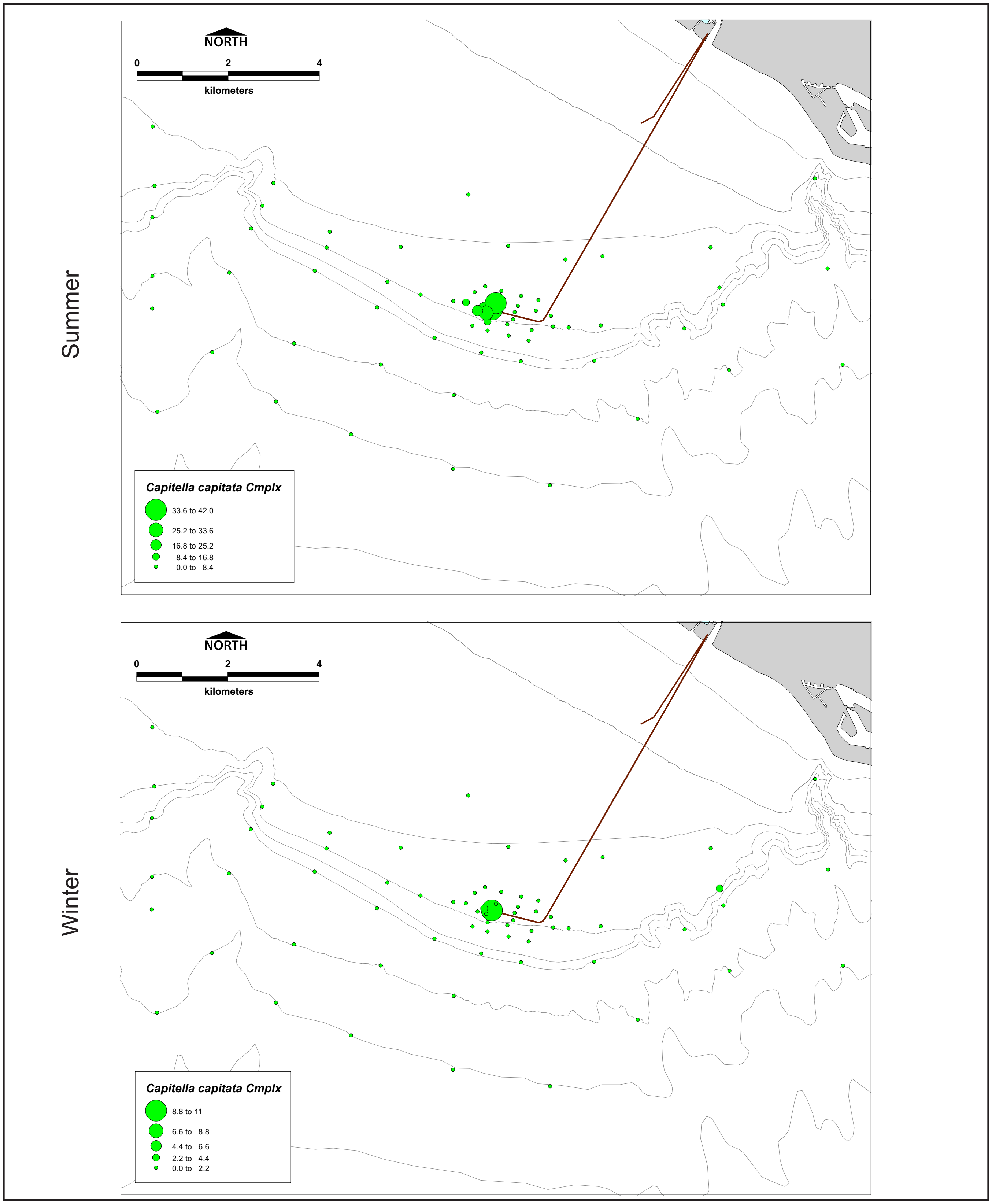


Figure 5-11. **Spatial trend bubble plots of *Capitella capitata* Cmplx abundance for summer 2011 (top) and winter 2012 (bottom).**

Orange County Sanitation District, California.

concentrations. However, due to the increased abundances near the outfall there appears to be an outfall influence on the presence and abundances of *C. capitata* Complex in the monitoring area. Infaunal communities at those stations classify as normal or only marginally deviated from reference conditions. Since 2005, *C. capitata* Complex abundances have increased from <300 to as many as 1300 at within-ZID Station 0 and from about 40 to 200 at Station ZB. Abundances have increased slightly from <5 to as much as 40, at non-ZID nearfield Stations 1, 3, and 5 suggesting changed conditions just outside the ZID (Figure 5-10). However, as noted above, *C. capitata* Complex abundances decreased greatly this year.

<u>Pollution Sensitive Species</u>

Amphiodia urtica
In summer 2011, *A. urtica* distribution was greatest at outer-shelf and downcoast mid-shelf stations, and to a lesser degree at upcoast middle-shelf stations (Figure 5-12). *A. urtica* distribution was significantly correlated with sediment grain size (r=0.44). While all stations where this species occurs are within *A. urtica*'s published depth range, the slope and basin stations are beyond the common depth range (15–85 m) (Bergen 1995), which may explain the absence of this species in deeper strata. There was no correlation to tLAB suggesting no effluent discharge influence on *A. urtica* distribution on the San Pedro Shelf. *A. urtica* abundances are consistently low (<5 individuals) at within-ZID Stations and non-ZID stations near the outfall. Outfall-depth stations 5, C, and CON have greater abundances and show high variability between years (Figure 5-10). Stations 5 and CON show a slight decreasing trend over time, while Station C has greater variability and no clear trend.

Amphipods (*Rhepoxynius* spp. and *Ampelisca* spp.)
Abundances of the amphipods *Rhepoxynius* and *Ampelisca* in the summer 2011 survey were lowest in the canyons and slope areas, and highest on the San Pedro Shelf upcoast and inshore of the outfall pipe (Figure 5-13). Regression analysis showed a small, but statistically significant correlation of abundance of these amphipods with increasing depth (r^2=0.18). Many of the species found routinely at shelf stations are not found at slope and basin stations because it is beyond their depth range. Correlation analysis showed no relationship between abundance of these amphipods and sediment tLAB concentrations indicating that the effluent discharge is not a significant factor affecting the distribution of *Rhepoxynius* and *Ampelisca*. Abundances of these amphipods at within-ZID stations show a decreasing trend over time with moderate variability, while non-ZID stations have slightly higher abundances, no discernible temporal trend, and high inter-annual variability (Figure 5-13).

Spatial Analysis

<u>Cluster Analysis</u>
Cluster analysis on the summer 2011 abundance data identified 10 station clusters with 47% similarity (Figures 5-14 and 5-15). The station clusters generally follow distance and direction from the outfall diffuser. 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. The output stress was low (2D = 0.16; 3D = 0.08) indicating good ordination. The 10 most numerically abundant species from each station cluster group are presented in Table 5-4.

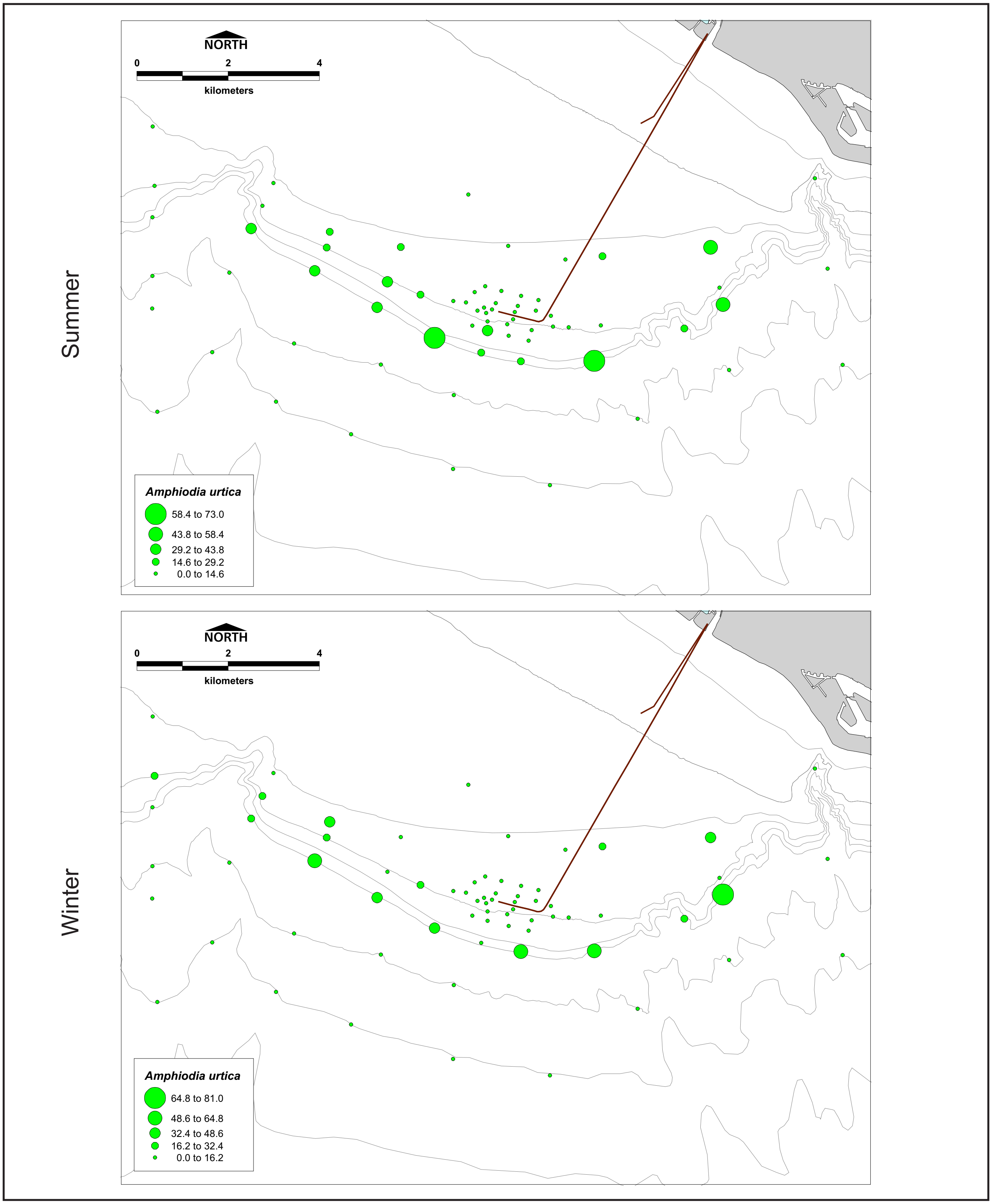


Figure 5-12. **Spatial trend bubble plots of *Amphiodia urtica* abundance for summer 2011 (top) and winter 2012 (bottom).**

Orange County Sanitation District, California.

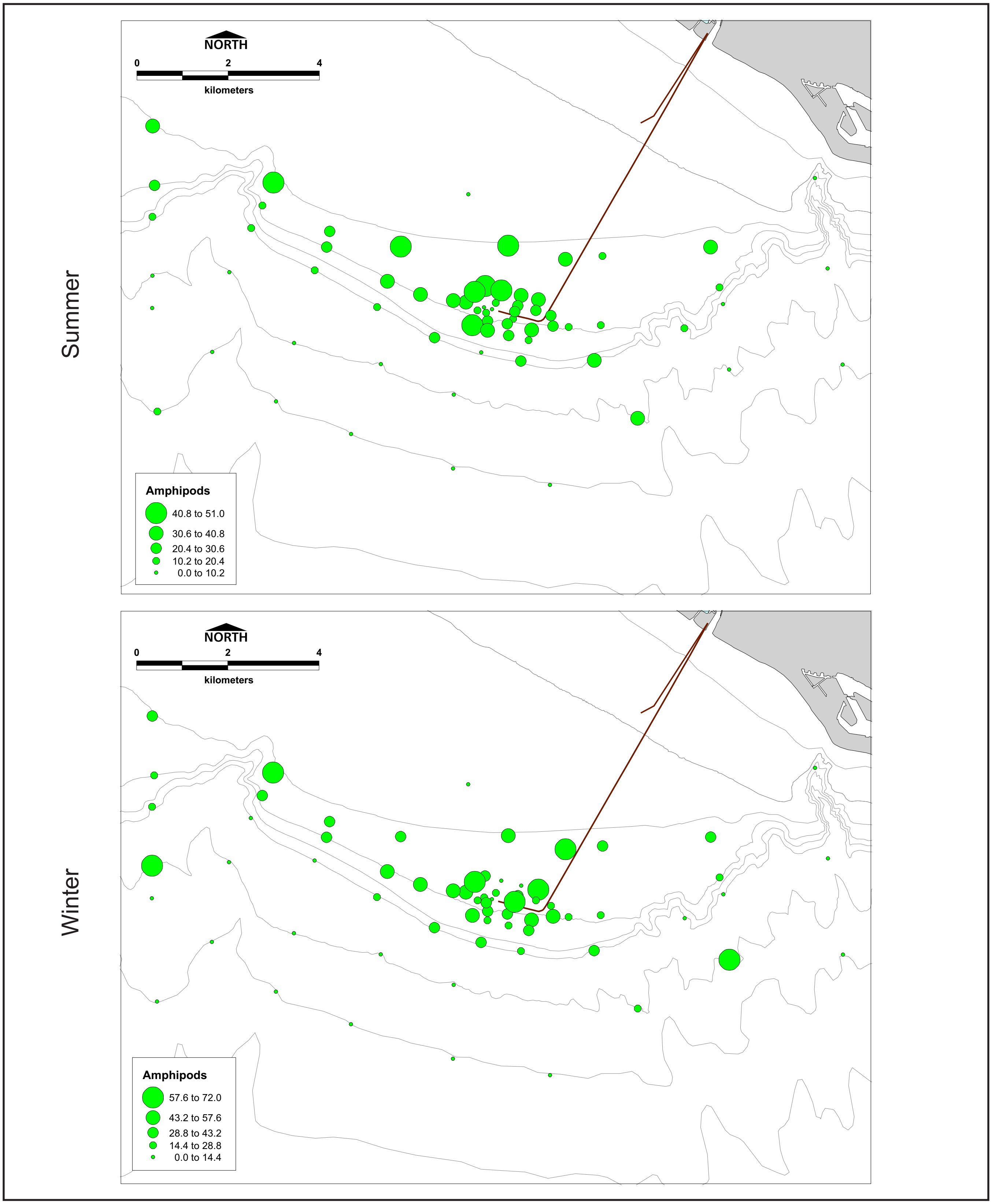


Figure 5-13. Spatial trend bubble plots of Amphipod abundance for summer 2011 (top) and winter 2012 (bottom).

Orange County Sanitation District, California.

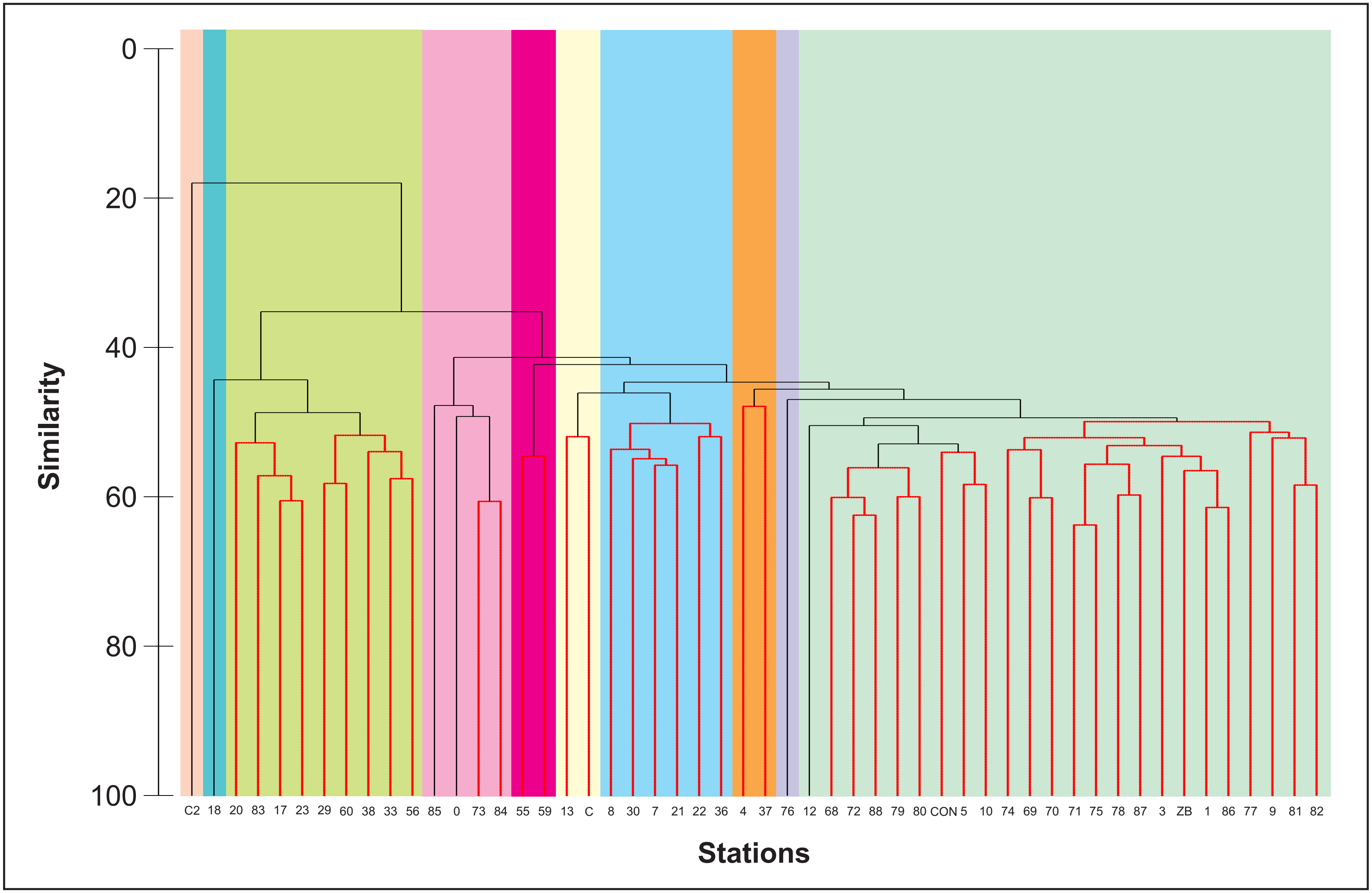


Figure 5-14. **Dendogram of cluster analysis results for July 2011.**

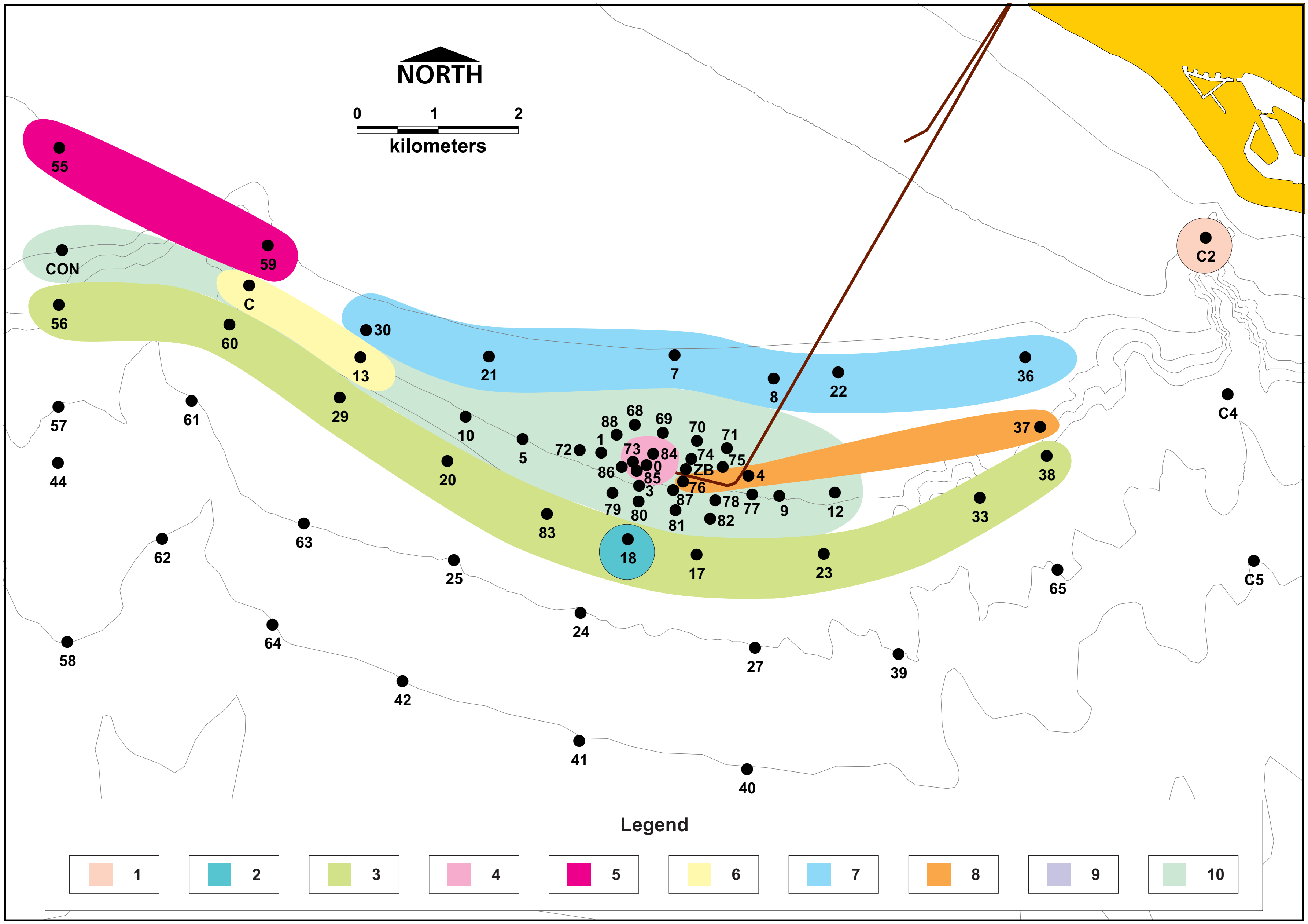


Figure 5-15. **Map of station groups from cluster analysis for July 2011**

Orange County Sanitation District, California.

Table 5-4. Description of station clusters (SC1 to SC10) defined in Figure 5-14. Data include the number of stations per cluster, mean number of species and abundance per station, and the 10 most abundant species per cluster. Bold values indicate species that were considered "characteristic" of a cluster by SIMPER analysis. *Indicates group comprised of a single station and SIMPER could not be applied.

Orange County Sanitation District, California

Parameter	SC1*	SC2*	SC3	SC4	SC5	SC6	SC7	SC8	SC9*	SC10
Number of Stations	1	1	9	4	2	2	6	2	1	24
Mean Number of Species/Station	48	65	95	75	102	102	112	102	84	95
Mean Abundance/Station	391	172	406	344	494	303	408	344	268	376
Species	**Total Abundance per Station Cluster**									
Ampelisca agassizi Judd 1896								6		
Ampelisca brevisimulata J.L. Barnard 1954							**8**			
Ampelisca careyi Dickenson 1982					**10**	6	**5**			
Ampelisca pugetica Stimpson 1864					**9**					
Amphiodia urtica Lyman 1860		20	**38**			**15**	**20**	6		8
Amphioplus sp A					**9**					
Amphissa undata Carpenter 1864				29						
Anobothrus gracilis Malmgren 1866						6				
Aphelochaeta glandaria Complex	106		32					**5**	12	**6**
Aphelochaeta sp LA1						7		6		
Aphelochaeta williamsae Blake 1996							10			
Aricidia (Acmira) catherinae Laubier 1967				**15**		**8**	**9**	**6**		**11**
Artacamella hancocki Hartman 1955					**14**					
Axinopsida serricata Carpenter 1864			24						16	
Caecognathia crenulatifrons Monod 1926		4				**5**	**6**	**10**		
Capitella capitata Complex				**33**						
Caprella californica Stimpson 1857								12		
Chaetozone Columbiana Blake 1996					**33**		**11**	45	39	**28**
Chloeia pinnata Moore 1911		24	10	**9**		**28**	41	**33**	11	**29**
Cossura sp A	29									

Table 5-4 continues.

Table 5-4 continued.

Parameter	SC1*	SC2*	SC3	SC4	SC5	SC6	SC7	SC8	SC9*	SC10
Species	**Total Abundance per Station Cluster**									
Dialychone veleronis Banse 1972					**28**					
Euphilomedes carcharodonta Smith 1952		6		**13**	**21**	**9**	21			12
Euphilomedes producta Smith 1953		5								
Glycera nana Johnson 1901	18			**10**					5	
Gnathiidae							18			
Heteromastus filobranchus Claparede 1864	11									
Leptochelia dubia Kroyer 1842							**7**	**6**		**8**
Lineidae	8									
Lumbrineris cruzensis Hartman 1944			**8**			12		12	11	**10**
Lumbrineris lingulata Hartman 1944									5	
Maldanidae			15							
Mediomastus sp	39		**14**	**28**		**6**	**21**	**16**	13	**25**
Mesolamprops bispinosus Given 1964					**21**	**10**				
Nuculana sp A		7								
Oligochaeta	43									
Paleonemertea				13					5	
Paramage scutata Moore 1923			10							
Paraprionospio alata Moore 1923	16		**10**					**5**		
Petaloclymene pacifica Green 1997			**14**							
Photis brevispes Shoemaker 1942				23						
Photis californica Stout 1913				20			**15**	13		8
Photis sp								7		
Pista estavanica Berkeley & Berkeley 1942					**54**					
Polycirrus sp A *SCAMIT 1995*		4					**4**	**4**		
Prionospio (Prionospio) jubata Blake 1996			**14**	**24**		**16**	14	**22**	13	**21**
Prionospio (Prionospio) lighti Blake 1995	9									
Protomedeia articulate Complex				28						

Table 5-4 continues.

Table 5-4 continued.

Parameter	SC1*	SC2*	SC3	SC4	SC5	SC6	SC7	SC8	SC9*	SC10
Species	**Total Abundance per Station Cluster**									
Pseudofabricola californica Fitzhugh 1991					17					
Rhepoxynius bicuspidatus J.L. Barnard 1960			12							
Rhepoxynius menziesi Barnard & Barnard 1982										**5**
Rhepoxynius stenodes Barnard & Barnard 1983									5	
Scalibregma californicum Blake 2000							**5**		5	
Schizocardium sp	34									
Scoletoma tetraura Cmplx			10							
Scoloplos armiger Cmplx					16				6	**8**
Sigambra tentaculata Treadwell 1941	8									
Spio filicornis O.F. Muller 1766						**5**				
Spiophanes duplex Chamberlin 1919					**10**					
Spiophanes kimballi Claparede 1870		4	**13**							
Spiophanes norrisi Claparede 1870					15					
Sthernelanella uniformis Moore 1910					**12**	**13**	**8**			
Tellina carpenteri Carpenter 1864		8							5	
Tellina modesta Carpenter 1864					19					
Travesia brevis Moore 1923		4	**6**							

Station Cluster 1 (SC1) includes only Station C2, located at the head of the Newport Submarine Canyon near the Newport Pier at a depth of 54 m. SIMPER analysis, used to determine characteristic species, cannot be applied to clusters composed of a single site (Clarke and Warwick 2001). Polychaetes dominated this station, comprising 56% of the species and 82% of the individuals. SC1 has lowest abundance of crustaceans comprising only 6% of the species and 1% of the abundance. The five most abundant species were the polychaetes *Aphelochaeta glandaria* Complex, *Cossura* sp A, *Mediomastus* sp, Oligochaeta, and the enteropneust chordate *Schizocardium* sp. These five taxa comprised 64% of the total abundance of individuals at this station.

Station Cluster 2 (SC2) consists of Station 18 only. This station is located offshore of the outfall pipe with a depth of 100 m. Polychaetes dominated this station cluster, comprising 45% of the species and 43% of the individuals. SIMPER analysis could not be applied to this station cluster. The five most abundant species were the polychaete *C. pinnata*, the brittlestar *A. urtica*, the mollusks *Tellina carpenteri* Carpenter 1864 and *Nuculana* sp A, and the ostracod crustacean *E. carcharodonta*. These five taxa comprised 38% of the total abundance of individuals at this station.

Station Cluster 3 (SC3) is composed of Stations 17, 20, 23, 29, 33, 38, 56, 60, and 83, at depths ranging from 91 m to 100 m. Polychaetes dominated SC3 with 57% of the species and 63% of the total abundance. SIMPER analysis showed that SC3 was characterized by the brittlestar *A. urtica*, the polychaetes *Lumbrineris cruzensis* Hartman 1944, *Mediomastus* sp, *Paraprionospio alata* Moore 1923, *Petaloclymene pacifica* Green 1997, *P. jubata*, *Spiophanes kimballi* Claparede 1870, and *Travesia brevis* Moore 1923.

Station Cluster 4 (SC4) consists of Stations 0 (within-ZID), 73, 84, and 85 (outside the ZID). Together they form a cluster located at the end of the outfall diffuser. This cluster represents the stations most impacted by the effluent discharge. Polychaetes dominated this cluster with 47% of the species and 56% of the abundance. SIMPER analysis showed that SC4 was characterized by the polychaetes *A. catherinae*, *C. pinnata*, *C. capitata* Complex, *Glycera nana* Johnson 1901, *Mediomastus* sp, *P. jubata,* and *E. Carcharodonta*.

Station Cluster 5 (SC5) consists of Stations 55 and 59, which are located upcoast and inshore of the outfall at 40 m depths. Polychaetes dominated SC5, accounting for 51% of the species and 60 of the total abundance, while crustaceans comprised 28% of the species and 28% of the abundance. SIMPER analysis showed that SC5 was characterized by the crustaceans *Ampelisca careyi* Dickenson 1982, *Ampelisca pugetica* Stimpson 1864, *E. characarodonta*, *Mesolamprops bispinosus* Given 1964, the polychaetes *Artacemella hancocki* Hartman 1955, *C. columbiana*, *Dialychone veleronis* Banse 1972, *Pista estavanica* Berkeley & Berkeley 1942, *Spiophanes duplex* Chamberlin 1919, *Sthenelanella uniformis* Moore 1910, and the echinoderm *Amphiolpus* sp A.

Station Cluster 6 (SC6) consisted of Stations 13, and C, which are outfall-depth farfield upcoast stations. Polychaetes dominated comprising 50% and 55% of the species and total abundance, respectively. Crustaceans accounted for 28% of the species and 28% of the abundance. SIMPER analysis showed that SC6 was characterized by the brittlestar *A. urtica*, the crustaceans *Caecognathia crenulatifrons* Monod 1926, *E. carcharodonta*, *M. bispinosus*, and the polychaetes *A. catherinae, Mediomastus* sp.*, P. jubata, and Spio filicornis* O.F. Muller 1766.

Station Cluster 7 (SC7) consisted of Stations 7, 8, 21, 22, 30, and 36, forming an inshore station cluster. Polychaetes dominated SC7 representing 47% of the species and 48% of the total abundance, while crustaceans accounted for 28% of the species and 34% of the abundance. Characteristic species identified by SIMPER were the crustaceans *Ampelisca brevisimulata* J.L. Bernard 1954, *A. careyi*, *C. crenulatifrons*, *Leptochelia dubia* Kroyer 1842, *Photis californica* Stout 1913, the brittlestar *A. urtica*, and the polychaetes *A. catherinae*, *Mediomastus* sp, *Polycirrus* sp A SCAMIT 1995, *Scalibregma californicum* Blake 2000, and *S. uniformis*.

Station Cluster 8 (SC8) consisted of Stations 4 and 37. Station 4 is located within the ZID at the downcoast end of the outfall diffuser, while Station 37 is at outfall-depth and located downcoast and inshore near the Newport Submarine Canyon. SC8 is dominated by polychaetes which comprise 45% of the species and 59% of the abundance. Crustaceans make up 26% of the species and abundance. SIMPER analysis showed that SC8 was characterized by the polychaetes *A. glandaria* Complex, *A. catherinae*, *C. columbiana*, *C. pinnata*, *Mediomastus* sp, *P. alata*, *Polycirrus* sp A, *P. jubata*, and the crustaceans *C. crenulatifrons* and *L. dubia*.

Station Cluster 9 (SC8) consisted of Station 76, which is located at the middle of the outfall diffuser on the offshore side of the pipe. Crustaceans dominated this cluster comprising 42% of the species and 58% of the individuals. SC8 has the lowest abundance of echinoderms comprising only 1% of the species and <1% of the abundance. SIMPER analysis could not be applied to this station cluster. The five most abundant species were the polychaetes *A. glandaria* Complex, *C. columbiana*, *Mediomastus* sp., *P. jubata*, and the mollusk *Axinopsida serricata* Carpenter 1864.

Station Cluster 10 (SC8) consisted of Stations 1, 3, 5, 9, 10, 12, 68, 69, 70, 71, 72, 74, 75, 77, 78, 79, 80, 81, 82, 86, 87, 88, CON, and ZB. This cluster comprises the majority of the middle-shelf stations, including farfield reference Station CON and within-ZID Station ZB. Polychaetes dominated SC10 with 46% of the species and 59% of the abundance. Crustaceans comprised 28% and 24% of the species and abundance, respectively. Characteristic species identified by SIMPER were the polychaetes *A. glandaria* Complex, *C. columbiana*, *C. pinnata*, *L. cruzensis*, *Mediomastus* sp, *P. jubata*, *Scoloplos armiger* Complex, and the crustaceans *L. dubia* and *Rhepoxynius menziesi* Barnard & Barnard 1982.

Overall, station depth and proximity to the outfall continue to be the most significant factors in determining infaunal distribution and abundance throughout the entire monitoring area. The main factors determining the station clusters were primarily the abundances of polychaetes (e.g., *C. capitata* Complex) and the brittlestar *A. urtica*. Historically, the within-ZID stations, particularly Stations 0 and ZB form a separate station cluster from the non-ZID shelf stations (OCSD 2009); while the other 60-m stations have typically clustered together. However, this year Station ZB clustered with other 60 m middle-shelf stations, including the farfield reference Station CON. This may be a result of the recent effluent discharge impact to nearfield stations reducing differences between stations in and out of the ZID, or it may be an artifact of the difference in methods of clustering. Historically, all stations across all depth strata (40 m to 303 m) were used in the analysis. This was changed to only shelf stations to eliminate depth-related factors.

CONCLUSIONS

Previous monitoring data have documented a general decline in community health at stations within the ZID since 2005 that resulted in degraded conditions within the ZID and changed conditions at several stations near the outfall diffuser (OCSD 2007-11). District staff conducted an investigation into the extent and cause(s) of the changes in benthic assemblages that began in 2005. That investigation is complete and is summarized in Chapter 7.

The 2011-12 data indicate that infaunal communities were improving. The 2011-12 surveys found diversity and community health index scores at previously degraded and changed sites are now generally indicative of normal communities. Pollution tolerant indicator species were in low abundances and population and community structures are returning to normal. The 2011-12 monitoring results showed only minor impacts at stations beyond the ZID. This was coupled with increases in pollution-sensitive species (e.g., amphipods and echinoderms) and large decreases in the pollution-tolerant polychaete species *C. capitata* Complex.

The majority of stations outside the ZID can be classified as reference condition based on BRI and ITI analyses. Minor impacts to community structure were observed at several stations immediately outside the ZID, but there were no significant correlations to measured sediment contaminants. This indicates that sediments and biota outside the ZID were not degraded by the effluent discharge and that permit criterion 5.3.a. was met.

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