Structure of the Amphiodia urtica Population Near a Municipal Wastewater Outfall off Orange County

For several years, SCCWRP scientists have been interested in the cause of the reduced abundance of the red brittlestar *Amphiodia urtica* in sediments near municipal wastewater outfalls off Southern California. Brittlestars recruited at low levels in a one-year study near municipal wastewater outfalls in Santa Monica Bay and off San Diego. There were no prominent recruitment events during the study, although a large peak in the brittlestar size frequency distribution at the control station in Santa Monica Bay suggested that a significant recruitment event occurred before the study began. While growth was not significantly different among stations, mortality was higher at the impacted stations compared to the control stations (Thompson and Bergen 1994).

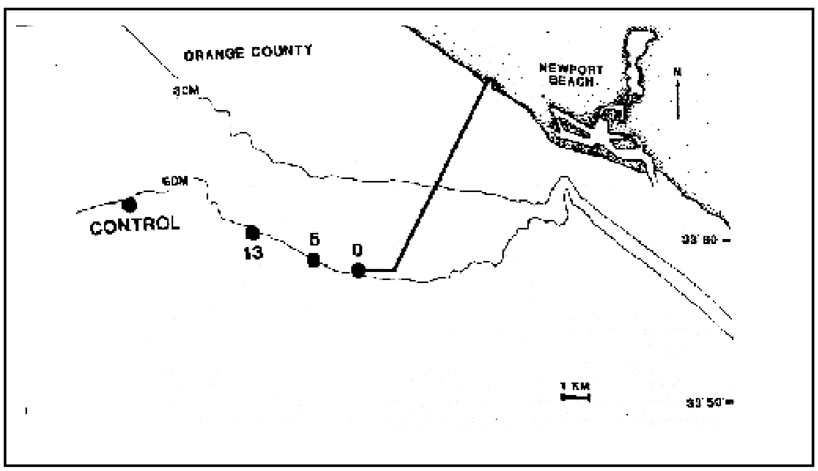
The objective of this study was to measure recruitment and population structure of *Amphiodia urtica* over a gradient of sediments impacted by a municipal wastewater outfall off Huntington Beach. The present study extended the Thompson and Bergen (1994) work to the mainland shelf off Orange County; data for all of these studies were collected during 1990 and 1991.

MATERIALS AND METHODS

Samples were collected during the sampling for the ocean monitoring program of County Sanitation Districts of Orange County (CSDOC 1990, 1991). Sediments were collected from four stations quarterly between January 1990 and July 1991 with a 0.1 m^2 chain-rigged Van Veen grab. The stations were located along the 60 m depth contour 0.06 km (station 0), 2.3 km (station 5), 4.8 km (station 13) and 8.7 km (control station) from the municipal wastewater outfall off Huntington Beach (Figure 1).

Three replicate samples were obtained from each station during each sampling period and sieved through 1.0 and 0.3 mm mesh screens. Organisms retained on the screens were placed into glass jars containing 10% borax-buffered formalin in seawater. After 48 h, specimens were transferred into 70% ethanol. All organisms from the 1.0 mm screen were sorted and identified. Only ophiuroids were sorted from the 0.3 mm screens. After the benthic samples were processed, the ophiuroids were sent to SCCWRP where they were identified to species and the oral width (OW) was measured to the nearest 0.001 mm. Individuals with oral width less than 1.0 mm were considered juveniles; Thompson and Bergen (1994) rarely observed mature gonads in *A. urtica* with oral width less than 1.0 mm.

FIGURE 1. Location of sampling stations near the County Sanitation Districts of Orange County municipal wastewater outfall off Huntington Beach.



The brittlestar abundance data were tested for normality and homogeneity of variances. Since the data were not normally distributed and the variances were unequal even after transformation, Kruskal-Wallis nonparametric analysis of variance and Tukey nonparametric multicomparison tests were used to test for differences among stations and time periods (Sokal and Rohlf 1981).

RESULTS

The average abundance of *A. urtica*, and the proportion of juveniles and adults, varied among the stations (Table 1). The abundance of *A. urtica* was lowest at station 0, the station closest to the outfall. Brittlestar abundance increased with increasing distance from the outfall (stations 5 and 13), but decreased at the control station (farthest from the outfall). Brittlestar abundance was significantly different among the stations (Kruskal-Wallis test, H=70.917, p<0.0001). The proportion of juveniles was

TABLE 1. Mean abundance of *Amphiodia urtica* and proportion of juveniles in sediment samples collected near the County Sanitation Districts of Orange County municipal wastewater outfall off Huntington Beach from January 1990 to July 1991. See Figure 1 for station locations.

Station	Distance from Outfall (km)	Individuals/m^2 (±1SD)	Juveniles (%)
0	0.06	20.5 (±23.1)	95.3
5	2.3	181.4 (±96.4)	79.8
13	4.8	956.0 (±231.1)	38.2
Control	8.7	641.1 (±183.4)	29.6

highest at station 0 and decreased with distance from the outfall to a low at the control station.

Station 0

Only a few *A. urtica* were collected at station 0 (Figure 2). Most of the individuals were less than 1.0 mm OW and no individuals larger than 1.1 mm OW were collected. The abundance of juveniles was highest from January to July 1990 (25-35 individuals/m^2) and lowest in October 1990 and January 1991 (5-15 individuals/m^2) (Figure 3). However, the number of individuals was not significantly different among months (Kruskal-Wallis test, H=5.26, p>0.05). Juveniles less than 0.5 mm OW were collected in April and July in 1990 and in 1991. No juveniles less than 0.5 mm were present in January 1990 or October and January 1991.

Station 5

Most of the *A. urtica* collected at station 5 were less than 1.0 mm OW (Figure 2). Relatively few juveniles were collected in January and April 1991. Only a few adults were collected each month, although the size range of adults was larger than at station 0. Individuals 1.6-1.8 mm OW were collected at station 5 in most months.

The abundance of juveniles at station 5 changed significantly during the study (Kruskal-Wallis test, H=14.27, p<0.05) (Figure 3). There were 110-170 juveniles/m^2 between January and October 1990, but only 50-65 juveniles/m^2 between January and April 1991. The decrease from October 1990 to January 1991 was significant (Tukey test, Q=3.46, p<0.05) and occurred primarily in the 0.50-0.65 mm OW size classes. In July, the number of juveniles increased significantly to 310 individuals/m^2 (Tukey test, Q=9.40, p<0.05); most of the increase was in the 0.45-0.60 mm size classes. Juveniles less than 0.5 mm were present in all months except January 1991.

The abundance of adults at station 5 changed significantly over time (Kruskal-Wallis test, H=14.27, p<0.05) (Figure 3). Between January and October 1990, there were 10-20 adults/m^2; between January and July 1991, there were 50-75 adults/m^2; the increase was significant (Tukey test, Q=4.70, p<0.05).

Station 13

Of the four stations sampled, *Amphiodia urtica* were most abundant at station 13. There were peaks in the size distribution between 0.55 and 0.75 mm OW in January, April and July 1990 (Figure 2). By January 1991, there were fewer juveniles and more adults in the population; in July 1991, the number of juveniles at 0.5-0.6 mm had increased.

There were significant changes in the abundance of juveniles (Kruskal-Wallis test, H=15.69) and adults (H=12.65, p<0.05) (Figure 3). The number of juveniles was significantly lower in January and April 1991 than during the rest of the year (Tukey test, Q=3.16-9.68, p<0.05). The number of adults was significantly higher in April and July 1991 than during the rest of the year (Tukey test, Q=4.15-7.51, p<0.05). Individuals less than 0.5 mm OW were present at all times except in January and April 1991.

Control Station

The size distributions at the control station were similar to the size distributions at station 13 (Figure 2). However, there were fewer individuals, particularly juveniles, at the control station. Juvenile abundance ranged from 125 to 300 individuals/m^2 and adult abundance ranged from 300 individuals/m^2 in October 1990 to 575/m^2 in April 1991 (Figure 3). However, the differences in abundance between sampling periods were not significant for juveniles (Kruskal-Wallis test, H=7.00, p>0.05) or adults (H=5.90, p>0.05). Juveniles less than 0.5 mm OW were present in all months except January 1990 and January 1991.

DISCUSSION

The abundance and structure of the *A. urtica* population changed across the gradient of outfall impacted sediments (Table 1). The trend in abundance over the gradient was non-linear; brittlestar abundance increased from 0 to 4.8 km from the outfall and then decreased at 8.7 km. However, the proportion of juveniles decreased linearly with increasing distance from the outfall. Except for the station closest to the outfall (station 0), the range of sizes of *A. urtica* was similar at each station (Figure 2). At station 0, no *A. urtica* larger than 1.04 mm OW were collected. The size distribution at station 5 was similar in

FIGURE 2. Mean abundance (±1 SD) of *Amphiodia urtica* by size class from January 1990 to July 1991 off Huntington Beach. N=3 except at station 13 in January 1991 (n=2) and control January 1990 (n=1). See Figure 1 for station locations.

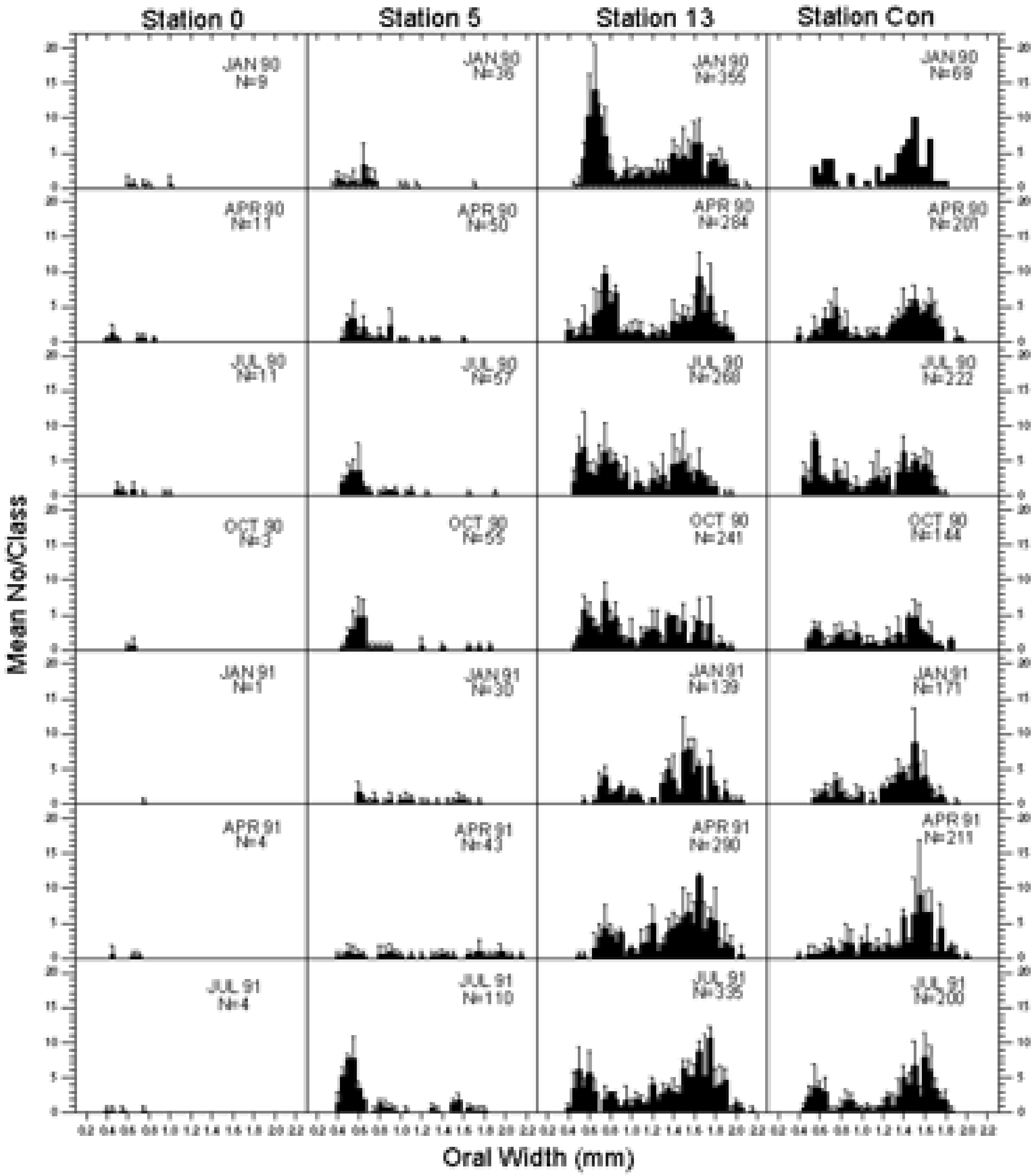
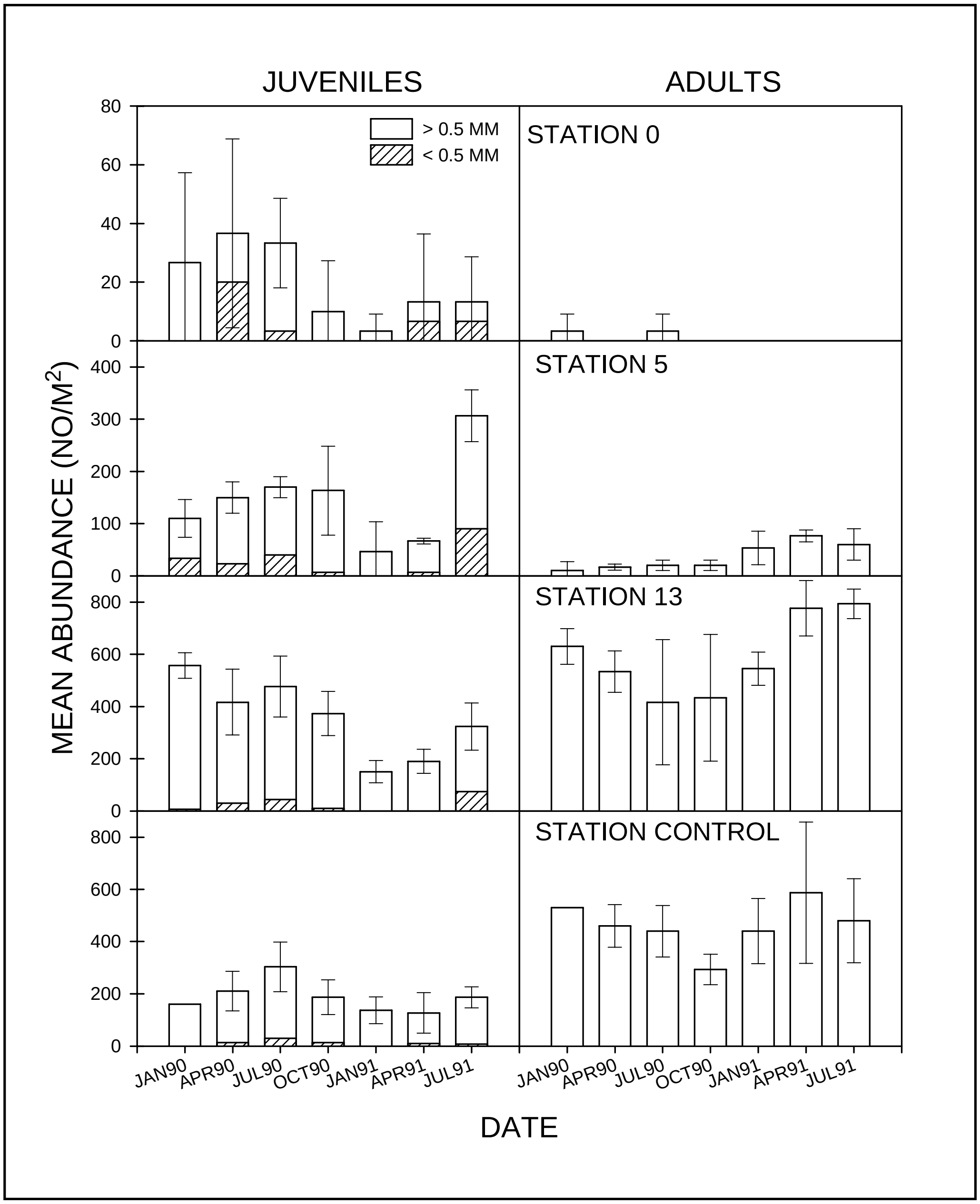


Figure 2. Mean number (± 1 SD) per size class of *Amphiodia urtica* at the stations sampled off Huntington Beach during 1990-91. Means are for three samples except at Station 13 in January 91 (2 samples) and at Station Con in January 90 (1 sample).

FIGURE 3. Mean abundance (±1 SD) of juvenile and adult *Amphiodia urtica* from January 1990 to July 1991 off Huntington Beach. N=3 except at station 13 in January 1991 (n=2) and control January 1990 (n=1). See Figure 1 for station locations.



brittlestars at stations 5 and 13 grew into the adult population between sampling periods. Between October and January, the adult population at station 5 increased by 33 individuals/m^2 and the juvenile population decreased by 116 individuals/m^2. At station 13, the adult population increased by 115 individuals/m^2 and the juvenile population decreased by 223 individuals/m^2. The decrease in juvenile abundance at stations 5 and 13 was probably caused by growth and mortality.

The number of juveniles at stations 5 and 13 increased significantly, mainly in the 0.52 mm size class, between April and July 1991. The increase may have been due to recruitment. If the average size at settlement was about 0.24 mm (SCCWRP, unpublished data) and settlement occurred just after the April sampling period, juveniles would have had to grow 0.023 mm/week to make it into the 0.52 mm size class in July. This growth rate is comparable to growth rates measured by Bay and Jirik (1994). At a growth rate of 0.02-0.03 mm/week, an individual would reach adult size in 25-58 weeks and would grow to 2.0 mm OW in 58-88 weeks. *Amphiodia urtica* may reach maturity in one year and have a life span of two to three years. However, since growth in the field is probably variable, and may slow with age, larger *A. urtica* may be more than two to three years old.

shape and range to the size distributions at moderately-impacted stations in Santa Monica Bay and off San Diego. The size distributions of adults at stations 13 and control was similar to the distribution at the control station in Santa Monica Bay (Thompson and Bergen 1994).

At stations 5 and 13, the number of juveniles decreased from October to January. The decrease was predominately in the 0.52, 0.67, and 0.82 mm size classes. In the laboratory, *A. urtica* exposed to sediment from the same stations grew an average of 0.03 mm OW/week; the maximum growth rate was 0.044 mm OW/week (Bay and Jirik 1994). At these growth rates, it is possible that the juvenile

Brittlestars less than 0.5 mm OW were present at a minimum of two stations in every month except January 1991; this suggests continuous, low-level recruitment to the *A. urtica* population off Huntington Beach. There was also evidence for large recruitment events. The prominent peak in the size distribution at station 13 in January 1990 (Figure 2) suggests that a large recruitment event occurred before the study began. And the large increase in the number of juveniles at stations 5 and 13 in July 1991 was probably due to recruitment.

The pattern of recruitment off Huntington Beach was similar to that reported by Thompson and Bergen (1994). During 1990, there was continuous, low-level recruitment in Santa Monica Bay and off of Point Loma. A large peak in the size distribution of brittlestars collected at the control station in Santa Monica Bay at the beginning of the study suggested that significant recruitment had occurred before the study began. However, there were no large recruitment events at any of the stations during the study. It is clear that recruitment of *Amphiodia urtica* varies among stations separated by a few kilometers, and within and between years.

The number of adults increased significantly at stations 5 and 13 in the last few months of the study, but not at the control station. The increase was probably due to the growth of juveniles into the adult population. However, the increase in the number of adults at stations 5 and 13 was small and the adult population was relatively constant at each station during the study.

CONCLUSIONS

The patterns of recruitment and mortality in *Amphiodia urtica* populations near the municipal wastewater outfall off Huntington Beach were comparable to the patterns observed in Santa Monica Bay and off San Diego (Thompson and Bergen 1994). In all three areas, there was evidence of continuous, low-level recruitment and occasional large recruitment events that were variable in space and time. In all three areas, the adult populations at the control stations were relatively stable through time. The size-frequency distributions at the moderately-impacted stations in Santa Monica Bay and off San Diego were similar to the size-frequency distribution at moderately-impacted off Orange County. There appeared to be a balance between recruitment, growth, and mortality in all three areas, but mortality was higher at the impacted stations compared to the control stations.

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