MAMALA BAY STUDY

DEFINITION OF INDICATOR SPECIES FOR POLLUTION MONITORING IN MAMALA BAY, OAHU, HAWAII

PROJECT MB-9

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1 EXECUTIVE SUMMARY

A multifaceted study of the sediment dwelling benthos was conducted in Mamala Bay to identify suitable species as indicators of sewage enrichment. There are five components to this study - 1) reproduction and life histories of potential indicator species, 2) seasonal abundance of each indicator species near the outfall and at the control site (Diamond Head) at 70m depth, 3) abundance and species richness of indicators and associated benthos at 6 sites and the control at 40m depth, 4) sediment grain size analyses at each site to characterize the infaunal habitat, 5) CHN and Nitrogen analyses from the study area to elucidate the role of sewage in the organic content of the sediments. Each component is presented as a separate section as methods and analyses differ for each. This same format is used for the appendices.

Sediment samples (7.6cm diam x 5.0cm depth) were collected with a Van Veen grab from 40m and 70m stations. Live worms were removed from freshly collected sediment and cultured in the laboratory for developmental and life history information. Reproductive data was gathered for designated indicator species, (Neanthes arenaceodonta, Capitella capitata, Pionosyllis heterocirrata and Ophryotrocha sp. A). N. arenaceodonta was not successfully cultured as only two individuals were found. Progeny were obtained for the three others and Ophryotrocha sp. A was the most successful in culture.

Seasonal abundance of indicators at the outfall (B3) and control site show that all indicator species are more abundant at B3, and in the summer months than at Diamond Head, or during winter months. P. heterocirrata is widely distributed throughout the year and Ophryotrocha sp. A was only found at the deep outfall site in any number.

Community studies based on preserved samples collected in the same way from the 40m (S series) stations show abundant and species assemblages at all stations, including the control. Overall polychaete abundances are higher at 40m stations than near the outfall and exceeded the abundance estimates at the control. Species richness estimates show some site by site variation but all stations are specious and often exceed the control. Differences are seen between the dominant species groups at outfall and 40m far field stations. The more westerly sites had more tubicolous and particle feeding worms (sabellids and oweniids) than the stations closest to the outfall (substantiated by historical data base, biomonitoring program), and a different community was evident at east Mamala site S6 and the control.

Grain size analyses show higher proportions of fine particles (clay and silt) at the westerly stations which receive input from Pearl Harbor and Keehi Lagoon. This may provide an explanation for the larger number of tubicolous worms which use fine particles for tube building. A larger proportion of coarse and fine sand were present in east Mamala sediments and may have partially determined the polychaete communities at those sites.

There is not enough data for the CHN and N signature analyses to provide definitive results, but preliminary information does not implicate the outfall as a major source of nitrogen. Indicator worm abundance seems to be a better measure of food availability as their numbers are highest at the outfall stations (for 40m and 70m). Abundance of the indicator species, Ophryotrocha sp. A, at 70m is elevated at the outfall (B3) and can be attributed to food availability and other appropriate habitat characteristics.

Neanthes arenaceodonta is not abundant enough to be a good indicator at 70m at this time, Pionosyllis heterocirrata is so widespread and numerous that it is not a good indicator of sewage enrichment. Capitella capitata is generally more abundant at 40m and only abundant at 70m in the summer, and may be a suitable indicator species. Sensitive species are also candidates for pollution indicators when they are rare or absent from an area. Euchone sp. B may be a sensitive species as it is abundant in near and far field stations, but not numerous near the outfall. Ophryotrocha sp. A seems to be the best benthic indicator and most promising for future Mamala Bay benthic studies. This species was absent, or virtually absent from outfield and control sites, but abundant at the outfall. Recommendations include adding the 40m stations to routine biomonitoring and improving the techniques to differentiate terrigenous and sewage derived sources of nitrogen.

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2 INTRODUCTION

2.1 Project Objectives

A number of benthic invertebrate species have been identified as useful indicators of organic pollution by sewage. Ecologists and monitoring agencies are anxious to find ways to qualitatively and quantitatively define a "healthy" or "polluted" benthic system. Research in temperate ecosystems has shown that many species of the benthos may be positively or negatively influenced by sewage. Species favored by sewage as a food source may show high levels of abundance, larger body size and more successful reproduction; species particularly sensitive to this form of perturbation which are otherwise a normal component of the local benthic community are absent.

Favored species can be regarded as good indicators, especially when their abundance is significantly greater than that of other community components and the overall species richness is lower than the adjacent areas not influenced by sewage. The polychaete, Neanthes arenaceodonta, is a good indicator of sewage input in temperate systems (Reish 1959, 1973). This species is usually present in Hawaiian coastal habitats and adjacent to the Sand Island sewage outfall, and has reached high levels of abundance at sewage enriched sites (Bailey-Brock, et al. 1991; Nelson, et al. 1992). Another polychaete indicator in temperate latitudes is Capitella capitata (considered to be a complex of sibling species) which also responds positively to the organic component of sewage. Capitella capitata occurs in Hawaii and can be numerically abundant. Whether these and other potential indicator species respond in the same manner to sewage input and community interaction in Hawaiian waters as they do in the temperate part of their range is one of the questions of our study.

Before a group of species can be identified as environmental indicators, their life history and population characteristics in the geographic location in question need to be investigated. This data base is either incomplete or not available for the species that are potential indicators of organic enrichment in Hawaiian waters. This information is essential to avoid misleading conclusions based on the behaviors, life histories or responses to environmental stress of these species.

Ideally, an indicator species should have the following attributes:

a) Regular and/or frequent reproduction to maintain populations. These are annual or multiannual reproducers according to Fauchald's (1983) life history diagrams.

b) Production of juveniles or advanced larval stages that have a brief pelagic stage, or direct development. This reduces the risk of progeny being carried away from the food source by currents.

c) The ability to reproduce asexually, which results in direct recruitment to the parent population without a pelagic dispersal phase.

d) Successful and regular recruitment to maintain populations by any or a combination of a, b and c.

e) Rapid response to the perturbation; i.e. individuals may grow fast, become sexually mature within a short period following recruitment, and become superior competitors in the habitat.

f) Ammensalistic effects on community components. Ammensalism occurs when a dominant species prevents associated species from becoming established in the immediate vicinity due to repeated disturbance or bioturbation. Functional group ammensalism (Wilson 1981) considers the abilities of motile species to displace tube dwellers, and deposit feeders to displace suspension feeders. Interaction between species, or groups of species, may lead to the dominance by indicators and absence of sensitive species.

Species with these traits help to structure communities and a typically more homogeneous community develops at the site of disturbance (e.g. sewage input or non-point sources of light industry pollutants) compared to more heterogeneous assemblages in similarly abiotically structured areas without the perturbation (Sanders 1968). In Hawaiian waters heterogeneous communities dominate soft (Bailey-Brock, 1977, 1984; Bailey-Brock, et al. 1991; Nelson, et al. 1992) and hard bottom habitats (Brock and Smith 1983, Dutch 1988) and species diversity is not significantly reduced at the outfalls. Instead, large numbers of some species may indicate response to increased food availability (Nelson, et al. 1992).

The objectives of this study are listed below and will be discussed individually in numerical order:

1. To determine if some of the abundant and frequently occurring species can be called indicator species based on life history parameters in Hawaiian waters. To accomplish this, indicator species were raised in the laboratory to follow life history events and compare them to those described in the literature.

2. To look for seasonality in indicator presence and associated benthic community structure at the outfall (Station B3) and a control site at Diamond Head, at depths of 70m. Specifically to look for seasonal peaks in abundance, changes in size (or age) of the population, and describe community changes that may occur seasonally.

3. To quantify the polychaete community at 40m from replicate cores to compare with the data available from 70m. This should help to determine if the discharge plume rises and infringes on the benthos.

4. To characterize the grain size distribution for 40m and 70m samples to define the infaunal habitat as determined by grain size composition.

5. To run CHN analyses and Nitrogen signatures for most of these samples to determine organic content of the sediments and the source of nitrogen in the tissues of benthic organisms.

2.2 Project Organization

Contributors to the project include Mr. Bob Rochleau, Sea Engineering Inc. and UH Maritime Center for boat charter, Dr. W.J. Cooke for advice on crustaceans, Dr. C. Fletcher for the loan of the sediment shaker, Mr. David Hashimoto for advice and training for CHN and N signatures, and Dr. E. Laws for the use of his laboratory facilities. I am most grateful to the Zoology Department staff for their assistance with all administrative aspects of this study.

<u>Contributors to this report:</u>

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McCarthy, Sheryl, candidate for the PhD., Department of Oceanography. Research Assistant. Researched grain size analytical methods and data presentation.

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Strasser, Karen, candidate for the MS, Department of Zoology. Research Assistant. Assisted with polychaete identifications and field work.

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2.3 Introduction

To establish whether commonly occurring and abundant polychaetes can be called indicators of the organic component of sewage effluent, designated species were quantified and their proximity to the zone of initial dilution (ZID) was noted.

The selection of possible indicator species was based on the annual database (Nelson et al. 1986, 1992 a,b, 1993, 1994,; Bailey-Brock et al. 1991) collected by the City and County of Honolulu. Species that showed a possible indicator role are Neanthes arenaceodonta, Capitella capitata, Pionosyllis heterocirrata (= P. gesae) and Ophryotrocha sp A.

Life history information - based on literature review

Neanthes arenaceodonta F. Nereididae

Active, omnivorous worms that live at the sediment - water interface where they feed on particulate materials of plant and animal origin (Fauchald and Jumars 1979). Reproductive individuals lay their eggs in mucus tubes and the parent stays with the developing eggs. Eggs hatch as small juvenile worms, so there is no pelagic larval stage in the life cycle (Reish 1959, 1973). Large numbers of these worms can build up in a short time to dominate the community when there is a plentiful food supply, because the young are not dispersed into the overlying water column.

Capitella capitata F. Capitellidae

These sediment burrowing worms are non-selective deposit feeders that engulf sediment and then digest the organic components. Worms lay yolky eggs in mucus-lined tubes and hatch as pelagic larvae or as small juvenile worms. This dual reproductive strategy allows dispersal of larvae to distant locations, or advanced juveniles to remain in the vicinity of the parent population (Grassle and Grassle 1974, Reish 1979). Reproduction is frequent and enhanced by food availability.

This opportunistic species has been declared an indicator of organic enrichment in many parts of the world. Specific studies have been done in the continental United States (Grassle and Grassle 1976), Japan and Europe (Warren 1976, Pearson and Pearson 1991). Capitella capitata is a complex of sibling species which have slight morphological differences, but with different reproductive modes and genetic and ecological characteristics (Grassle and Grassle 1976, Grassle 1980, Wu et al. 1991). Two sibling species from the North Sea had different tolerances to hydrogen sulfide and anaerobic conditions as well as different size and reproductive characteristics (Gamenick and Gierre 1994).

Pionosyllis heterocirrata (=P. gesae) F. Syllidae

A sand dwelling species that is widely distributed in coral reef habitats (Uebelacker and Johnson 1984). These small worms are omnivorous and found in shallow depths (less than 8 m) and at 40 and 70 m depths off Oahu's south shore.

Ophryotrocha sp. A F. Dorvilleidae

This dorvilleid genus is characterized by minute, ciliated, jawed worms that resemble advanced larval stages of polychaetes because of the segmentally arranged ciliary bands. The jaws are thought to grasp and shred algae and particulate matter, and this species is categorized as a motile detritivore (Fauchald and Jumars 1979). Ophryotrocha spp. are known to have short life spans of a few weeks, are frequent reproducers or multiannual species that are well adapted to surviving in unpredictable and unstable environments (Fauchald 1983). Ophryotrocha sp. A may prove to be a new species, and is widely distributed and often abundant at the outfall stations in Mamala Bay (70m).

2.4 Methods

Field methods

Sediments were collected from 40 m and 70 m stations (Fig. 2.1) with a 0.25 m^2 Van Veen grab from vessels equipped with a winch and GPS. Sediments for live worm extraction were either placed in fresh sea water in plastic containers with lids and stored in a cooler, or in a large bucket with portable aerators. Samples were transported to the laboratory and aerated until they were sorted using a dissecting microscope.

Laboratory methods

Live worms were removed by manually sorting through small amounts of sediment while viewing with a dissecting microscope and pipetting worms to aerated containers for culture. This method was found to be the least destructive to the worms which could be damaged by sieving and elutriation.

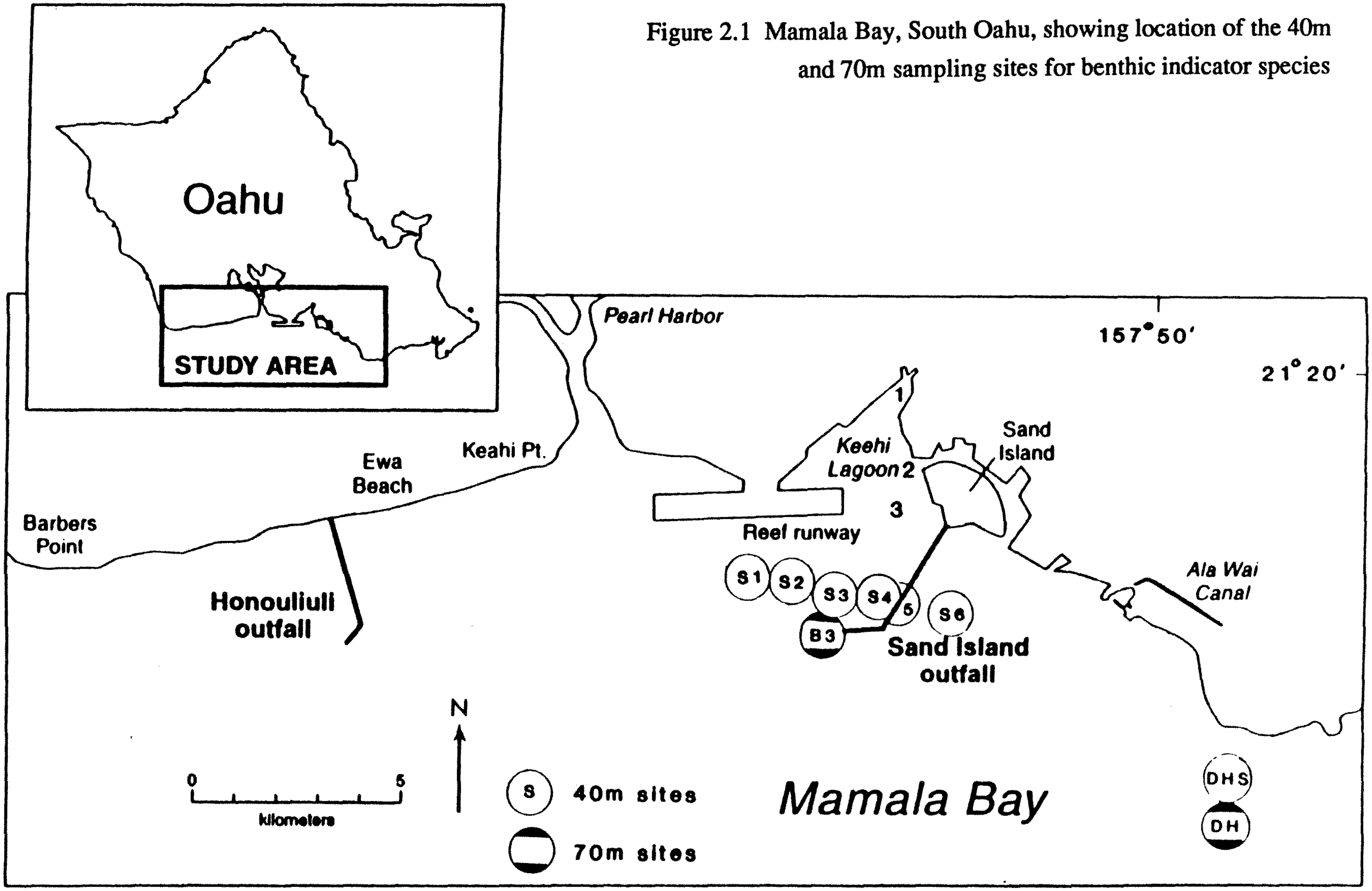
Worms were held in an air conditioned lab (water temp. 22.9^{o}C) in small containers (petri dishes holding 30ml of filtered sea water) and larger containers, glass dishes with 100-200ml of sea water and one gallon aquaria. Sea water used for cultures was collected from Diamond Head and treated in a microwave to kill microorganisms (60sec per 100ml), or Millipore filtered water (0.2 micron) was obtained from the Kewalo Marine Laboratory (UH, PBRC). Worms were fed crushed Tetramin fish flakes and oven-dried, powdered Enteromorpha intestinalis (green alga).

2.5 Results

Neanthes arenaceodonta - only two specimens (one small male and a larger female) were found during the entire study, neither were from the Mamala sediment samples, but collected from a shallow reef flat near the entrance to Pearl Harbor. Worms did not reproduce, although the female twice produced oocytes in the coelom. The animals lived in culture for about one month.

Capitella capitata - a few worms were collected and maintained in the laboratory where they formed mucus tubes and burrowed in the sediment lining the culture dishes. They did reproduce and trochophore larvae were seen in the culture, but they did not survive to settle.

Figure 2.1 Mamala Bay, South Oahu, showing location of the 40m and 70m sampling sites for benthic indicator species



Pionosyllis heterocirrata - a number of worms were isolated and maintained in petri dishes. Worms could be observed moving around in their transparent tubes which later became occluded with algal fragments. They showed a preference for making tubes in scratched grooves in the dish which provided a third dimension to the flat substrate. Individuals comprised of 12 setigers (segments with setae) were observed in the dishes after 3 weeks, indicating that young had been produced in the tubes by asexual or sexual means.

Ophryotrocha sp A - this was the most successful species for laboratory culture. Four or more generations were maintained in the laboratory on a diet of powdered algae and tetramin flakes. Life history as observed in the lab is shown in Fig. 2.2. Mating and cross fertilization occurred in a mucus "tent" between individuals with about 13 setigers (minimum of 8 setigers), 6-9 eggs were visible in the coelom. Within one to two days eggs were deposited in the tent. A parent actively kept down the growth of fungi and microorganisms, as well as defending the brood from worms of both sexes. One to two days later, free swimming trochophore larvae were seen in the culture dishes, and 1-2 days after seeing larvae, newly settled, one setiger, jawed juveniles were seen on the bottom of the dishes. These juveniles grew at a rate of 1 setiger every 2-3 days, and the largest worms had 17 setigers. Worms were photographed at each developmental stage.

We are not sure whether our worms were hermaphroditic or of separate sexes (gonochoristic), but mating occurs more than once in a life history and a number of generations are predictable in culture. Species belonging to this genus are known to have reproductive strategies that include ovoviviparity, viviparity and neotenic developmental characteristics (Akesson 1994). Changes in the jaw structure of juveniles and adults are evident from scanning electron and light microscopy and may reflect a change in diet as the worms grow (Paavo pers. observ., 1995).

2.6 Conclusions

Ophryotrocha sp. A completed a generation (from egg deposition to 13 setigers) in 28-46 days, and worms grew a setiger every 2-3 days. Normal sexual maturity was assumed at 13 setigers although individuals with 8 were observed mating. Observations of field-gathered Ophryotrocha sp. A support laboratory life history data stating sexual maturity (as indicated by oocyte appearance in the coelom) was reached in worms typically possessing 13 setigers, but minimally 8.

Pionosyllis heterocirrata had produced young within 3 weeks and are often found with young attached indicating that asexual reproduction by budding had occurred. Eggs could sometimes be seen through the transparent body wall indicating that sexual reproduction is also possible for this species. Capitella capitata may thrive in the lab, but not enough worms were obtained to maintain a viable culture and larvae did not survive to settle under these conditions. Neanthes arenaceodonta can be successfully raised from pairs in individual containers and the life history traits are well known (Reish 1957). If we had been able to retrieve more live worms during this study we should have been successful with this species.

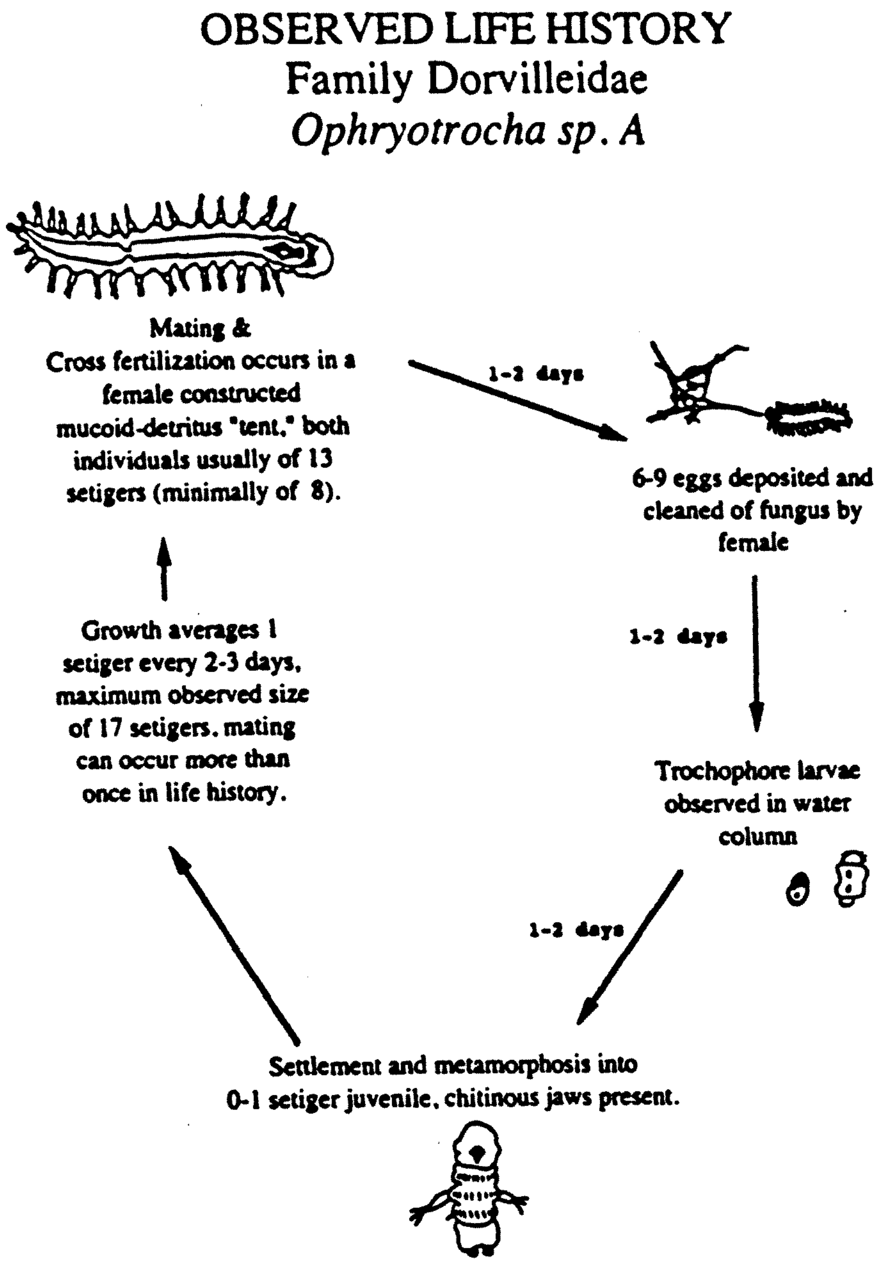


Figure 2.2 Life history schematic for Ophryotrocha sp. A as observed in the laboratory

3 SEASONAL ABUNDANCE OF INDICATORS AT 70M

3.1 Introduction

To determine if any of the four species selected as indicators showed seasonal peaks of abundance, samples were collected in the summer, winter and quarterly.

3.2 Methods

Quantitative samples from 70m depth were collected with a Van Veen grab sampler from B3 and Diamond Head (5 replicates at each) in Aug 93, Nov 93, Jan 94, and May 94 and Aug 94. Samples were fixed in 10% formalin on the boat and, after 48 hrs., elutriated and sieved into nested sieves of 0.5mm and 0.25mm at the lab. This procedure separated the macrofauna onto the 0.5 mm sieve and the meiofauna (which may include recently settled larvae) onto the 0.25mm sieve. Unless otherwise stated, abundance and species data reflect the macrofaunal fraction of the samples.

WORM MEASUREMENTS

A dissecting scope was used to obtain several measurements of indicator species. The right eyepiece contained a measuring reticle. The reticle was calibrated at different magnifications by viewing a metric ruler and noting the number of reticle divisions that corresponded to the number of observed millimeters. Worms to be measured were placed on a microscope slide in a small drop of glycerin. The drop was small enough to provide sufficient surface tension to straighten the worm for accurate measurement, but large enough to keep the worm from shrinking under the heat of microscope illuminators. The total length of the worm was measured from the anterior border of the head, not including palps, antennae, extended pharynges, or cirri. The length of the first ten setigers was measured from the back of the peristomium to the posterior border of the tenth setiger. The width of the fifth segment was also measured, not including parapods. The number of setigers was counted, not including the prostomium or peristomium, and if the worm was complete, it was noted whether or not the worm was regenerating or if the coelom contained oocytes.

3.3 Results

May 94, Aug 93 and Aug 94 samples represent the "summer" data set while Nov 93 and Jan 94 are the "winter" data set (Table 3.1, Figs. 3.1, 3.2). Only three of the indicator species were found but all three show seasonal and/or site differences.

Ophryotrocha sp. A was not found at the Diamond Head site, but was abundant at B3. Total absence at DH versus repeated presence at B3 shows suitability of B3 to Ophryotrocha sp. A life history. Aug 93 presented significantly more individuals of this species than Jan 94, May 94 and Aug 94, but not more than those collected in Nov 93. While Aug 93 showed extremely elevated numbers of Ophryotrocha sp. A, a trend appears to exist for elevated macrofaunal Ophryotrocha sp. A individuals in the late summer, declining through winter and increasing in the early summer. Capitella capitata was found at both sites and was most abundant in the summer B3 collection. Though numbers of individuals are too low for detailed analyses, the greatest abundance of Capitella capitata occurred during August samplings while lowest abundances were retrieved during winter samplings. Winter lows were comparable between sites while summer values increased at B3 and not at the DH site.

Table 3.1 Abundances of macrofauna for winter (Nov93 and Jan94) and summer

		WINTER		SUMMER			
Indicator species		Nov93	Jan94	Aug93	May94	Aug94	Totals
Ophryotrocha sp. A	DH	0	0	0	0	0	0
	B3	51	18	142	28	23	262
Capitella capitata	DH	0	4	4	1	2	11
	B3	3	3	53	1	21	81
Pionosyllis heterocirrata	DH	17	35	7	9	13	81
	B3	24	43	31	30	20	148
Neanthes arenaceodonta	DH	0	0	0	0	0	0
	B3	0	0	0	0	0	0
DH Totals		17	39	11	10	15	
B3 Totals		78	64	226	59	64	
Grand Totals		95	103	237	69	79	583

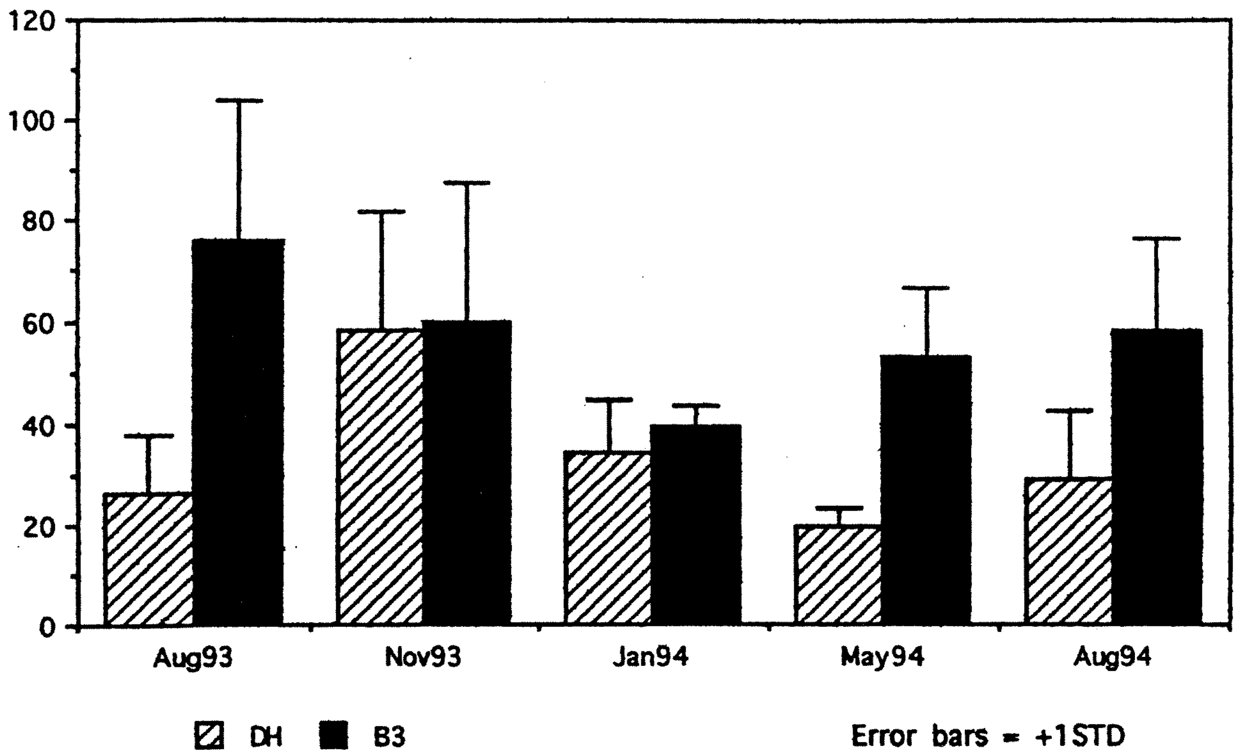


Figure 3.1 Comparative polychaete abundances through time at stations DH and B3 (70m)

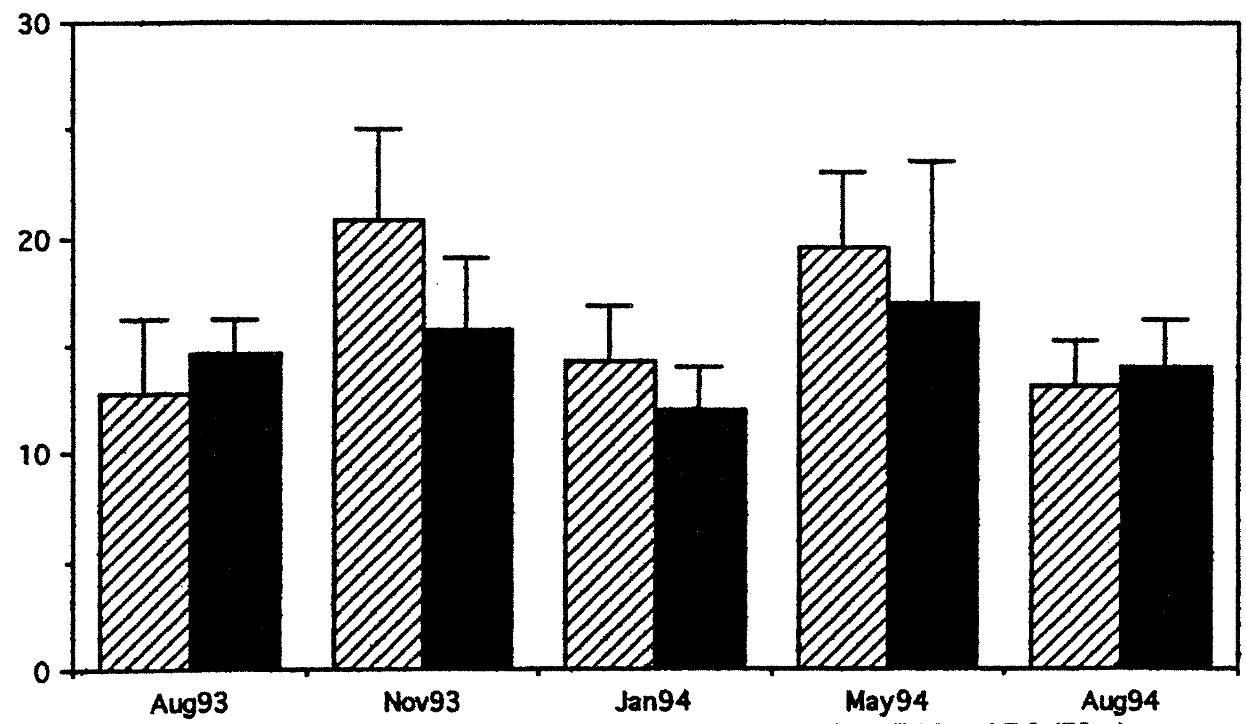


Figure 3.2 Comparative species richness through time at stations DH and B3 (70m)

Pionosyllis heterocirrata was consistently more abundant at both sites than the other two species and was in greater numbers at B3 in summer and winter than at Diamond Head. Evidence for reproduction in P. heterocirrata (the presence of oocytes in the coelom or asexual budding) was found throughout the year at shallow sites (Temporal variability - MB9).

Ophryotrocha sp A would fit the criteria for an indicator species favoring conditions near the outfall, and not occurring at the DH site. Ophryotrocha sp. A was especially abundant during the summer months when the population was 2-3 times greater than during the winter. Capitella capitata was more than 7 times as abundant at B3 in the summer compared to the winter, but only showed a small increase at Diamond Head in the summer. Neanthes arenaceodonta - was not found in any of our 70 m samples although it did occur in the 40 m samples from S1 and S2, but should not be considered as a good indicator species for the Sand Island region at this time due to low abundances in recent surveys.

Table 3.2 Commonly occurring polychaetes at B3 and DH at 70m in winter (W) and summer (S) samplings.

Protodrilus sp. A.	-	B3S	-	-
Protodorvillea biarticulata	-	B3S	-	-
*Capitella capitata	-	B3S	-	-
*Ophryotrocha sp. A.	B3W	B3S	-	-
*Schistomeringos rudolphi	B3W	B3S	-	-
Pionosyllis spinisetosa	B3W	-	-	-
Pionosyllis heterocirrata	B3W	B3S	DHW	DHS
Prionospio cirrobranchiata	B3W	B3S	DHW	DHS
Podarke angustifrons	B3W	B3S	DHW	DHS
Nereimyra sp. A.	-	-	DHW	DHS
Lumbrineris latreilli	-	-	DHW	-
Nereis sp. B	-	-	DHW	-
Prionospio cirrifera	-	-	DHW	-
Synelmis acuminata	-	-	-	DHS
Microspio granulata	-	-	-	DHS
Myriochele oculata	-	-	-	DHS

* Indicator species of organic enrichment

MEIOFAUNAL POLYCHAETES

SITE COMPARISONS

In all sampled months the means of meiofaunal polychaetes collected at B3 were greater than those presented by DH collections. In three of the five samplings, meiofaunal polychaete abundances were two to three times greater at B3 than DH (Fig. 3.3). Aug 93 and Nov 94 presented significantly more meiofaunal polychaetes at B3 than DH, while Aug 94 possessed a nearly significant number.

SEASONALITY

Although numbers of meiofaunal polychaetes at DH were marginally depressed during winter samplings, no significant seasonal variation existed. In contrast, a trend becomes apparent at B3. More meiofaunal individuals were recorded in late summer and early winter (Aug 93 and Nov 93), numbers decreased in the winter and early summer (Jan 94 and May 94), followed by another rise in Aug 94. Statistically, Aug 93 and Nov 93 had significantly more polychaetes than subsequent samplings.

Seasonal fluctuations at B3 were exaggerated by a single species, Ophryotrocha sp. A, present at B3, but not at DH. Abundance records of macrofaunal Ophryotrocha sp. A show identical significant differences as general meiofaunal numbers (of all polychaete species) attesting to the importance of the life history of this one species to the meiofaunal polychaete community. Removing Ophryotrocha sp. A from meiofaunal counts reduces the enormity of B3 abundances, but the same seasonal trend is apparent, especially when compared to the barely fluctuating DH abundances.

MEIOFAUNAL POLYCHAETE FRACTION COMPOSITION

In order to better understand the composition of the meiofaunal polychaete communities at the 70m Mamala Bay sample sites from Aug 93 through Aug 94, the polychaetes in the meiofaunal fractions from two randomly selected replicates (of five) from each of the stations were identified to family. It became evident that the site abundance differences were primarily attributable to the presence of one species, Ophryotrocha sp. A, at B3, which was absent from DH. In fact, this species comprised 45.9% of the individuals sampled at B3. Excluding the seasonal contribution of this species at B3, the resident community was similar to DH. The Syllid (Fam.) and Hesionid (Fam.) species at B3 and DH made up 80% and 70% of the individuals, respectively (Table 3.3). Although the sites show similarities in their dominant families, five families were unique to DH and one to B3. The differences in the total number (17 families vs. 13) and the number of unique families (5 vs. 1) between the sites, suggest that the meiofaunal polychaete community at B3 is less complex than the DH community.

Table 3.3 Family composition of meiofaunal polychaetes at 70m (omitting the Dorvilleid *Ophryotrocha* sp. A.)

B3 Families	% of Total Station Individuals	DH Families	% of Total Station Individuals
Syllidae	60.1	Syllidae	55.8
Hesionidae	20.5	Hesionidae	14.3
Capitellidae	6.0	Sabellidae	6.6
Dorvilleidae (other)	5.1	Spionidae	6.0
Pilargidae	2.4	Pilargidae	5.7
Amphinomidae	1.8	Dorvilleidae (other)	3.0
Spionidae	1.2	Nereidae	3.0
Pisionidae	1.2	Ophelidae	1.5
Nereidae	0.6	Pisionidae	0.6
Lumbrineridae	0.3	Lumbrinereidae	0.6
Ophelidae	0.3	Amphinomidae	0.6
Sabellidae	0.3	Phyllodocidae	0.6
Questidae	0.3	Cirratulidae	0.6
		Questidae	0.3
		Ampharetidae	0.3
		Paraonidae	0.3
		Glyceridae	0.3

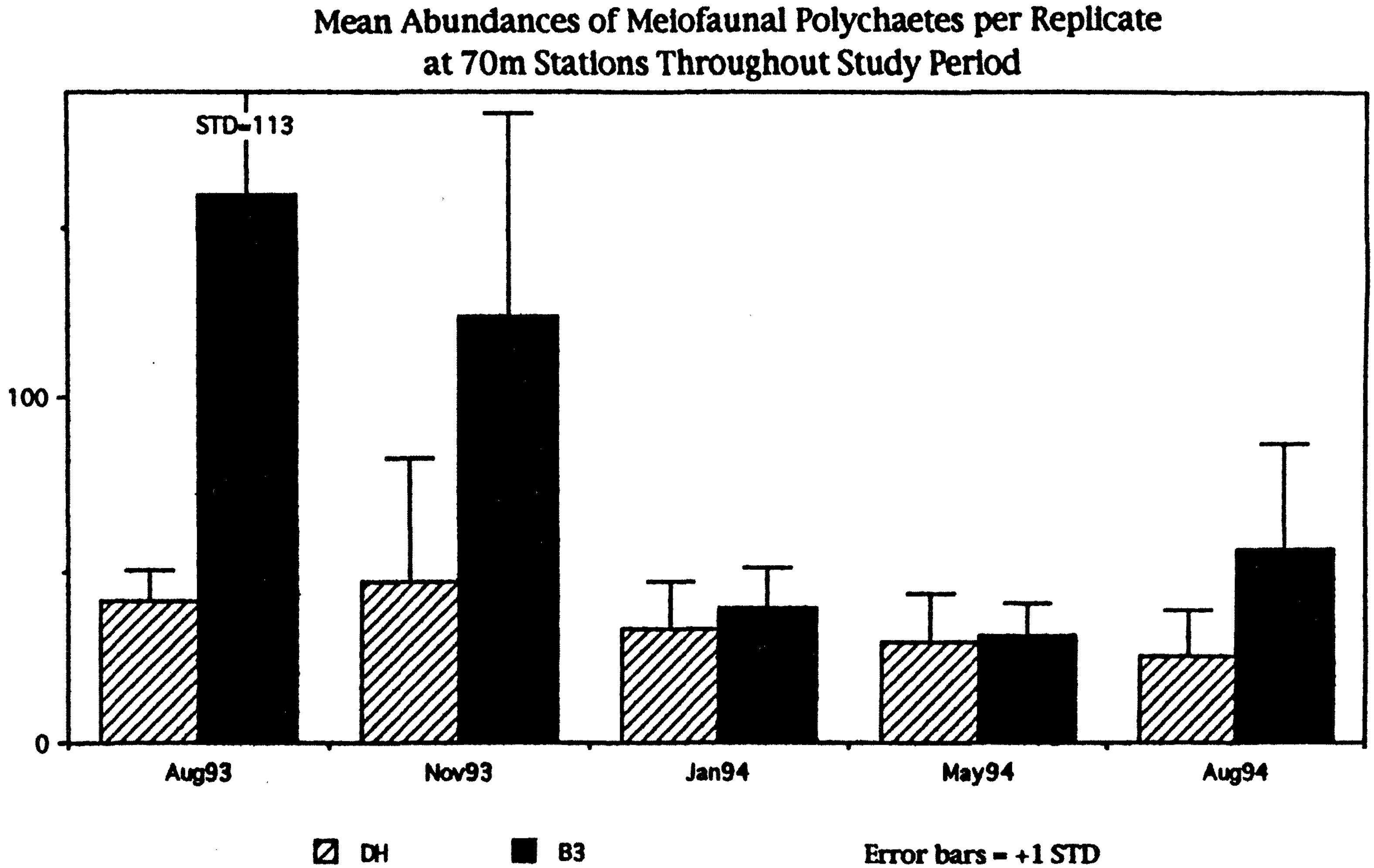


Figure 3.3 Meiofaunal Polychaete seasonality at 70m stations

INDICATOR SPECIES MEASUREMENT

Capitella capitata specimens were observed to be marginally larger at the B3 stations than at the DH stations. The overall average length of the first 10 setigers was 0.85mm, the average width was 0.25mm, and the average total length was 4.29mm. The average number of setigers was 28. Incomplete worms were not used in the total length or setiger averages. All of the specimens measured were from Aug 93 or Aug 94 samples, so seasonal comparisons could not be made.

Pionosyllis heterocirrata specimens were found to be longer at B3 than at DH. At DH the average 10 setiger length was 0.57mm, and the average total length was 2.00mm. At B3 the average 10 setiger length was 0.68mm, and the average total length was 3.53mm. The width of the specimens did not seem to be affected by season or station. The overall average 10 setiger length was 0.63mm, the average width was 0.12mm and the average total length was 2.51mm. The average number of setigers was 30. Incomplete worms were not used in the total length and setiger averages.

Ophryotrocha sp. A seemed to display an increase in length and width in May 94. In Aug 93 the greatest number of individuals with eggs was observed. As this species was not found at DH, a size comparison between DH and B3 could not be made. The overall average 10 setiger length was 0.82mm, the average width was 0.26mm and the average total length was 1.26mm. The average number of setigers was 13. Incomplete worms were not used in the total length and setiger averages.

OLIGOCHAETES

Macrofaunal oligochaetes from 70m sites showed no significant indication of seasonal abundance fluctuations at either site. Although B3 oligochaete collections were always greater than DH collections, only one sampling (Jan 94) presented a significantly greater abundance at B3 than DH. Variation between the replicates largely accounts for this lack of significance (Fig. 3.4).

NEMATODES

Macrofaunal nematodes were consistently significantly more abundant at B3 than at DH (Fig. 3.5). Significant differences suggest seasonal variation of nematode abundance at both sites, but more detailed analyses are required before conclusions may be drawn.

3.4 -Conclusions

Conditions at B3 in the summer months appear to stimulate population increases of two indicator species (Capitella capitata and Ophryotrocha sp. A) when compared to the abundances at the control site. Comparing these data to the 1993 and 1994 Sand Island studies (Nelson et al. 1994, 1995) shows that Ophryotrocha sp. A was rare or not found at all at the outfield stations (B1, B2 and B6) but was abundant at the ZID stations (B3, B4 and Z) and at B5 in 1993. This supports our results that Ophryotrocha sp. A is a ZID associated species that probably benefits from the outfall. Similarly in 1993 and 1994, Capitella capitata was usually most abundant at B3 and poorly represented at the other stations. It is not considered to be a ZID associated species, but may be more numerous nearer the ZID than further away at the outfield and control sites.

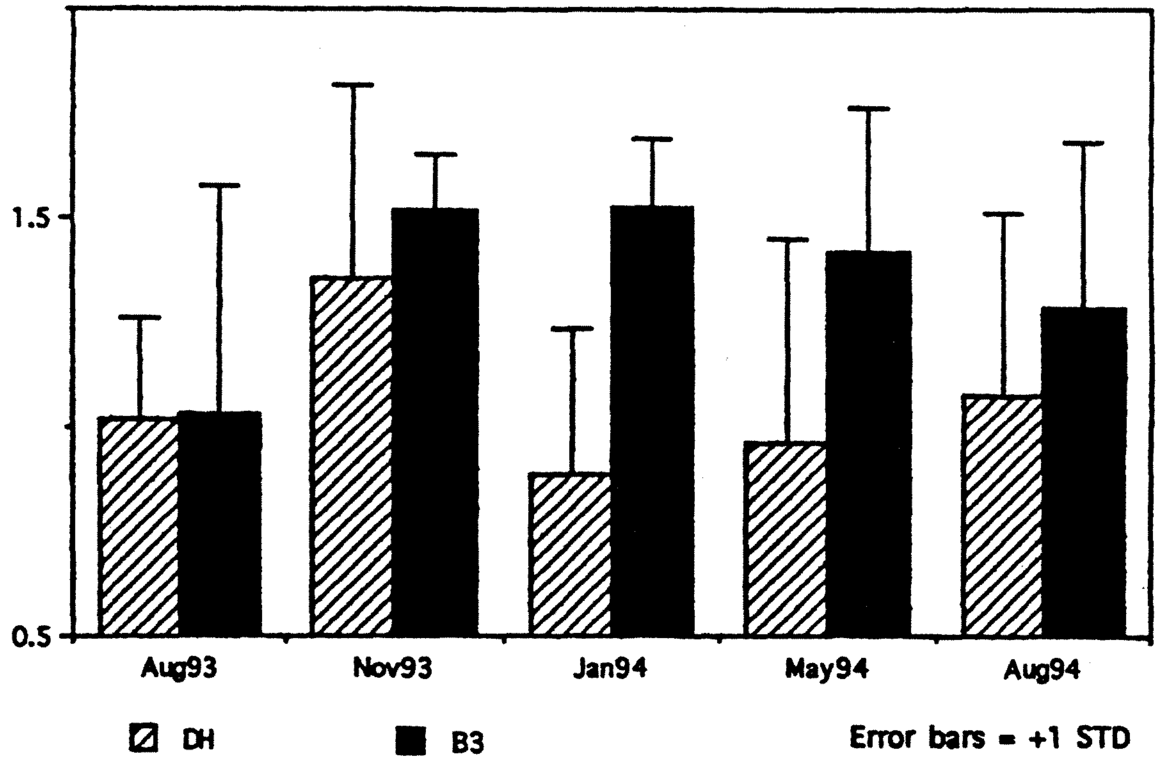


Figure 3.4 Oligochaete abundance at 70m stations
(Log transformed)

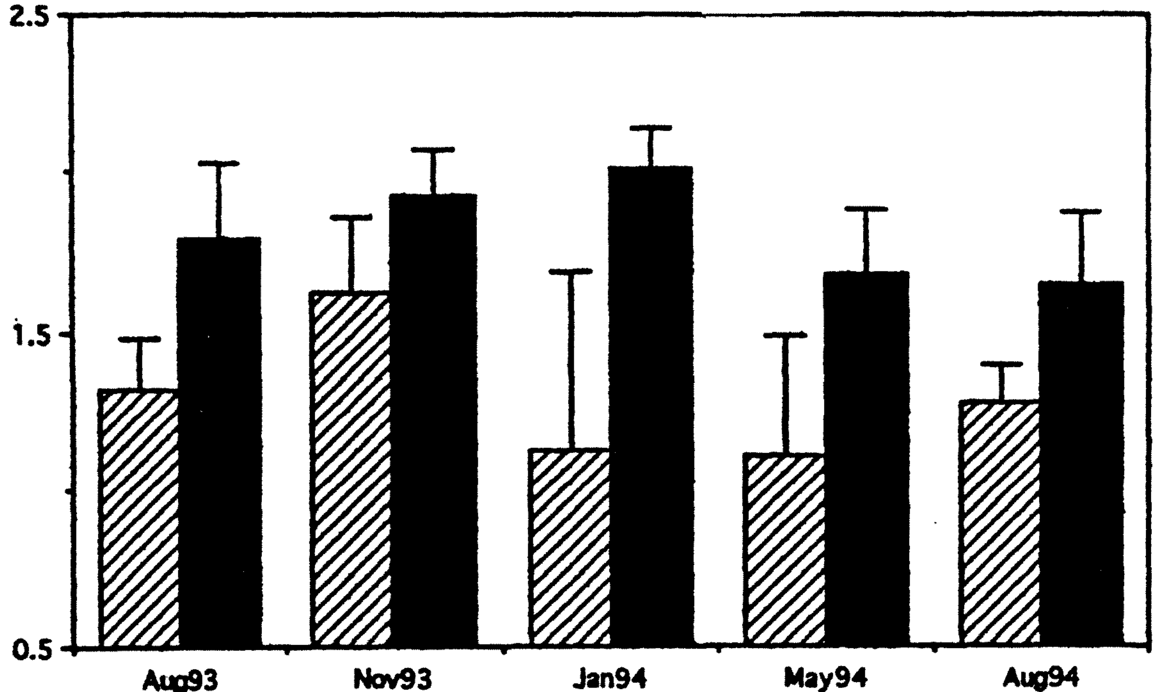


Figure 3.5 Nematode abundance at 70m stations
(Log transformed)

4 SEASONAL ABUNDANCE OF BENTHOS AT 40M

4.1 Introduction

A preliminary computer generated model (MB-5 report) showed that the discharge plume could be present at a depth interval of 30-50m approximately 40% of the time. To determine if there is an influence of the sewage plume on the benthos inshore of the 70m stations surveyed in the existing monitoring program, infaunal communities from 40m were analyzed and potential indicator species were evaluated.

4.2 Methods

Six replicate cores of 7.6cm (diam) x 5cm (deep) were collected from 40m at each station using a $0.25m^2$ Van Veen grab sampler (S1, S2, S3, S4, S5, S6 and DHS, Figure 4.1) in Feb 94 and Aug 94. Samples were fixed in 10% formalin on the boat, and, after 48 hours, elutriated and sieved using nested sieves of 0.5 mm and 0.25 mm mesh in the lab. This procedure separated the macrofauna onto the 0.5 mm and the meiofauna (which may include recently settled larvae) onto the 0.25 mm sieve.

4.3 Results

Aug 94 represents the "summer" 40m data set, while Jan 94 is the "winter" 40m data set. All potential indicator species were recorded for both winter and summer sampling sessions (Table 4.1).

Table 4.1 Abundances of macrofauna for winter (W, Jan 94) and summer (S, Aug 94) 40 m depth, for stations S1-S6 and 40 m control (DHS). Abundances given are total numbers of individuals per station.

Species	Season	S1	S2	S3	S4	S5	S6	DHS	Totals
Ophryotrocha sp. A	W	0	1	0	0	2	1	0	4
	S	1	0	0	0	0	0	0	1
Capitella capitata	W	2	2	1	2	1	2	2	12
	S	3	3	9	2	1	3	1	22
Pionosyllis heterocirrata	W	7	10	53	33	102	62	85	352
	S	1	6	41	29	51	26	19	173
Neanthes arenaceodonta	W	0	47	0	0	0	0	0	47
	S	0	0	1	0	0	0	1	2
Euchone sp. B	W	72	328	4	0	2	18	13	437
	S	753	461	72	1	1	77	6	1371
Total Winter		81	388	58	35	107	83	100	
Total Summer		758	470	123	32	53	106	27	
Grand Total		839	858	181	67	160	189	127	2421

Pionosyllis heterocirrata was in greatest abundance (among indicators) and present along an abundance gradient at 40m relative to the proximity of the diffuser. During both summer and winter, abundances were relatively low at sites S1 and S2, increasing through S3, S4 and S5, and declining to an intermediate value at site S6 and DHS control. A suitable inverse trend was presented by another abundant worm, Euchone sp. B, which may illustrate a particular sensitivity to outfall perturbations.

Table 4.2 Historical data set for the sabellid, Euchone sp. B at the 70m stations of the biomonitoring program (1990-94, City and County of Honolulu) and the 40 and 70m stations of this study.

	B1	B2	B3	B4	B5	B6	Z	
1990	18	14	0	7	0	6	0	
1991	63	14	0	1	0	60	0	
1992	87	0	0	0	1	18	0	
1993	155	144	0	3	8	54	2	
1994	226	422	0	0	0	27	0	
Site Totals	549	594	0	11	9	165	2	
								DH
AUG93	-	-	0	-	-	-	-	1
NOV93	-	-	0	-	-	-	-	1
JAN94	-	-	0	-	-	-	-	0
MAY94	-	-	0	-	-	-	-	0
AUG94	-	-	0	-	-	-	-	1
	S1	S2	S3	S4	S5	S6		DHS
JAN94	753	461	72	1	1	77		6
AUG95	72	328	4	0	2	18		13
Site Totals	325	789	76	1	3	95		19

Historical data (Table 4.2) shows marked exclusion of Euchone sp. B from sites nearest the diffuser at 70 m stations while it was present in stations farther east and west. Mamala data support these findings, presenting a similar gradient at the 40 m isobath and Euchone sp. B absence during all samplings of the B3 (70 m) site (Table 4.2).

Only Pionosyllis heterocirrata and Euchone sp. B were sufficiently abundant (among potential indicators) to be considered commonly occurring species at the 40m stations (10% or greater of total sampled polychaetes at a minimum of one station per sampling session) (Table 4.3). Neanthes arenaceodonta, once a commonly occurring polychaete at B3 (Bailey-Brock et al 1991, Nelson et al 1992) was only found at S3 in any numbers. Ophryotrocha sp. A was rare at all 40m stations. Comparative polychaete abundances and species richness at the 40m stations for winter and summer are given in Figs. 4.1 and 4.2 while the full data set is presented in Appendix 3.

Table 4.3 Abundances of commonly occurring macrofaunal species (each representing 10% or greater of total collected polychaetes for at least one station per sampling session, for winter (W, Jan 94) and summer (S, Aug94) of 40m isobath, stations S1-S6 and control (DHS).

		S1	S2	S3	S4	S5	S6	DHS
Augeneriella dubia	W	43	56	54	12	70	19	5
	S	243	16	106	84	0	15	5
Euchone sp. B	W	73	328	4	0	2	18	13
	S	753	484	81	1	4	77	6
Linopherus microcephala	W	0	0	9	9	52	4	2
	S	0	0	10	1	20	3	1
Myriochele oculata	W	8	107	6	12	17	12	17
	S	37	76	38	12	31	31	4
Pionosyllis heterocirrata	W	7	10	53	33	102	62	85
	S	1	6	50	43	63	26	19
Podarke angustifrons	W	1	8	23	16	31	28	36
	S	16	17	37	39	14	28	44
Synelmis acuminata	W	40	80	28	51	266	54	60
	S	52	76	63	57	31	105	69
Prionospio cirrifera	W	14	13	2	4	5	4	18
	S	16	25	11	8	16	10	13
Prionospio cirrobranchiata	W	17	8	2	5	12	7	27
	S	3	2	3	0	5	4	18
Prionospio steenstrupi	W	10	7	3	3	8	1	3
	S	8	13	3	2	1	2	14
Notomastus tenuis	W	0	0	0	0	2	1	1
	S	0	7	4	8	4	6	6
Total winter	W	213	617	184	145	567	210	267
Total summer	S	1137	722	406	255	189	307	199
Total Collected (40m)		1350	1339	590	400	756	517	466

Three tubicolous worms (A. dubia, Euchone sp. B and M. oculata) were in notably low numbers adjacent to and west of the diffuser. Prionospio heterocirrata and Podarke angustifrons (omnivorous and carnivorous respectively, both are motile) showed an eastward increase in abundance along the stations.

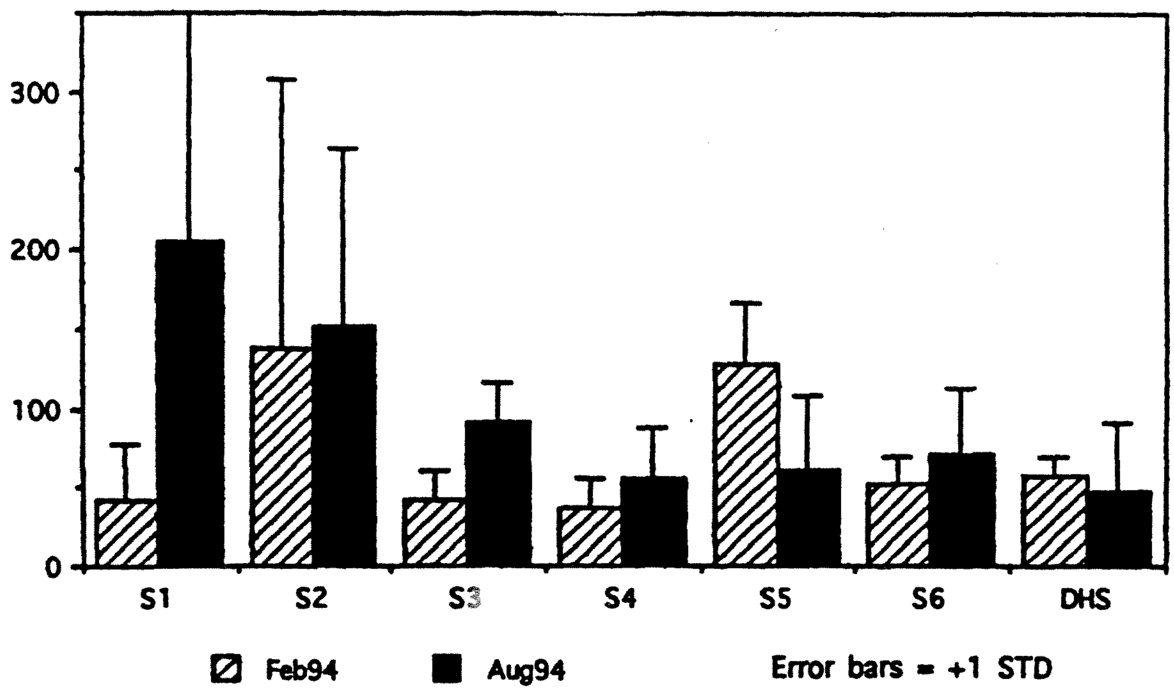


Figure 4.1 Comparative polychaete abundance at 40m stations

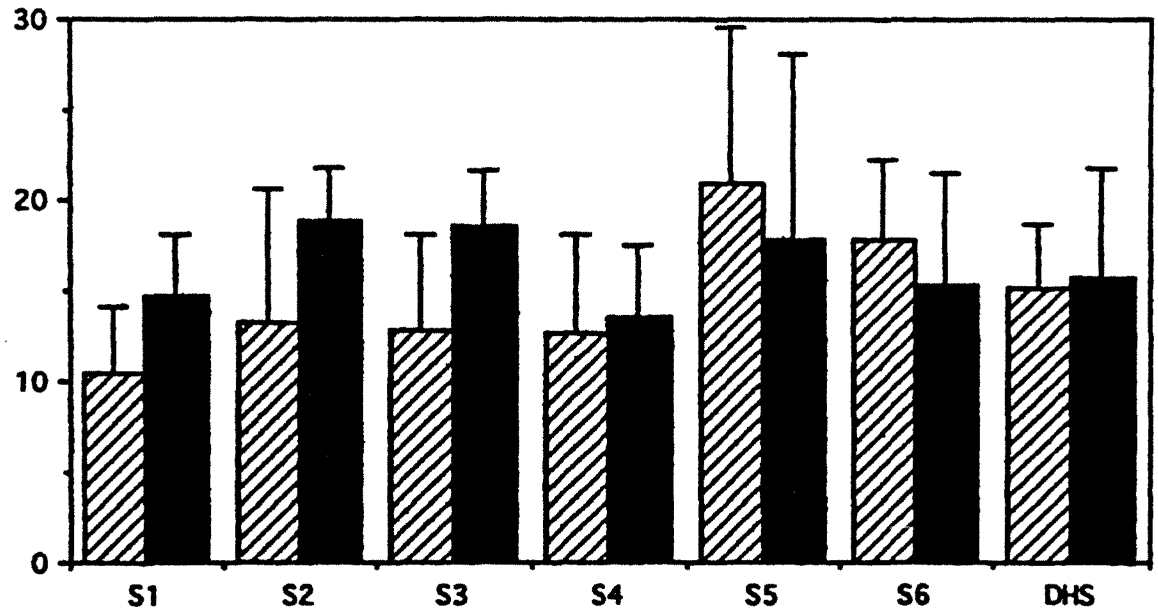


Figure 4.2 Comparative polychaete species richness at 40m stations

4.4 Conclusions

Conditions at S1 and S3 appear to stimulate population increases of polychaetes in general although indicator species were rare at all shallow stations in both winter and summer. Warmer summer water temperatures may stimulate reproduction and growth (Thorson, 1946 and 1950) at 40m, causing temporary increases in polychaete abundance at these two stations. Station S2 showed an increase in species richness with no increase in mean number of polychaetes per replicate. This may be due to summer recruitment of invertebrates from adjacent areas, with no enhancement of individual species. The winter increase in abundance observed at S5 is due mainly to greater densities of *Augeneriella dubia* and *Synelmis acuminata*. Colder winter temperatures may have redirected the sewage plume to this area, providing additional food resources.

5 CRUSTACEANS OF THE BENTHOS

5.1 Introduction

Mamala Bay Study collections in 1993 and 1994 yielded a total of sixty-two (62) discrete crustacean taxa from the nine sampling stations across the study area. As in studies conducted in the vicinity of the Sand Island outfall under the City and County of Honolulu biomonitoring program, collections for the Mamala Bay Study Commission are dominated by amphipods, isopods and tanaidaceans. Since these dominant taxa are brooders, releasing juvenile young directly into the benthic community, abundance numbers can be easily inflated and skewed by the presence of several generations of particular taxa at a "hot spot". Therefore, crustacean diversity (richness, as measured by the number of different taxa at a station) was judged likely to be a better initial measure of any impacts of the Sand Island WWTP outfall than abundance data or a combination of abundance and richness (such as Shannon-Weiner diversity index). Other crustacean taxa (copepods, shrimps, crabs) which recruit into the benthic community from drifting planktonic larva were also collected, but were generally less important. However copepods were found at all study stations, and as demonstrated by Station B3M (meiofauna) data, were an important part of the total benthic community. Study site B3 appeared somewhat less diverse than either study sites DH, DHS, or S1-S6 with only 21 taxa collected at this station. No further detailed analyses or statistics on the crustacean communities from different sites were done in this study. Several crustacean taxa not previously collected in the C&C Honolulu monitoring program were collected in this study. Occurrence of these additional taxa likely results from this sampling program extending into shallower water than earlier samplings. General observations are discussed below as well as suggestions for focusing further crustacean studies in this area.

5.2 Methods

Sample sequencing. The sample vials provided were grouped to ensure all replicates from a single station and sampling date would be examined together. Similarly, samples from the same station taken over several different sampling dates (August 1993 through November 1994) were examined sequentially to ensure consistent treatment of problematic taxa from each station.

Sample handling. Each individual vial was examined before opening, and the station data from the vial label(s) recorded on the log sheets. The cotton plug on the top of the sample vial and the inner label were examined under 6X binocular dissecting scope upon initial removal to ensure that no specimens were lost on the plug or label. The contents of each vial were then emptied into a small glass dissecting dish. If necessary, the contents of the vial were rinsed into the dissecting dish with a gentle stream of 70 % isopropyl alcohol. Each sample was initially examined in total under a low (6X to 12X) power binocular dissecting microscope. This determined the range of different crustacean taxa in the sample and a rough estimate of abundance. Specimens were then sorted and grouped to simplify identification. Specimens were maintained under 70 % isopropyl alcohol to maintain flexibility at all times.

Identification. Taxa were identified under a high power (25X to 50X) binocular dissecting microscope with in some cases, confirmation of certain diagnostic features under a compound microscope (100X - 500X). Identifications were made with reference to published literature (see References) and/or specimens collected from earlier studies in this area. When no published name was available, but the taxa could be correlated with samples identified in the earlier studies, the "working name" was recorded. Examples of this included the Myodocope ostracods Myodocope sp. A through Myodocope sp. C. Otherwise, each taxa was recorded with the best determination that could be reached given the adequacy of published literature and/or the condition of the specimens.

Counts. As each taxon was identified in a sample, a count was made of that taxon, and specimens were removed from the dissecting dish and returned to the original sample vial. All specimens were returned to the original vials except the reference specimens. The following notes relate to the identifications and counts.

a. Copepods, cumacea and mysidacea were not identified below the listed level.

b. Counts for Podocopid ostracods (particularly Bairdia kauaiensis) were based on intact specimens with visible appendages extending from the valves. Such counts probably somewhat over estimate live abundances since some specimens with visible appendages were without body tissue upon dissection. However, microscopic dissection of each podocope would not have been warranted and was not judged to be cost-effective for this study.

c. Some various small and juvenile Gammaridean amphipods may have been inadvertently lumped with other similar taxa in the same (or a closely related) genus. No diagnostic characters have been reliably identified for many of the smaller (and in some cases, female) stages of the gammaridean species encountered in this study. True gammaridean diversity across the study area is thus probably somewhat slightly higher than indicated here.

5.3 Results

Table 5.1 Summary species (taxon) numbers and total counts of specimens (all collection dates, all replicates per station).

STATION	COLLECTIONS	NUMBER OF SPECIMENS - TAXA
B3	Aug 93 - Nov 94	159 / 21
DH	Aug 93 - Nov 94	410 / 35
DHS	Feb 94 / Aug 94	324 / 22
S1	Feb 94 / Aug 94	394 / 25
S2	Feb 94 / Aug 94	304 / 25
S3	Feb 94 / Aug 94	267 / 18
S4	Feb 94 / Aug 94	363 / 20
S5	Feb 94 / Aug 94	314 / 22
S6	Feb 94 / Aug 94	343 / 22

Station tables in the Appendix show station data by replicates.

5.4 Conclusions

Study site B3 appeared somewhat less diverse than study site DH, the putative control site for this study. Site B3 also appeared less diverse than sites DHS or S1-S6. Only 21 of the 62 "available" taxa were present in the twenty-five (25) B3 samples (five samplings of five replicates) provided. Most taxa collected at Station B3 were collected only once, with the average occurrence being 1.48 (+/- 0.52). This rate of occurrence was not, however, significantly lower than the average occurrence at Station DH where the average occurrence was 1.64 (+/- 0.38). In other words, most taxa collected at both sites were "rare" taxa. Station B3 was notable in totally lacking tanaids, which were common at all other study stations. It is possible that the large numbers of copepods found in the meiofaunal sampling at B3 (see Station B3M) fulfilled the role that tanaids would normally fill. The average number of crustacean taxa in B3 samples was 6.0 taxa per sample (of five replicates). More sophisticated community diversity analyses would likely confirm this dichotomy between Station B3 and Station DH.

In contrast, DH collections included 35 of the 62 study area taxa (vs. 21 at B3). The average number of crustacean taxa for DH series samples was 13.0 taxa per sample (of five replicates). There was, however, higher internal variation in DH collections with the lowest having seven (7) taxa per collection, and the highest 25 taxa per collection.

Interestingly, the DHS station collections yielded only twenty-two (22) taxa. However, DHS had only twelve samples (6 reps. X 2 dates) versus the twenty-five (5 reps. X 5 dates) in B3 and DH samplings. DHS's reduced diversity is more likely related to this lower sampling effort than any indication that site DHS is significantly less diverse than DH. (By way of comparison at fifteen cumulative samplings, B3 had 13 taxa and DH had 31 taxa.)

Diversity at S-series samples from shallow sites inshore from the Sand Island WWTP outfall ranged from eighteen (18) to twenty-five (25) of the 62 study taxa. As at DHS these were twelve replicates total from two sampling dates. The range of diversity at stations S1 - S6 is comparable, and similar to the diversity observed at Station DHS. This suggests a lack of impact from the outfall at the S1 - S6 stations at 40 meters depth.

Several crustaceans not previously collected were seen in these samples. Most interesting were the podocope ostracod Bairdia hanaumaensis, previously collected from the shallow waters of Hanauma Bay. Similarly, two small brachyuran crabs, Achaeus sp. A. and Chlorinoides cf. goldsboroughi were also newly collected in this study. These larger crustaceans, including shrimps and the hermit crab, were collected too infrequently, in too low numbers, to be useful in examining differences between the study sites.

Overall species richness would appear to be the best measure of the status of these crustacean communities given the ability of most of these species to rapidly reproduce, giving wide swings in the abundance data.

If individual crustacean taxa are to be subjected to more detailed analyses, the following more common taxa would be likely candidates. They have been found in sufficient numbers across a range of sites. These include the ostracod, Bairdia kauaiensis; the tanaids Leptochelia dubia and Leptochelia sp. A.; and the gammaridean amphipods Eriopisella sechellensis, Ericthonius brasiliensis, Konatopus paao, and Photis kapapa.

6 GRAIN SIZE ANALYSES

6.1 Introduction

Grain size analyses were done for samples collected at 40 m and 70 m stations to help define the primary component of the infaunal habitat of the benthic communities. Grain sizes and their distribution is a critical habitat feature, as benthic organisms occupy the sediments in many ways: they are moving over the surface or burrowing through the upper few centimeters, using some grain sizes for tube construction, and swallowing and digesting various components as their major food resource. Mamala Bay sediments are primarily carbonacious and derived from the erosion and breakdown of the limestone pavement and biological byproducts (e.g. coral skeletons, molluscan shells, foraminiferans, etc.) Particles may be coated with sources of food, e.g. an organic film of bacteria, unicellular algae and particulate and dissolved organic materials. At shallow depths filamentous and thalloid algae adhere to rubble and smaller particles providing food for herbivores.

Porosity, stability and oxygen availability in sediments are also part of the habitat and are resources required to varying degree by the infaunal and interstitial benthic components. Protection from predators is provided to bioeroders that excavate and occupy burrows in carbonate rock. This component of the community is revealed by acid dissolving the rubble and large pieces of substrate (Brock and Brock 1977).

6.2 Methods

Seven stations across a 40m isobath (6 replicates at each) and two stations at the 70m isobath (5 replicates at each) were sampled (Fig. 2.1) and frozen until processing. Methods of sediment separation and analysis followed are after Folk (1968) as well as Holme and McIntyre (1984).

MUD FRACTION

Once thawed, a 63μm sieve was placed over a clean white bucket and the wet sample placed into the 63μm sieve. Approximately 950ml of distilled water was slowly added to the sample. The sieve was then gently puddled in a white bucket for a minimum of two minutes. The sieve was then carefully lifted above the surface of the water and the sides of the sieve sprayed with distilled water. After the excess water dripped into the bucket, the sieve was placed in a drying oven (80ºC) and the sediment allowed to dry (approximately 20min). This was the sand fraction for which the procedures will be discussed below.

The water in the white bucket was swirled and carefully poured into a 1 liter graduated cylinder. Tubing attached to a syringe was placed into the graduated cylinder and lowered approximately 20cm below the surface. Then 20 ml of the mud suspension was extracted from the graduated cylinder and squirted into a pre-weighed aluminum boat. The mud suspension and weigh boat combination was dried in an oven (80ºC) to constant weight. The weight of the aluminum boat was subtracted from the weight of the dried mud suspension and aluminum weigh boat combination to obtain the weight of the mud. Since only 20ml of the 1 liter sample was dried, the mud weight was then multiplied by 50 to arrive at a mud fraction weight.

SAND FRACTION

The dried samples were weighed and placed on a graded series of sieves (2mm, 1mm, 0.5mm, 0.25mm and 0.063mm). The graded series was set on a mechanical sediment shaker and shaken for 10 min. Each sieve was gently turned over a piece of white paper and tapped or brushed out to ensure all sand was off the sieve. The sediment from each sieve, along with the weigh boat was then weighed. The sediments which passed through the 0.063mm sieve and into the closing pan at the bottom were weighed and added to the mud fraction. Sediment fractions (including the mud) were summed for a total weight. From that, the percent by weight of each fraction was determined.

DATA ANALYSIS

Due to an inability to normalize the data or stabilize the variance, the non-parametric Kruskal-Wallis test was used to compare the mud, fine and coarse sand fractions. A confidence interval of 95% ($P \leq 0.05$) was used to determine if a significant difference existed through space or time.

6.3 Results

SPATIAL COMPARISON

Appendix 5A contains raw data for percent composition of each sediment size fraction and figures 6.1 through 6.4 represent high/low and mean percentage composition for each sediment size class at each station.

Figure 6.1 depicts the mud, fine and coarse sand data for Feb 94. The largest percentages of coarse sand occurred at stations S3-S6. The largest percentages of fine sand occurred at stations S1 and S2. The largest percentages of mud occurred at stations S1-S3. A Kruskal-Wallis test showed significant differences in percent composition of mud (P=0.023), fine sand (P=0.001) and coarse sand (P=0.001).

Figure 6.2 depicts the mud, fine and coarse sand data for Aug 94. The largest percentages of coarse sand occurred at stations S4-DHS. The largest percentages of fine sand occurred at stations S1-S3. The largest percentages of mud occurred at stations S1 and S2. A Kruskal-Wallis test showed significant differences in percent composition of mud (P=0.003), fine sand (P=0.001) and coarse sand (P=0.001).

TEMPORAL COMPARISON

Figure 6.3 depicts analyses at station B3 through time. The largest percentages of coarse sand occurred during Nov 93. The largest percentages of fine sand and mud occurred during Aug 94.

Figure 6.4 depicts Diamond Head through time. The largest percentages of coarse sand occurred during May 94. The largest percentages of fine sand and mud occurred during Aug 93.

6.4 Conclusions

Comparing stations along the 40m isobath over time (Feb to Aug 94) shows more coarse grain sizes at stations S4, S5 and S6 with a greater mud fraction at stations S1, S2 and S3. Between winter and summer the composition at station S3 changed the most, with twice as much coarse sediment in winter (Feb 94), as well as a larger mud fraction.

Along the 70m isobath, the sediment grain sizes showed 60% more coarse sand in winter (Nov 93) at station B3 than Diamond Head . In the summer (Aug 93 and May 94) however, the opposite occurred, with more coarse sediments at Diamond Head.

Results are consistent from shallow (40m) to deep (70m). Station S3 (40m) and B3 (70m) showed similar proportions of coarse to mud sediments in the winter time. Particle redistribution may occur in conjunction with seasonal water movements. Other factors also affect habitat as well, but characterization of grain size across stations do indicate a favorable habitat for worms. When grain size and polychaete abundances are compared, the higher the ratio of mud fraction to coarse sand sediment, the more favorable the environment, and the more worms observed.

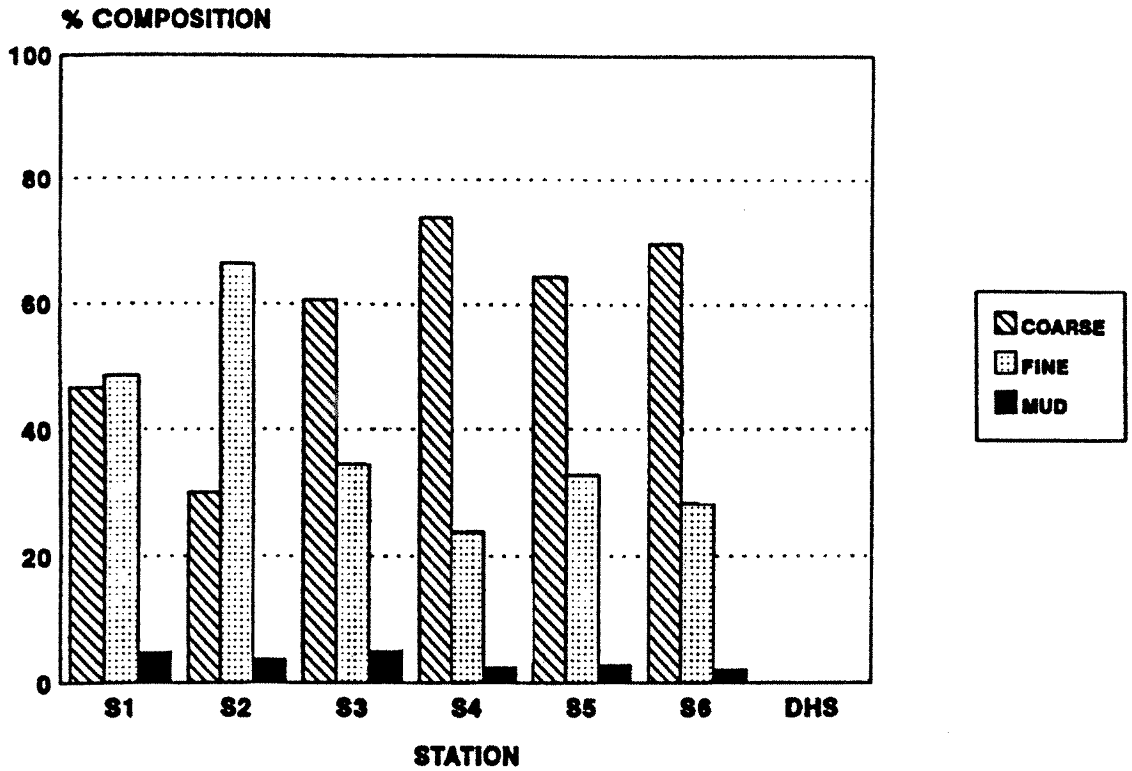


Figure 6.1 Grain size analyses for Feb 94 at the 40m stations (n=6)

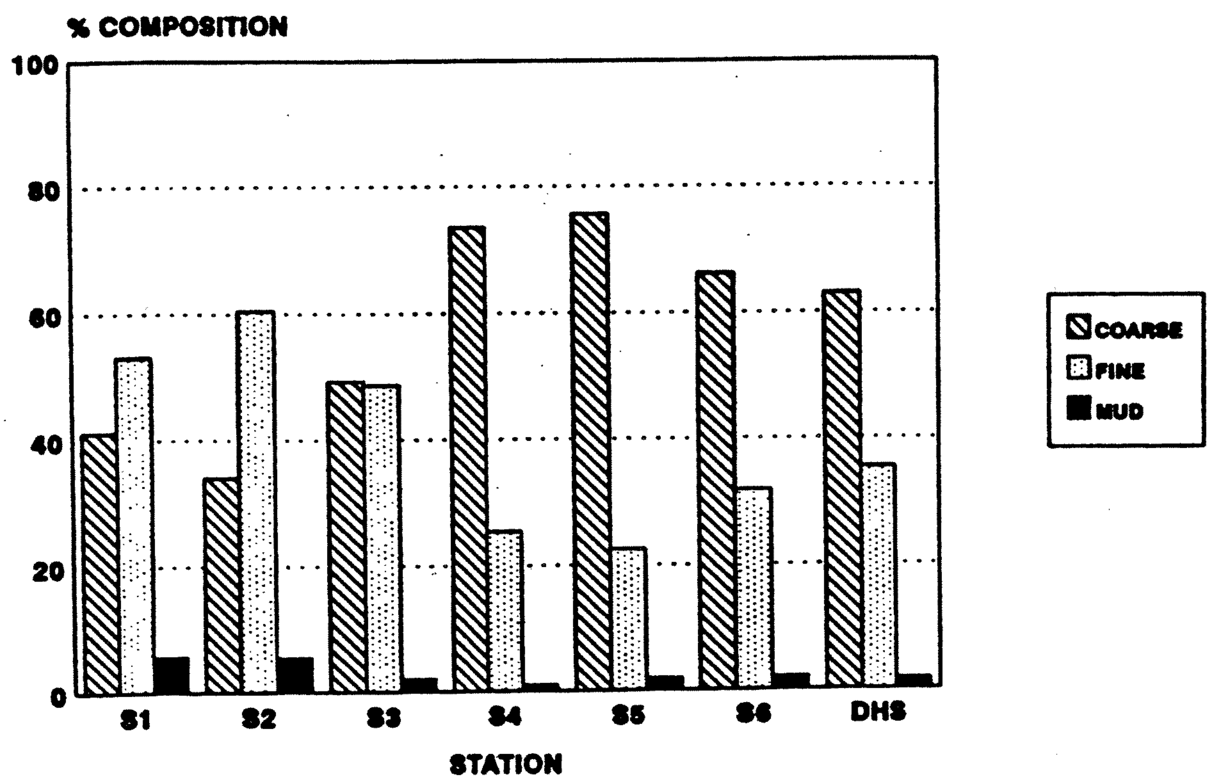


Figure 6.2 Grain size analyses for Aug 94 at the 40m stations (n=6)

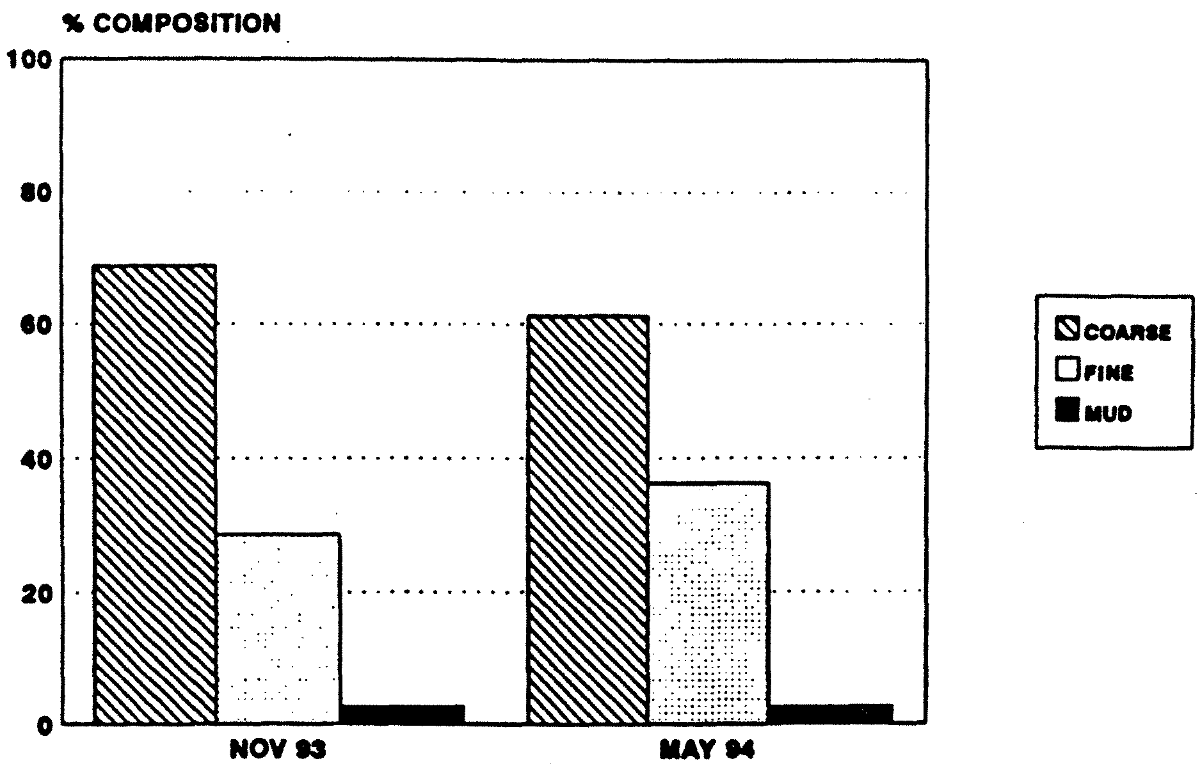


Figure 6.3 Grain size analyses at B3 (70m) for Nov 93 and May 94 (n=5)

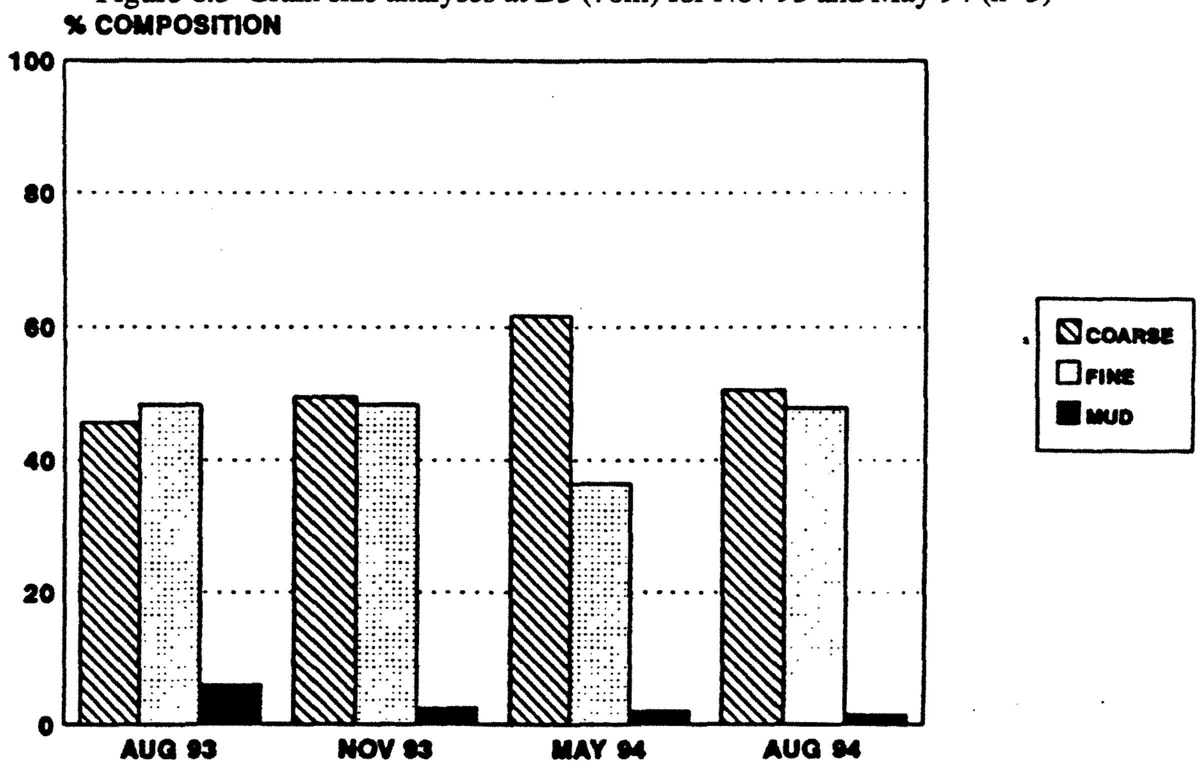


Figure 6.4 Grain size analyses at DH (70m control) for Aug 93, Nov 93, May 94, Aug 94 (n=5)

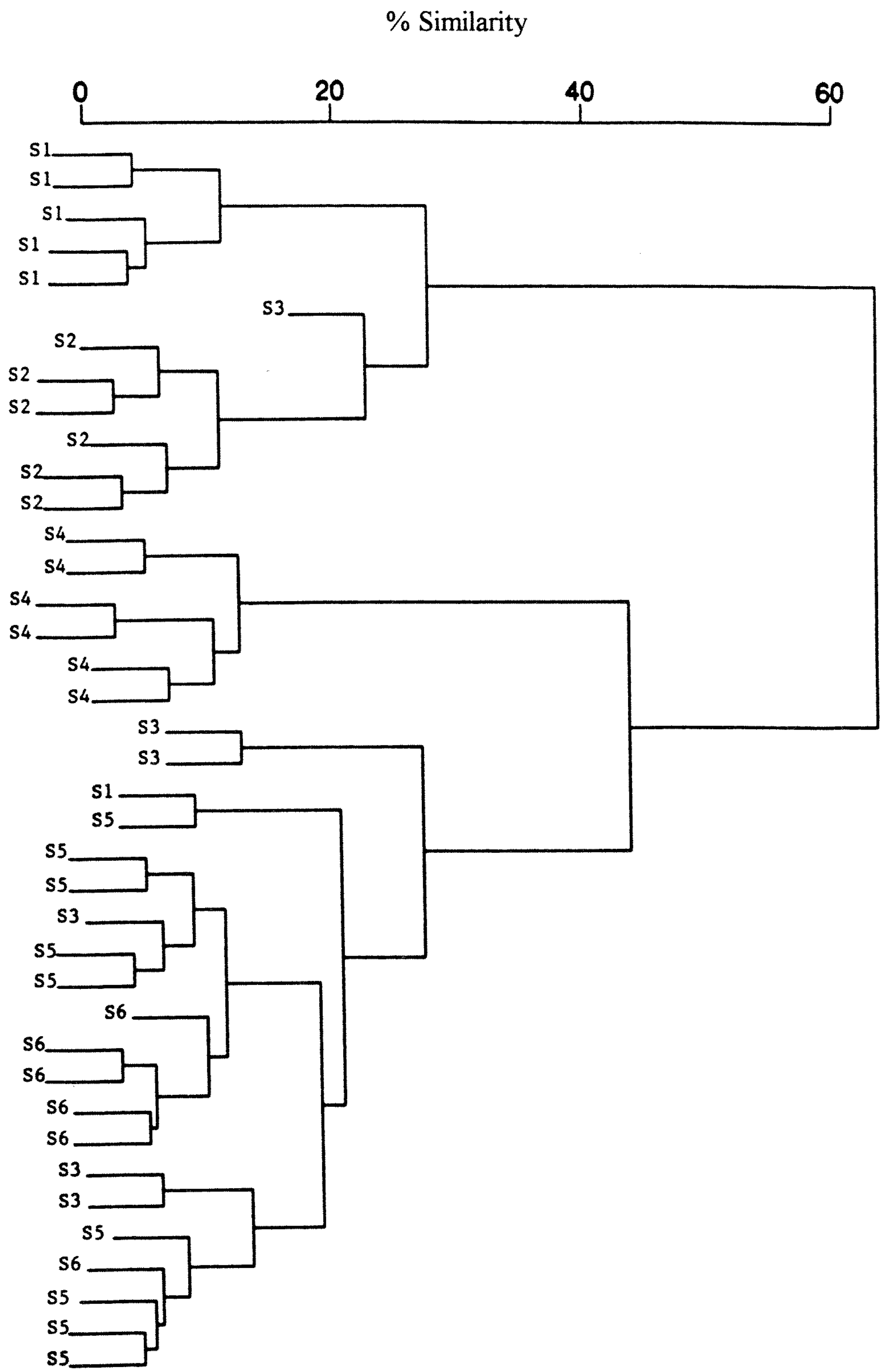


Figure 6.5 Sediment similarity dendogram using Euclidean distances for 40m stations in Feb 94

% Similarity

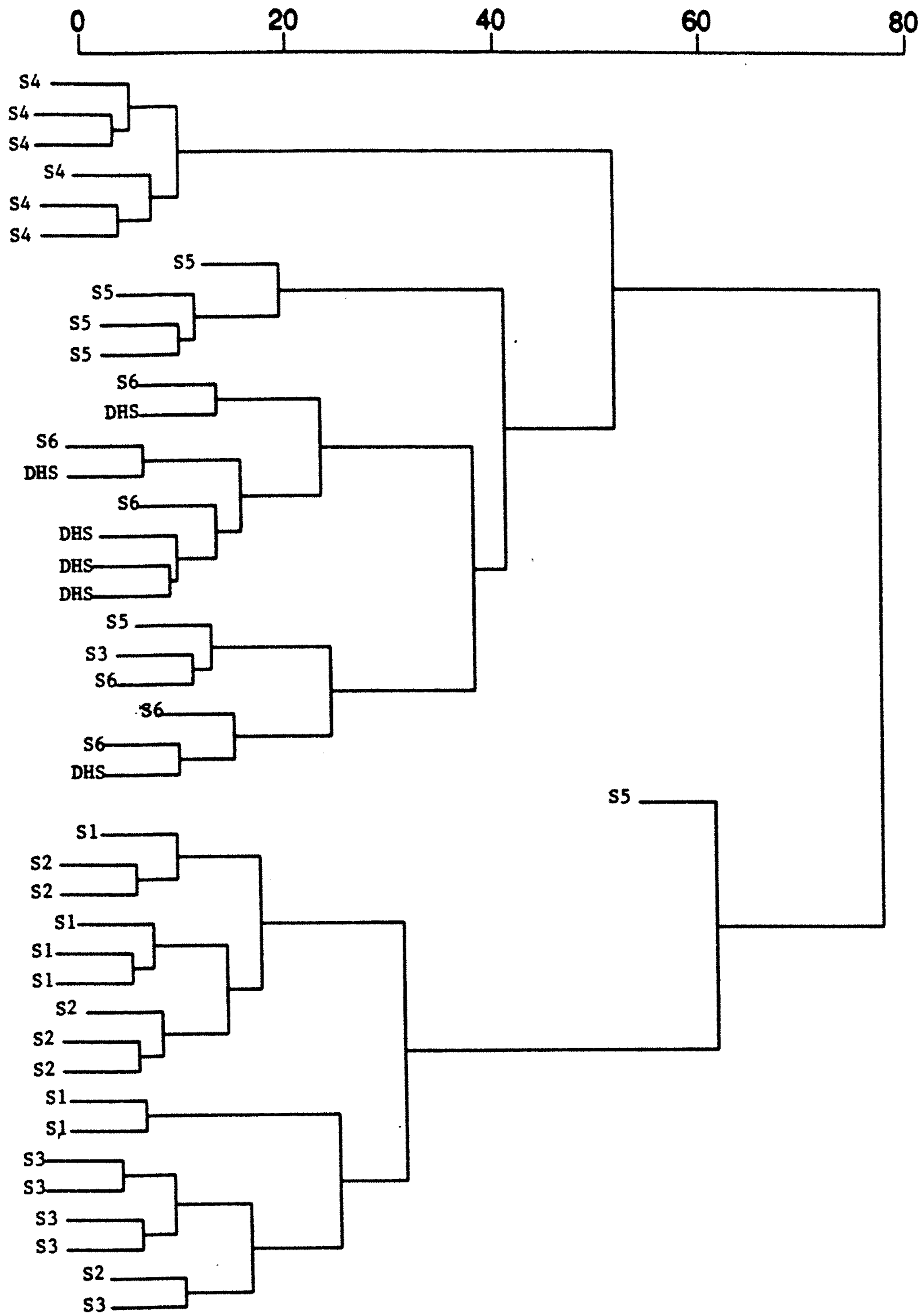


Figure 6.6 Sediment similarity dendogram using Euclidean distances for 40m stations in Aug 94

7 CHN ANALYSES AND N SIGNATURE DATA.

7.1 Introduction

These techniques were used to determine whether or not the nitrogen from the sewage outfall is a contributor to the N component of the sediments and tissues of benthic organisms. Branchiostoma sp. A (a small detritivorous chordate) and the spionid polychaete, Prionospio cirrobranchiata (particulate feeder) were selected because of their size and abundance, for mass spectrophotometric analysis of the $\delta^{15}N$.

7.2 Methods

A relatively new technique for carbonate sediments was used to recover the N values from sediments collected at S3 and DHS (40 m) and B3 and DH (70 m), and at 3 additional stations in Keehi Lagoon (10 m) shown in Fig. 2.1. The protocol was based on the method in Verardo et al. (1990) which involves acidifying the carbonate fraction with sulfurous acid and then combusting the remaining fraction. Three replicates from each sample were processed (Appendix 5.1).

A mass spectrophotometer was used to read the $\delta^{15}N$ values of the two benthic species. Specimens were removed from archived samples originally fixed in formalin with Rose Bengal dye, subsequently stored in 70% ethanol and then processed.

7.3 Results

Nitrogen values expressed as mg/g dry weight are listed in Appendix 5.2. The highest N values were at Keehi stations 1 and 2, which are closest to the entrance of Moanalua stream. The 70 m Diamond Head stations had N values from 0.3 to 1.2 but the lower end of the range prevailed, especially for the winter samples (Feb 94). Samples from Keehi 3, B3, S3 and DHS (Diamond Head 40 m) were most similar with S3 having N values around 0.6 mgN/g/dry wt. but up to 1.0 for a winter and a summer replicate.

7.4 Conclusions

There is no conclusive evidence from these data that the outfall is affecting the N in the sediments. Stations closest to the outfall (B3 and S3) have N values with ranges lower than the 70 m control site at Diamond Head and the stream influenced Keehi stations.

Preliminary nitrogen signature data show a gradient from east to west, higher to lower values, respectively. If the nitrogen was from the sewage, a peak would be expected near the outfall, at B3 and S3. This was not the case and overall trends were not apparent, therefore further work with more specimens/sample should be done.

8 CONCLUSIONS AND RECOMMENDATIONS

Grain size and distribution partially determine the assemblage of worm species that will successfully become established in a given area. Station S1 and S2 have a finer grain size profile while S3-S6 and DHS contain an overall coarser sediment composition. The sediment grain size analysis profile of S1 and S2 may favor tubicolous and/or discretely motile species. These worms tend to use the fine grains to build their tubes. The mud fraction is also of considerable importance as its organic component may serve as a food source for many of these species.

Another consideration for these stations is the stability of the benthos throughout the year. The ratio of coarse to fine sands at B3 (70m) and S3 (40m) changed significantly from winter (Jan 94) to summer (Aug 94). This seasonal component of diffuser perturbation may affect the community throughout the year by favoring different species at different times, allowing no particular assemblage to become firmly established and dominant. This may be supported by our findings of lower abundances of individuals (Figs. 3.1, 4.1) but comparable numbers of species (Figs. 3.2, 4.2) at both stations (B3 and S3).

The data gathered in this study did not yield conclusive evidence regarding the effect of the outfall on nitrogen in the sediments of study areas. The greatest increase in CHN and N values were expected to be nearest the source of sewage. The B3 and S3 stations showed lower values of N than the 70m control site. This result should be confirmed by additional sampling. In addition, the techniques for determining CHN and N signatures must be refined to insure that the results of future samplings yield more definitive results about the role of sewage in this benthic system. The signature data, as well as grain size analyses and invertebrate community information presents a complex set of data which will require further analysis and future monitoring to confirm these results.

It may be difficult to separate the influence of the sewage effluent on the benthos at the study site from other perturbations, due to the many changes that have occurred in Mamala Bay. One factor is the proximity to Pearl Harbor which is high in organics and fine sediments, and could strongly affect stations S1, S2, B1 and B2. Other factors include outflow from Honolulu Harbor and Keehi Lagoon (terrigenous stream outflow and influence of Keehi Boat Harbor), and possible impacts from the Honolulu airport reef runway located adjacent to the study site.

9 RECOMMENDATIONS

1. A database should be developed at the 40m isobath to compare with the 70m communities which have been documented since 1986. This will establish whether the suspension feeding, tubicolous communities of stations S1, S2, S3 and B3 (in the central part of Mamala Bay) are driven by particulate materials from the sewage outfall and harbors.

2. The Diamond Head control sites at 40m and 70m should be retained for outfall monitoring purposes.

3. Techniques for CHN and N signatures should be further developed in an effort to establish the role of sewage in community dynamics.

4. Trophic and motility categories of polychaetes and station similarity indices should be calculated with the data from this study (in appendices).

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70m

Month	Station	Rep	N deg	N min	N sec	W deg	W min	W sec	Depth (m)	Time	fth
Aug93	DH	1									
		2									
		3									
		4									
		5									
	B3										
		1									
		2									
		3									
		4									
		5									
Nov93	DH	1	21	15	16.26	157	50	19.68	69.00	1456	
		2	21	15	16.92	157	50	21.18	75.50	1509	
		3	21	15	16.38	157	50	16.56	72.40	1518	
		4	21	15	19.56	157	50	19.2	66.60	1528	
		5	21	15	19.08	157	50	16.68	64.20	1538	
	B3										
		1	21	16	48.36	157	54	31.74	70.50	1248	
		2	21	16	47.94	157	54	29.46	73.90	1315	
		3	21	16	48.06	157	54	31.2	74.50	1328	
		4	21	16	47.46	157	54	30.3	74.90	1401	
		5	21	16	50.76	157	54	32.34	65.10	1413	
Jan94	DH	1									
		2									
		3									
		4									
		5									
	B3										
		1									
		2									
		3									
		4									
		5									
May94	DH	1	21	15	38.4	157	50	7.68	88.88	834	48.6
		2	21	14	58.62	157	50	2.4	87.60	905	47.9
		3	21	14	58.98	157	49	55.74	84.86	916	46.4
		4	21	14	58.56	157	49	52.74	81.56	928	44.6
		5	21	14	52.68	157	49	0	98.94	943	54.1
	B3										
		1	21	16	48.72	157	53	53.82	68.76	1050	37.6
		2	21	16	48.12	157	54	32.7	79.19	1140	43.3
		3	21	16	49.32	157	54	29.82	65.11	1154	35.6
		4	21	16	48.96	157	54	30.48	73.15	1218	40
		5	21	16	52.44	157	54	37.2	65.84	1246	36
Aug94	DH	1	21	15	15	157	50	18	40.00	1109	40
		2	21	15	16	157	50	16	38.00	1126	38
		3	21	15	17	157	50	16	38.00	1139	38
		4	21	15	17	157	50	15	37.00	1153	37
		5	21	15	16	157	50	18	36.00	1209	36
	B3										
		1	21			157					
		2	21			157					
		3	21			157					
		4	21			157					
		5	21			157					

Month	Station	Rep	N deg	N min	N sec	W deg	W min	W sec	Depth (m)	Time	Date
AUG94	s1a	1	21	17	29.00	157	55	36.00	36.58	1238	20
		2	21	17	29.00	157	55	36.00	38.40	1249	21
		3	21	17	30.00	157	55	40.00	38.40	1307	21
		4	21	17	30.00	157	55	36.00	37.86	1316	20.7
		5	21	17	30.00	157	55	38.00	36.58	1327	20
		6	21	17	30.00	157	55	36.00	38.40	1336	21
	s2a	1	21	17	17.00	157	55	21.00	43.89	1400	24
		2	21	17	21.00	157	55	19.00	43.16	1410	23.6
		3	21	17	20.00	157	55	18.00	42.98	1420	23.5
		4	21	17	19.00	157	55	18.00	42.06	1430	23
		5	21	17	20.00	157	55	20.00	42.79	1440	23.4
		6	21	17	18.00	157	55	19.00	42.06	1450	23
	s3	1	21	17	3.00	157	54	37.00	41.15	1238	22.5
		2	21	17	5.00	157	54	39.00	40.42	1351	22.1
		3	21	17	2.00	157	54	38.00	45.90	1408	25.1
		4	21	17	5.00	157	54	37.00	38.95	1422	21.3
		5	21	17	2.00	157	54	38.00	42.25	1435	23.1
		6	21	17	2.00	157	54	37.00	41.51	1447	22.7
	s4	1	21	16	47.00	157	54	13.08	35.30	838	19.3
		2	21	16	57.48	157	54	14.40	37.86	856	20.7
		3	21	16	58.26	157	54	14.46	39.14	906	21.4
		4	21	16	57.60	157	54	15.18	36.58	922	20
		5	21	16	58.20	157	54	14.76	40.23	931	22
		6	21	16	55.98	157	54	14.22	36.58	941	20
	s5	1	21	17	3.00	157	53	54.00	34.75	1049	19
		2	21	17	4.00	157	53	53.00	27.43	1255	15
		3	21	17	4.00	157	53	59.00	34.75	1307	19
		4	21	17	5.00	157	53	56.00	31.09	1338	17
		5	21	17	6.00	157	53	51.00	27.43	1408	15
		6	21	17	4.00	157	53	55.00	27.43	1420	15
	s6	1	21	17	1.00	157	53	17.00	37.31	1116	20.4
		2	21	17	1.00	157	53	16.00	36.58	1123	20
		3	21	17	0.00	157	53	16.00	36.94	1134	20.2
		4	21	17	1.00	157	53	16.00	36.58	1142	20
		5	21	17	2.00	157	53	15.00	36.58	1149	20
		6	21	16	59.00	157	53	16.00	37.49	1154	20.5
	dhs	1	21	15	16.80	157	50	11.40	49.38		
		2	21	15	16.20	157	50	9.60	43.89		
		3	21	15	16.20	157	50	9.60	43.89		
		4	21	15	16.20	157	50	9.60	49.89		
		5	21	15	16.20	157	50	9.60	49.89		
		6	21	15	16.20	157	50	9.60	49.89		

40m

Month	Station	Rep	N deg	N min	N sec	W deg	W min	W sec	Depth (m)	Time	Date
Feb94	s1	1	21	17	29.00	157	55	37.00	37.67	1036	15
		2	21	17	29.00	157	55	36.00	38.04	1046	
		3	21	17	28.00	157	55	36.00	38.95	1102	
		4	21	17	29.00	157	55	36.00	37.86	1112	
		5	21	17	30.00	157	55	36.00	36.58	1118	
		6	21	17	29.00	157	55	39.00	37.86	1014	
	s2	1	21	17	19.00	157	55	13.00	38.04	1135	15
		2	21	17	20.00	157	55	17.00	39.50	1143	
		3	21	17	19.00	157	55	15.00	39.87	1151	
		4	21	17	18.00	157	55	17.00	40.97	1201	
		5	21	17	18.00	157	55	16.00	38.59	1208	
		6	21	17	19.00	157	55	15.00	39.50	1216	
	s3	1	21	17	3.00	157	54	37.00	40.97	1251	15
		2	21	17	3.00	157	54	36.00	39.69	1303	
		3	21	17	4.00	157	54	36.00	39.87	1314	
		4	21	17	3.00	157	54	38.00	38.95	1336	
		5	21	17	4.00	157	54	37.00	39.32	1351	
		6	21	17	2.00	157	54	36.00	38.95	1359	
	s4	1	21	17	0.00	157	54	12.00	40.97	1417	15
		2	21	16	58.00	157	54	13.00	39.87	1427	
		3	21	16	59.00	157	54	13.00	38.22	1436	
		4	21	16	59.00	157	54	12.00	37.31	1445	
		5	21	16	59.00	157	54	12.00	36.58	1453	
		6	21	16	58.00	157	54	13.00	37.31	1401	
	s5	1	21	17	2.00	157	53	53.00	43.89		16
		2	21	17	3.00	157	53	52.00	42.06		
		3	21	17	0.00	157	53	54.00	54.86		
		4	21	16	54.00	157	53	53.00	54.86		
		5	21	16	54.00	157	53	54.00	54.86		
		6	21	16	54.00	157	53	55.00	54.86		
	s6	1	21	17	0.00	157	53	15.00	42.06		16
		2	21	17	0.00	157	53	15.00	42.06		
		3	21	17	1.00	157	53	14.00	40.23		
		4	21	17	0.00	157	53	16.00	40.23		
		5	21	17	0.00	157	53	16.00	38.95		
		6	21	17	2.00	157	53	16.00	40.23		
	dhs	1	21	15	28.00	157	50	19.00	49.38		16
		2	21	15	27.00	157	50	16.00	49.38		
		3	21	15	27.00	157	50	16.00	43.89		
		4	21	15	27.00	157	50	16.00	43.89		
		5	21	15	27.00	157	50	16.00	43.89		
		6	21	15	27.00	157	50	16.00	43.89		

Appendix 2.1 Species abundances from five replicates at the B3 and DH stations (70m), taken quarterly

August
1993
70m

	DHR1	DHR2	DHR3	DHR4	DHR5	B3R1	B3R2	B3R3	B3R4	B3R5
Amaeana accraensis										
Amphicteis gunneri										
Amphiduros sp. A										
Amphiglena mediterranea										
Amphiglena sp. A										
Aonides oxycephala										
Aonides sp A.		1	1	2	3					
Aricidea catherinae					1					
Aricidea sp. A										
Armandia intermedia		1		2		1				
Augeneriella dubia	1					2	1		1	
Augeneriella sp. A										
Axiothella quadrimaculata										
Axiothella quadrimaculata										
Branchiomma nigromaculata										
Branchiosyllis exilis										
Brania mediodentata										
Brania sp. A										
Capitella capitata				3	1	14	18		18	3
Capitella sp. A						2				
Capitellidae sp. B						1			1	
Capitellidae sp D (?)										
Caulleriella acicula	1				1			1		1
Caulleriella bioculatus										
Caulleriella capensis										
Chloeia flava										
Cirratulus acicula										
Cirratulus africanus (?)										
Cirratulus filiformis										
Cossura sp. B										
Dorvillea rubrovittata										
Euchone sp. B				1						
Eulalia sp.										
Eunice antennata										
Eunice australis										
Eunice siciliensis										
Eunice vittata										
Euthalenessa sp. A							1			
Exogone longicornis										
Exogone sp. A										
Exogone sp. B										
Exogone sp. C										
Exogone sp. D										
Exogone sp. E						1			1	
Fabricia capensis										
Fabricia sp. A				1						
Glycera tesselata										
Goniada emerita		1								
Grubeulepsis mexicana										
Haplosyllis spongicola										
Hesionidae sp. A						2				
Hesionura sp. B										
Jasmineira caudata										
Langerhansia cornuta									1	1
Langerhansia sp. A								2		
Laonome sp. A										
Laonome sp. C										
Lepidasthenia sp.										
Linopherus microcephala						1	1			
Lumbrineris sp.	1		1	1	1		1		1	1
Lysidice ninetta										
Magelona cincta										
Magelona sp. A				1				1		
Maldanidae sp. A				1						
Megalomma intermedium										
Micronereis A										
Microphthalmus aberrans										
Microphthalmus sczelkowii										
Microspio granulata										
Myriochele oculata	1		2	15	8				1	1
Myriochele pygidialis										
Myriochele sp. A									1	
Naineris sp. A										

August 1993 70m

	DHR1	DHR2	DHR3	DHR4	DHR5	B3R1	B3R2	B3R3	B3R4	B3R5
Neanthes arenaceodonta										
Nematonereis unicornis										
Nereididae sp. A										
Nereimyra sp. A			2	5	3	4	3	2	2	
Nereis sp. B			1							1
Notomastus tenuis					1					
Onuphis geophiliformis										
Ophyrotrocha sp. A						38	4	9	61	30
Oriopsis sp. A										
Oriopsis sp. B										
Paleonotus sp. B										
Palymyra sp. B										
Pholoe sp. A										
Pholoe sp. F										
Phyllochaetopterus verrilli										
Phyllodoce madeirensis			2			1				
Phyllodoce sp. A										
Phyllodocidae sp. B										
Phyllodocidae sp. F			1							
Pionosyllis heterocirrata	3	2	1	1		11	7	4	6	3
Pionosyllis spinisetosa						1		3		25
Pionosyllis weismanni								1	1	
Pisione africana (?)										
Pisione sp. A										
Podarke angustifrons	5	4		2		12	2	7		20
Podarke sp. A										
Polycirrus plumosus										
Polydora armata										
Polydora normalis										
Polyophthalmus pictus			1	1	3					
Prionospio cirrifera		2		1	2		1		2	
Prionospio cirrobranchiata	2	1	4			7	2	5	1	4
Prionospio steenstrupi					1					
Progoniada sp. A										
Protodorvillea biarticulata		1						1		
Protodorvillea egena										
Protodorvillea sp. B										
Protodrillus sp. A										
Protomistides sp.										
Pseudopotamilla sp. A										
Pygospio sp. A										
Questa caudicirra										
Questa sp. A								1		2
Rhodine sp. A										
Sabellastarte sanctijosephi										
Sabellidae sp.										
Salmacina dysteri										
Samythella sp. A										
Schistomeringos rudolphi						1		1	1	
Scololepis victoriensis										
Scyphoproctus djiboutiensis										
Sigambra parva						1				1
Sphaerodoridium sp. A										
Sphaerodoropsis sp. C										
Sphaerosyllis capensis					1					
Sphaerosyllis riseri										
Sphaerosyllis taylori			1	2	1				3	1
Spio blakei				1						
Spionidae sp. B										
Spionidae sp. D		2			1					
Spiophanes bombyx			1		2					
Streptosyllis pettibone										
Syllidae sp. C										
Syllinae sp. A										
Synelmis acuminata	4	1	1	7	1		1	3		
Synelmis albini										
Synelmis sp. A										
Terebellidae sp. A										
Terebellidae sp. B										
Tharyx marioni										
Typosyllis aciculata										
Individual Polys per Replicate	18	16	19	47	31	100	42	41	102	94
Poly Species per Replicate	8	10	13	17	16	17	12	14	16	14

Total Number of Species Found During This Sampling 46

DH species 31

B3 species 32

Shannon-Wiener Diversity Index (SWidx) for this SAMPLING 1.18

DH SWidx 1.264

B3 SWidx 0.977

DH Abund 131

B3 Abund 379

Tot Abund 510

d:\123w\dummy\aug9370.wk3

TAXON	Aug93 DHR1	70m DHR2	Aug93 DHR3	70m DHR4	Aug93 DHR5	Aug93 B3R1	70m B3R2	Aug93 B3R3	70m B3R4	Aug93 B3R5
OLIGOCHAETA	15	4	19	5	12		34	24	9	15
NEMATODA	19	10	24	32	21	108	56	85	73	21
PLATYHELMINTHES					1					
ECHINODERMATA					1					
ANTHOZOA						1			3	
NEMERTEA	2	1		8	6	3		4	1	5
SIPUNCULA/PRIAPULA	8	11	5	3	11				2	2
BRYOZOA										
PHORONID										
HEMICHORDATA										
CHAETOGNATHA										
CHORDATA		1			2	3	1	5	2	2
PYCNOGONIDA										
MOLLUSCA						3				
=======================										
Total # other taxa per replicate	44	27	48	48	54	118	91	118	90	45
Taxa per replicate										
Total Macro Animals	62	43	67	95	85	218	133	159	192	139
Total # Meiofaunal Polychaetes	34	57	32	45	42	363	71	75	202	87

November
1993
70m

	DHR1	DHR2	DHR3	DHR4	DHR5	B3R1	B3R2	B3R3	B3R4	B3R5
Amaeana accraensis	1									
Amphicteis gunneri										
Amphiduros sp. A										
Amphiglena mediterranea										
Amphiglena sp. A										
Aonides oxycephala										
Aonides sp A.		1	1							
Aricidea catherinae										
Aricidea sp. A										
Armandia intermedia					2				1	
Augeneriella dubia	1		2		1					
Augeneriella sp. A										
Axiothella quadrimaculata										
Axiothella quadrimaculata										
Branchiomma nigromaculata					1					
Branchiosyllis exilis		1								
Brania mediodentata		1	1							
Brania sp. A										
Capitella capitata							1			2
Capitella sp. A										
Capitellidae sp. B										
Capitellidae sp. D (?)				1						
Caulleriella acicula					1					
Caulleriella bioculatus										
Caulleriella capensis										
Chloeia flava										
Cirratulus acicula										
Cirratulus africanus (?)										
Cirratulus filiformis										
Cossura sp. B										
Dorvillea rubrovittata										
Euchone sp. B			1							
Eulalia sp.										
Eunice antennata										
Eunice australis										
Eunice siciliensis				1						
Eunice vittata										
Euthalenessa sp. A										
Exogone longicornis			1		1		1			
Exogone sp. A										
Exogone sp. B		1								
Exogone sp. C				2						
Exogone sp. D				2						
Exogone sp. E				1	2					
Fabricia capensis										
Fabricia sp. A	2				2					
Glycera tesselata									2	
Goniada emerita										
Grubeulepsis mexicana										
Haplosyllis spongicola										
Hesionidae sp. A										
Hesionura sp. B										
Jasmineira caudata		1								
Langerhansia cornuta					1					
Langerhansia sp. A	1				1					
Laonome sp. A										
Laonome sp. C										
Lepidasthenia sp.										
Linopherus microcephala							4	1	1	
Lumbrineris sp.	1		3	1	7		1	1		2
Lysidice ninetta										
Magelona cincta										
Magelona sp. A										
Maldanidae sp. A					1					
Megallomma intermedium										
Micronereis A										
Microphthalmus aberrans									1	1
Microphthalmus sczelkowii						4		2	3	
Microspio granulata					1					
Myriochele oculata	5			8			6			3
Myriochele pygidialis										
Myriochele sp. A										
Naineris sp. A						1				1

November
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70m

	DHR1	DHR2	DHR3	DHR4	DHR5	B3R1	B3R2	B3R3	B3R4	B3R5
Neanthes arenaceodonta										
Nematonereis unicornis										
Nereididae sp. A										
Nereimyra sp. A	1	8	4		18	1	3	1	3	1
Nereis sp. B	3	6	8	3	8					
Notomastus tenuis										
Onuphis geophiliformis										
Ophyrotrocha sp. A						1	28		15	7
Oriopsis sp. A										
Oriopsis sp. B			1							
Paleonotus sp. B		1			1					
Palymyra sp. B										
Pholoe sp. A				1						
Pholoe sp. F										
Phyllochaetopterus verrilli										
Phyllodoce madeirensis			3		1				1	
Phyllodoce sp. A										
Phyllodocidae sp. B										
Phyllodocidae sp. F										
Pionosyllis heterocirrata	1	6	3		7	3	7	1		13
Pionosyllis spinisetosa			2			5	26	1	12	7
Pionosyllis weismanni		2		1	3					1
Pisione africana (?)		1								
Pisione sp. A						2				2
Podarke angustifrons	2	5	5		3	11	12	7		8
Podarke sp. A			1							
Polycirrus plumosus										
Polydora armata										
Polydora normalis										1
Polyophthalmus pictus	1		1	1	1					
Prionospio cirrifera		3	9	3	9	1	4			1
Prionospio cirrobranchiata	8	10	5	3	9	4	2	5		2
Prionospio steenstrupi			1			1	1	1	1	1
Progoniada sp. A										
Protodorvillea biarticulata							1	1	3	
Protodorvillea egena						1				
Protodorvillea sp. B										
Protodrillus sp. A										
Protomistides sp.										
Pseudopotamilla sp. A										
Pygospio sp. A										
Questa caudicirra										
Questa sp. A						1				3
Rhodine sp. A										
Sabellastarte sanctijosephi				5						
Sabellidae sp.										
Salmacina dysteri										
Samythella sp. A	1			2						
Schistomeringos rudolphi		3		2		7		1	2	10
Scololepis victoriensis										
Scyphoproctus djiboutiensis										
Sigambra parva	2								1	1
Sphaerodoridium sp. A										
Sphaerodoropsis sp. C										
Sphaerosyllis capensis		2	1	2	6	2				
Sphaerosyllis riseri			1	1	1					
Sphaerosyllis taylori	4		1		8		2		1	7
Spio blakei		1								
Spionidae sp. B					1					
Spionidae sp. D		1								
Spiophanes bombyx			1							
Streptosyllis pettibone										
Syllidae sp. C					2					
Syllinae sp. A										
Synelmis acuminata	2	2	2		3	2				4
Synelmis albini										
Synelmis sp. A										
Terebellidae sp. A										
Terebellidae sp. B										
Tharyx marioni							4			
Typosyllis aciculata						1				
Individual Polys per Replicate	38	56	58	40	102	48	103	22	47	78
Poly Species per Replicate	16	19	23	18	28	17	16	11	14	21

Total Number of Species Found During This Sampling	DH species	B3 species
67	53	32

Shannon-Wiener Diversity Index (SWidx) for this SAMPLING	DH SWidx	B3 SWidx	DH Abund	B3 Abund	Tot Abund
1.45	1.415	1.204	292	298	590

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TAXON	Nov93 DHR1	70m DHR2	Nov93 DHR3	70m DHR4	Nov93 DHR5	Nov93 B3R1	70m B3R2	Nov93 B3R3	70m B3R4	Nov93 B3R5
OLIGOCHAETA	31	10	4	29	112	45	36	21	23	42
NEMATODA	17	57	28	49	84	79	156	68	62	78
PLATYHELMINTHES					1					
ECHINODERMATA			4		3					
ANTHOZOA							42		16	20
NEMERTEA	9		2	12		1	2	1	3	5
SIPUNCULA/PRIAPULA	8	19	12	28	31	1	3	5	4	1
BRYOZOA										
PHORONID		1								
HEMICHORDATA										
CHAETOGNATHA										
CHORDATA	1	4	1	5		2	22	5	11	17
PYCNOGONIDA										
MOLLUSCA					1					
=======================										
Total # other taxa per replicate	66	91	51	123	232	128	261	100	119	163
Taxa per replicate										
Total Macro Animals	102	147	109	163	334	176	364	122	166	241
Total # Meiofaunal Polychaetes	8	73	104	27	25	84	229	58	103	145

August 1994 70m

	DHR1	DHR2	DHR3	DHR4	DHR5	B3R1	B3R2	B3R3	B3R4	B3R5
Amaeana accraensis										
Amphicteis gunneri	1		1							
Amphiduros sp. A										
Amphiglena mediterranea										
Amphiglena sp. A										
Aonides oxycephala										
Aonides sp A.										
Aricidea catherinae										1
Aricidea sp. A										
Armandia intermedia		2			2	1				
Augeneriella dubia										
Augeneriella sp. A										
Axiothella quadrimaculata										
Axiothella quadrimaculata										
Branchiomma nigromaculata										
Branchiosyllis exilis										
Brania mediodentata										
Brania sp. A										
Capitella capitata	1		1			9	6			6
Capitella sp. A										
Capitellidae sp. B										
Capitellidae sp. D (?)										
Caulleriella acicula								1		
Caulleriella bioculatus										
Caulleriella capensis										
Chloeia flava										
Cirratulus acicula										
Cirratulus africanus (?)										
Cirratulus filiformis										
Cossura sp. B										
Dorvillea rubrovittata										
Euchone sp. B			1							
Eulalia sp.										
Eunice antennata										
Eunice australis										
Eunice siciliensis										
Eunice vittata										
Euthalenessa sp. A										
Exogone longicornis										
Exogone sp. A										
Exogone sp. B										
Exogone sp. C	1		1		2					
Exogone sp. D										
Exogone sp. E										
Fabricia capensis										
Fabricia sp. A										
Glycera tesselata										1
Goniada emerita										
Grubeulepsis mexicana										
Haplosyllis spongicola										
Hesionidae sp. A										
Hesionura sp. B										
Jasmineira caudata	1	1								
Langerhansia cornuta					1	1				
Langerhansia sp. A										
Laonome sp. A										
Laonome sp. C										
Lepidasthenia sp.										
Linopherus microcephala									1	
Lumbrineris sp.	1	1	1	2	2					
Lysidice ninetta										
Magelona cincta										
Magelona sp. A	1									
Maldanidae sp. A					1					
Megalomma intermedium										
Micronereis A										
Microphthalmus aberrans										
Microphthalmus sczelkowii										
Microspio granulata	2	3							2	
Myriochele oculata						5	3	2	2	1
Myriochele pygidialis										
Myriochele sp. A										
Naineris sp. A										

August
1994
70m

	DHR1	DHR2	DHR3	DHR4	DHR5	B3R1	B3R2	B3R3	B3R4	B3R5
Neanthes arenaceodonta										
Nematonereis unicornis										
Nereididae sp. A										
Nereimyra sp. A			4	1	3	1	1	1	2	1
Nereis sp. B			1	1						
Notomastus tenuis	1									
Onuphis geophiliformis	1	2								
Ophyrotrocha sp. A						10		1	4	8
Onopsis sp. A										
Onopsis sp. B										
Paleonotus sp. B										
Palymyra sp. B										
Pholoe sp. A										
Pholoe sp. F										
Phyllochaetopterus verrilli										
Phyllodoce madeirensis										2
Phyllodoce sp. A										
Phyllodocidae sp. B										
Phyllodocidae sp. F										
Pionosyllis heterocirrata	4	1	4	1	3	2	6	1	7	4
Pionosyllis spinisetosa	1	1								2
Pionosyllis weismanni										
Pisione africana (?)									1	3
Pisione sp. A										
Podarke angustifrons	12	8	1	4	5	8	8	9	15	11
Podarke sp. A										
Polycirrus plumosus										
Polydora armata										
Polydora normalis										
Polyophthalmus pictus										
Prionospio cirrifera		2	2	1	1	2	2	2	1	4
Prionospio cirrobranchiata	11	3	1		4	3	4	2	9	10
Prionospio steenstrupi		1		1	2				1	
Progoniada sp. A										
Protodorvillea biarticulata						1	8	2	2	8
Protodorvillea egena										
Protodorvillea sp. B										
Protodrillus sp. A										
Protomistides sp.										
Pseudopotamilla sp. A										
Pygospio sp. A										
Questa caudicirra										
Questa sp. A						8	7	2		
Rhodine sp. A										
Sabellastarte sanctijosephi										
Sabellidae sp.										
Salmacina dysteri										
Samythella sp. A										
Schistomeringos rudolphi		1		1		5		4	13	6
Scololepis victoriensis										
Scyphoproctus djiboutiensis										
Sigambra parva				1			1		1	4
Sphaerodoridium sp. A										
Sphaerodoropsis sp. C										
Sphaerosyllis capensis			1	1			1			
Sphaerosyllis riseri	1									
Sphaerosyllis taylori				1						8
Spio blakei										
Spionidae sp. B	2									
Spionidae sp. D										
Spiophanes bombyx										
Streptosyllis pettibone										
Syllidae sp. C										
Syllinae sp. A										
Synelmis acuminata	12	1	2		2	5	4	4		7
Synelmis albini										
Synelmis sp. A	1									
Terebellidae sp. A										
Terebellidae sp. B										
Tharyx marioni										
Typosyllis aciculata										
Individual Polys per Replicate	54	27	21	15	28	61	51	31	61	87
Poly Species per Replicate	17	13	13	11	12	14	12	12	14	18

Total Number of Species Found During This Sampling 39

DH species 29

B3 species 26

Shannon-Wiener Diversity Index (SWidx) for this SAMPLING 1.27

DH SWidx 1.204

B3 SWidx 1.176

DH Abund 145

B3 Abund 291

Tot Abund 436

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TAXON	Aug94 DHR1	70m DHR2	Aug94 DHR3	70m DHR4	Aug94 DHR5	Aug94 B3R1	70m B3R2	Aug94 B3R3	70m B3R4	Aug94 B3R5
OLIGOCHAETA	15	39	18	1	9	34	51	11	3	29
NEMATODA	16	20	11	21	25	84	35	18	41	68
PLATYHELMINTHES							4			1
ECHINODERMATA	1			2					1	
ANTHOZOA										
NEMERTEA		2	4		1			10		3
SIPUNCULA/PRIAPULA	1	4	2	2	5	3	2	2	3	3
BRYOZOA					1					
PHORONID										
HEMICHORDATA										
CHAETOGNATHA										
CHORDATA	1			1		1	1	2	9	6
PYCNOGONIDA										
MOLLUSCA	2	4			5	2				4
========================										
Total # other taxa per replicate	36	69	35	27	46	124	93	43	57	114
Taxa per replicate										
Total Macro Animals	90	96	56	42	74	185	144	74	118	201
Total # Meiofaunal Polychaetes	39	44	16	9	18	85	37	16	50	97

Appendix 2.2 Indicator species measurements

Capitella capitata

Date	Sample	long 1	long 10 (m	Mag-->	Worm lon	Worm lngth (mm)	Width 5	Width 5 (mm)	Sets	egg	regen	comp
aug94	B3R1	10.2	1.02	1	6.9	3.83	2.8	0.28	22	N	N	C
		9.8	0.98	0.8	9.4	6.20	2.5	0.25	38	N	N	C
		9.5	0.95	1	8.4	4.66	2.6	0.26	27	N	N	C
		9.4	0.94	1	7.1	3.94	2.8	0.28	27	N	N	C
		9.3	0.93	1	7.5	4.16	3	0.30	29	N	N	C
		9.5	0.95	1	6.4	3.55	3.2	0.32	20	N	N	C
aug93	DHR4	5.6	0.56	1	4.1	2.28	1.8	0.18	23	N		I
		8.5	0.85	1	6.9	3.83	2.2	0.22	30	N	N	C
		6.9	0.69	1	6.1	3.39	1.8	0.18	26	N		I
aug94	DHR1	6.1	0.61	1	4.7	2.61	1.6	0.16	21	N		I
aug93	B3R2	4.2	0.42	0.8	8.3	5.48	1.7	0.17	27	N	N	C
		9.6	0.96	0.8	7.9	5.21	3	0.30	31	N	NN	C
		10.3	1.03	0.8	10.6	7.00	4.1	0.41	34	N	N	C
		8.2	0.82	1	8.3	4.61	2.7	0.27	34	N	N	C
		9.8	0.98	1	9.2	5.11	3.4	0.34	35	N	N	C
		7.3	0.73	1	7.3	4.05	1.7	0.17	32	N	N	C
aug93	B3R4	4.7	0.47	2	9.5	2.38	1.3	0.13	24	N	N	C
		8.7	0.87	1	4.9	2.72	2	0.20	22	N	N	C
		8.6	0.86	0.8	8.2	5.41	3	0.30	28	N	N	C
		8.7	0.87	2	9.8	2.45	1.8	0.18	19	N	N	C
		6.8	0.68	1	6.7	3.72	2.6	0.26	29	N	N	C
		7.5	0.75	1	5	2.78	2.5	0.25	26	N	N	C
		8.3	0.83	1	5.7	3.16	2.9	0.29	21	N	N	C
		6.5	0.65	1	4.8	2.66	2.5	0.25	22	N	N	C
		9.1	0.91	0.8	8.8	5.81	3.2	0.32	32	N	N	C
		10	1	0.8	8.8	5.81	3	0.30	34	N	N	C
			0			0.00		0.00				

Pionosyllis heterocirrata

Date	Sample	long 1	long 10 (m	Mag-->	Worm lon	Worm lngth (mm)	Width 5	Width 5 (mm)	Sets	egg	regen	comp
aug94	DHR1	6.3	0.63	2	9.5	2.38	1.2	0.12	33	N	N	C
		8.2	0.82	1	5.8	3.22	1.1	0.11	28	N	N	C
		6.8	0.68	1	5.6	3.11	1	0.10	29	N	N	C
AUG93	DHR4	6.6	0.66	2	5.5	1.38	1.2	0.12	22	N	N	C
AUG93	B3R4	5.7	0.57	1	3.8	2.11	1.6	0.16	24	N	N	I
		5.7	0.57	1	4.9	2.72	1.4	0.14	42	N	N	C
		6	0.6	1	4	2.22	1.3	0.13	28	N	N	C
		5.2	0.52	1	4	2.22	1.3	0.13	32	N	N	C
		6.8	0.68	1	3.7	2.05	1.2	0.12	25	N	N	C
		4.8	0.48	1	3.6	2.00	1.4	0.14	35	N	N	C
MAY94	B3R4	8.3	0.83	1	9.6	5.33	1.5	0.15	42	N	N	C
		8	0.8	1	6.9	3.83	1.1	0.11	34	N	N	C
		8	0.8	1	6.1	3.39	1	0.10	32	N	N	C
		8.5	0.85	0.8	8.3	5.48	1.2	0.12	41	N	N	C
		6.1	0.61	1	5.6	3.11	0.9	0.09	32	N	N	C
		8.1	0.81	0.8	9.8	6.47	1.4	0.14	47	N	N	C
		7.9	0.79	1	5.6	3.11	1.1	0.11	31	N	N	I
NOV93	DHR2	6.2	0.62	2	5.8	1.45	1.2	0.12	37	N	N	C
		5.6	0.56	2	5.7	1.43	1.5	0.15	37	N	N	C
AUG93	DHR3	5.2	0.52	2	6.1	1.53	1.1	0.11	23	N	N	C
AUG93	DHR2	5.3	0.53	2	7.6	1.90	1.5	0.15	29	N	Y	C
		5	0.5	2	7.3	1.83	1	0.10	28	N	N	C
AUG93	DHR1	5.8	0.58	2	5.9	1.48	1.1	0.11	23	N	N	C
		6.5	0.65	2	5.5	1.38	1.1	0.11	22	N	Y	C
		6.7	0.67	2	6.5	1.63	1	0.10	25	N	Y	C
MAY94	DHR1	7	0.7	2	7.7	1.93	1.3	0.13	24	N	Y	C
		7.8	0.78	1	5	2.78	1.3	0.13	36	Y	N	C
JAN94	DHR1	5.2	0.52	1	7.4	4.11	1.4	0.14	46	N	N	C
		4.3	0.43	2	6.8	1.70	1.2	0.12	29	N	N	C
		4.4	0.44	2	5.4	1.35	1	0.10	25	N	?	?
		5.7	0.57	2	7.4	1.85	1.4	0.14	29	N	N	C
		6.8	0.68	2	8.8	2.20	1.2	0.12	29	N	N	C
		4.9	0.49	2	5.5	1.38	1.2	0.12	23	N	N	C
		4.3	0.43	2	3.9	0.98	1.1	0.11	17	N	NN	I
		5.1	0.51	2	7.7	1.93	1.3	0.13	28	N	N	C
		5.5	0.55	2	4.1	1.03	1.1	0.11	15	N	?	I
		5.1	0.51	2	5.7	1.43	1.3	0.13	21	N	N	C
MAY94	DHR2	8.2	0.82	2	6.9	1.73	1	0.10	20	N	N	I
		6.9	0.69	1	6.1	3.39	1.3	0.13	37	Y	?	I
			0			0.00		0.00				
			0			0.00		0.00				
			0			0.00		0.00				
			0			0.00		0.00				

Neanthes arenaceodonta

Date	Sample	long 1	long 10 (m	Mag-->	Worm lon	Worm lngth (mm)	Width 5	Width 5 (mm)	Sets	egg	regen	co
			0			0.00		0.00				
			0			0.00		0.00				
			0			0.00		0.00				
			0			0.00		0.00				
			0			0.00		0.00				

Ophryotrocha sp. A

Date	Sample	long 1	long 10 (m	Mag-->	Worm lon	Worm lngth (mm)	Width 5	Width 5 (mm)	Sets	egg	regen	co
jan94	B3R5	6.3	0.63	2	4.1	1.03	2.6	0.26	14	Y	N	C
		7.7	0.77	2	4.1	1.03	3.3	0.33	13	Y	N	C
		5.4	0.54	2	3.8	0.95	1.3	0.13	16	N	N	C
		6.3	0.63	2	4	1.00	2.2	0.22	15	Y	N	C
		5.1	0.51	2	3	0.75	1.7	0.17	13	N	N	C
		7.2	0.72	2	4.6	1.15	2.5	0.25	14	Y	N	I
may94	B3R4	8.3	0.83	2	4.7	1.18	2.8	0.28	11	N	N	C
		8.6	0.86	2	5.2	1.30	2.5	0.25	12	N	N	C
		6.5	0.65	2	3.8	0.95	3	0.30	12	N	N	C
		9.5	0.95	2	6.1	1.53	3	0.30	12	N	N	C
		9.1	0.91	2	5.1	1.28	2.7	0.27	12	N	N	C
		8.3	0.83	2	5.5	1.38	2.6	0.26	14	N	N	C
		9.6	0.96	2	7.1	1.78	3.2	0.32	15	N	N	C
		10.2	1.02	2	6	1.50	2.9	0.29	12	N	N	C
		11.4	1.14	2	7.1	1.78	3.8	0.38	13	Y	N	C
		10.4	1.04	2	5.6	1.40	2.7	0.27	12	N	N	C
		9.5	0.95	2	6.1	1.53	3.1	0.31	14	N	N	C
		9.9	0.99	2	5.6	1.40	2.6	0.26	13	N	N	C
		9	0.9	2	5.7	1.43	3.3	0.33	13	Y	N	C
		7	0.7	2	4.4	1.10	3.1	0.31	13	Y	N	C
		7.5	0.75	2	4.5	1.13	2.5	0.25	12	N	N	C
		9.2	0.92	2	5.4	1.35	3.2	0.32	12	Y	N	C
		10.7	1.07	2	6.9	1.73	2.2	0.22	12	N	N	C
		9.6	0.96	2	6.8	1.70	2	0.20	13	N	N	C
		8	0.8	2	5.5	1.38	2.2	0.22	12	N	N	C
aug93	B3R4	7.6	0.76	2	4.6	1.15	2.3	0.23	13	Y	N	C
		7.8	0.78	2	4.6	1.15	2.4	0.24	13	Y	N	C
		7.9	0.79	2	5.4	1.35	2.5	0.25	12	Y	N	C
		7.3	0.73	2	4.3	1.08	2.4	0.24	14	Y	N	C
		7	0.7	2	4.1	1.03	1.8	0.18	13	N	N	C
		8.5	0.85	2	4.9	1.23	2.7	0.27	13	Y	N	C
		6.2	0.62	2	3.7	0.93	2.3	0.23	14	Y	N	C
		7	0.7	2	3.9	0.98	2.7	0.27	12	Y	N	C
		8.6	0.86	2	5.2	1.30	3.8	0.38	13	Y	N	C
		8.6	0.86	2	4.3	1.08	1.7	0.17	11	N	N	C
			0			0.00		0.00				
			0			0.00		0.00				
			0			0.00		0.00				
			0			0.00		0.00				
			0			0.00		0.00				

Appendix 3.1 Species abundances for six replicates at stations S1-S6 and DHS (40m) for Feb 94 and Aug 94

February
1994
40m

	S1R1	S1R2	S1R3	S1R4	S1R5	S1R6	S2R1	S2R2	S2R3	S2R4	S2R5	S2R6	S3R1	S3R2	S3R3	S3R4	S3R5	S3R6
Amaeana accraensis																		
Amphicteis gunneri			1															
Amphiduros sp. A																		
Amphiglena mediterranea																		
Amphiglena sp. A																		
Aonides oxycephala																		
Aonides sp A																		
Aricidea catherinae																		
Aricidea sp. A															1			
Armandia intermedia		1	1									1						
Augeneriella dubia		5	16				3	4	1	1	10	37		10	6	12	26	
Augeneriella sp. A																		
Axiothella quadrimaculata																		
Axiothella quadrimaculata																		
Branchiomma nigromaculata																		
Branchiosyllis exilis																		
Brania mediodentata										1								
Brania sp. A				1														
Capitella capitata				1		1				1		1	1					
Capitella sp. A								1							2			
Capitellidae sp. B										1								
Capitellidae sp. D (?)																		
Caulleriella acicula			1															
Caulleriella bioculatus																		
Caulleriella capensis											1							
Chloeia flava																		
Cirratulus acicula																		
Cirratulus africanus (?)																		
Cirratulus filiformis																		
Cossura sp. B																		
Dorvillea rubrovittata																		
Euchone sp. B		13	53		6			3			89	236			1	1	2	
Eulalia sp																		
Eunice antennata																		
Eunice australis																		
Eunice siciliensis																		
Eunice vittata																		
Euthalenessa sp. A																		
Exogone longicornis				1							2				2			
Exogone sp. A																		
Exogone sp. B																		
Exogone sp. C																1		
Exogone sp. D																		
Exogone sp. E																		
Fabricia capensis																		
Fabricia sp. A			6									33			3	1	1	
Glycera tesselata				1														
Goniada emerita																	1	
Grubeulepsis mexicana																		
Haplosyllis spongicola																		
Hesionidae sp. A																		
Hesionura sp. B																		

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	S4R1	S4R2	S4R3	S4R4	S4R5	S4R6	S5R1	S5R2	S5R3	S5R4	S5R5	S5R6	S6R1	S6R2	S6R3	S6R4	S6R5	S6R6	DHSR1	DHSR2	DHSR3	DHSR4	DHSR5	DHSR6
Amaeana accraensis																								
Amphicteis gunneri									1				2											
Amphiduros sp. A																								
Amphiglena mediterranea		1																						
Amphiglena sp. A																								
Aonides oxycephala																								
Aonides sp. A									2															
Aricidea catherinae							2					1												
Aricidea sp. A																								
Armandia intermedia								1	1				1	2	1	1		1			2			1
Augeneriella dubia	5	4	1	2			6		4	22	32	28	4	9	2	3	1			3		2		
Augeneriella sp. A					4		1																	
Axiothella quadrimaculata																								
Axiothella quadrimaculata																								
Branchiomma nigromaculata																								
Branchiosyllis exilis									3															
Brania mediodentata								5	2													1		
Brania sp. A																								
Capitella capitata	1			1			1								1			1				2		
Capitella sp. A							3																	
Capitellidae sp. B							1																	
Capitellidae sp. D (?)							2																	
Caulleriella acicula											1													
Caulleriella bioculatus																								
Caulleriella capensis																								
Chloeia flava																								
Cirratulus acicula										1														
Cirratulus africanus (?)																								
Cirratulus filiformis																								
Cossura sp. B																								
Dorvillea rubrovittata																								
Euchone sp. B							1		1				9	1		3	5				12			1
Eulalia sp.																								
Eunice antennata									1															
Eunice australis																								
Eunice siciliensis																								
Eunice vittata																								
Euthalenessa sp. A										1												2		
Exogone longicornis							2									2					1	1		
Exogone sp. A																	1							
Exogone sp. B														1										
Exogone sp. C		1																			3			
Exogone sp. D																								
Exogone sp. E	1						1						1									1		
Fabricia capensis																3	1							
Fabricia sp. A				1	2				2	2			4			5								
Glycera tesselata					1		1																	
Goniada emerita									1						2									
Grubeulepsis mexicana																								
Haplosyllis spongicola													1											
Hesionidae sp. A	3																							
Hesionura sp. B																								

February 1994 40m

	S1R1	S1R2	S1R3	S1R4	S1R5	S1R6	S2R1	S2R2	S2R3	S2R4	S2R5	S2R6	S3R1	S3R2	S3R3	S3R4	S3R5	S3R6
Jasmineira caudata										1		1						
Langerhansia cornuta													2			1	1	
Langerhansia sp. A	1					2												
Laonome sp. A											1	12						
Laonome sp. C																		
Lepidasthenia sp.																2		
Linopherus microcephala															1	2	5	1
Lumbrineris sp				2			1	1				2						
Lysidice ninetta																		
Magelona cincta			1															
Magelona sp. A			1			1		2	2									
Maldanidae sp. A																		
Megalomma intermedium																		
Micronereis A				1														
Microphthalmus aberrans																		
Microphthalmus sczelkowii																		
Microspio granulata					1			2										
Myriochele oculata		8								8	73	26		4				2
Myriochele pygidialis										1								
Myriochele sp. A																		
Naineris sp. A																		
Neanthes arenaceodonta											47							
Nematonereis unicornis																		
Nereididae sp. A																		
Nereimyra sp. A			3	3	1						1	1			2		1	
Nereis sp. B											1	1					1	
Notomastus tenuis								1		1	2	1			1			
Onuphis geophiliformis																	1	
Ophyrotrocha sp. A												1						
Oriopsis sp. A												9						
Oriopsis sp. B												1						
Paleonotus sp. B																		
Palymyra sp. B																		
Pholoe sp. A																		
Pholoe sp. F																		
Phyllochaetopterus verrilli																		
Phyllodoce madeirensis			1								2						4	
Phyllodoce sp. A																		
Phyllodocidae sp. B																	1	
Phyllodocidae sp. F																		
Pionosyllis heterocirrata	2	4			1			3		2	2	3	12	2	3	8	14	14
Pionosyllis spinisetosa		4	2	3	1		5	2	3	1	1	4			3	2		2
Pionosyllis weismanni	3			1							1	1				1		1
Pisione africana (?)																1	2	
Pisione sp. A															1	1	1	
Podarke angustifrons				1			1			2	2	3		1	3	2	9	8
Podarke sp. A						1												
Polycirrus plumosus																		
Polydora armata																		

	S4R1	S4R2	S4R3	S4R4	S4R5	S4R6	S5R1	S5R2	S5R3	S5R4	S5R5	S5R6	S6R1	S6R2	S6R3	S6R4	S6R5	S6R6	DHSR1	DHSR2	DHSR3	DHSR4	DHSR5	DHSR6
Jasmineira caudata																						1		
Langerhansia cornuta			1				1	1		1			2		1		1							
Langerhansia sp. A							1		5								1							
Leonome sp A																1								
Leonome sp. C					1																			
Lepidasthenia sp.																								
Linopherus microcephala	2			4	3		10	4	29	2	6	1			1	3					1	1		
Lumbrineris sp	1															1	2	1	1				1	
Lysidice ninetta																								
Magelona cincta																								
Magelona sp. A							1			1	3	1												
Maldanidae sp. A													1											
Megalomma intermedium																								
Micronereis A																								
Microphthalmus aberrans	1																							
Microphthalmus sczelkowii																				1				
Microspio granulata							1					2		1			1	1						
Myriochele oculata	2			10			7	9	1			1	7	1		2	1	1	1	1	6	1	4	4
Myriochele pygidialis																								
Myriochele sp A				2			1	3								6			4	2		4		
Naineris sp. A																								
Neanthes arenaceodonta																								
Nematonereis unicornis							1																	
Nereididae sp A																								
Nereimyra sp. A	2			2			1	1	2	1	2			1		1	2	2	1	1		3	1	
Nereis sp B							2		1						1					2		3		2
Notomastus tenuis							2											1		1				
Onuphis geophiliformis																								
Ophyrotrocha sp A										1	1		1											
Oriopsis sp A																								
Oriopsis sp B					1												1	1						
Paleonotus sp B																								
Palymyra sp B																								
Pholoe sp A																								
Pholoe sp F							1																	
Phyllochaetopterus verrilli																								
Phyllodoce madeirensis							3		1		1		1	1			1		2		1	1		
Phyllodoce sp A									1															
Phyllodocidae sp B																								
Phyllodocidae sp F																								
Pionosyllis heterocirrata	11	12	2	1	3	4	29	26	29	6	4	8	11	18	10	4	11	8	4	6	15	32	11	17
Pionosyllis spinisetosa							4		1	1	2		3				1			1	1			
Pionosyllis weismanni				1	1		2	5	1	1			1	2					1			1		
Pisione africana (?)		1																			2			
Pisione sp A								1						1										
Podarke angustifrons	3	5		4	4		6	1	6	11	4	3	11	5	4	3	4	1	2	11	3	8	9	3
Podarke sp. A	1			1																				
Polycirrus plumosus																								
Polydora armata	4																							

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	S1R1	S1R2	S1R3	S1R4	S1R5	S1R6	S2R1	S2R2	S2R3	S2R4	S2R5	S2R6	S3R1	S3R2	S3R3	S3R4	S3R5	S3R6
Polydora normalis	1	2		1	1			1	5		5	37		1				
Polyophthalmus pictus												1			1			
Prionospio cirrifera		2	3	7		2	2	1	1		6	3			1			1
Prionospio cirrobranchiata	3	4	5	5						3	4	1					1	1
Prionospio steenstrupi		1	5	4				3			2	2	1		1			1
Progoniada sp. A																		1
Protodorvillea biarticulata					2			1			2				2	1		
Protodorvillea egena																		
Protodorvillea sp. B					1													
Protodrillus sp. A																		
Protomistides sp.																		
Pseudopotamilla sp. A																		
Pygospio sp. A														1				
Questa caudicirra																		
Questa sp. A												1	1		6			1
Rhodine sp. A																		
Sabellastarte sanctijosephi																		
Sabellidae sp																		
Salmacina dysteri																		
Samythella sp. A												1						
Schistomeringos rudolphi	1															2		1
Scololepis victoriensis																		
Scyphoproctus djiboutiensis																		
Sigambra parva																		
Sphaerodondium sp. A																		
Sphaerodoropsis sp. C																		
Sphaerosyllis capensis											1							
Sphaerosyllis riseri												1						
Sphaerosyllis taylori					1						2							
Spio blakei																		
Spionidae sp. B																		
Spionidae sp. D																		
Spiophanes bombyx																		
Streptosyllis pettibone																		
Syllidae sp. C																		
Syllinae sp. A																	1	
Synelmis acuminata		6	15	10	4	5	6	8	10	8	6	42		10	9		6	3
Synelmis albini																		
Synelmis sp. A																		
Terebellidae sp. A																		
Terebellidae sp. B																		
Tharyx marioni																		
Typosyllis aciculata																		
Individual Polys per Replicate	11	50	114	42	19	12	18	33	22	31	263	463	17	29	49	38	78	37
Poly Species per Replicate	6	11	15	15	10	6 *	6	14	6	13	23	28 *	5	7	19	15	18	13 *

d:\123w\dummy\feb9440.wk3

	S4R1	S4R2	S4R3	S4R4	S4R5	S4R6	S5R1	S5R2	S5R3	S5R4	S5R5	S5R6	S6R1	S6R2	S6R3	S6R4	S6R5	S6R6	DHSR1	DHSR2	DHSR3	DHSR4	DHSR5	DHSR6
Polydora normalis									1															
Polyophthalmus pictus												1												
Prionospio cirrifera		2		2			4			1			1		2	1			1	1	5	1	7	3
Prionospio cirrobranchiata	2	1		1	1		5				5	2	1	6					6	4	5	3	5	4
Prionospio steenstrupi					1	2	5	2				1					1		2				1	
Progoniada sp. A													1							1				
Protodorvillea biarticulata	3	5			1	2	3	2							2			1	1		2	1		1
Protodorvillea egena																								
Protodorvillea sp. B							1																	
Protodrilus sp. A					1																			
Protomistides sp.																								
Pseudopotamilla sp. A																								
Pygospio sp. A										1														
Questa caudicirra				1																				
Questa sp. A		1	1	1	3	6	1	1			1						1	1	1		2			
Rhodine sp. A							29		5															
Sabellastarte sanctijosephi																								
Sabellidae sp.													2											
Salmacina dysteri																								
Samythella sp. A																								
Schistomeringos rudolphi						1		1			2		1	1									2	
Scolelepis victoriensis																								
Scyphoproctus djiboutiensis																								
Sigambra parva		1																						
Sphaerodoridium sp. A																								
Sphaerodoropsis sp. C																								
Sphaerosyllis capensis				2				2	5				4	2			2		1	1				
Sphaerosyllis riseri									9							1								
Sphaerosyllis taylori	2			2	2			1	1				1	2		1	3			1	1	1	5	4
Spio blakei					1				3					1										
Spionidae sp. B																								
Spionidae sp. D																								
Spiophanes bombyx																1								
Streptosyllis pettibone																								
Syllidae sp. C																								
Syllinae sp. A																								
Synelmis acuminata	24	5	3	13	3	3	46		18	59	47	96	9	6	10	12	11	6	25	6	5	6	12	6
Synelmis albini							6																	
Synelmis sp. A					2								1											
Terebellidae sp. A																								
Terebellidae sp. B																								
Tharyx marioni						•					1													
Typosyllis aciculata																								
Individual Polys per Replicate	68	39	8	51	35	18	194	66	137	112	112	145	81	61	37	54	52	26	53	43	67	76	56	46
Poly Species per Replicate	17	12	5	18	18	6 •	37	17	28	16	15	12 •	25	18	12	19	20	13 •	15	16	17	21	11	11

Total Number of Species Found During This Sampling
98

S1 sp	S2 sp	S3 sp	S4 sp	S5 sp	S6 sp	DHS sp
33	41	37	38	60	48	34

Shannon-Wiener Diversity Index (SWidx) for this SAMPLING
-1.31

S1 SWidx	S2 SWidx	S3 SWidx	S4 SWidx	S5 SWidx	S6 SWidx	DHS SWidx
1.118	0.986	1.16	1.24	1.122	1.298	1.06

S1 Abund	S2 Abund	S3 Abund	S4 Abund	S5 Abund	S6 Abund	DHS Abund	Tot Abund
248	830	248	219	766	311	343	2965

FEBRUARY 1994 40m

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TAXON	Feb94	40m	Feb94	40m	Feb94	40m	40m	Feb94	40m	Feb94	40m	Feb94	Feb94	40m	Feb94	40m	Feb94	40m
	S1R1	S1R2	S1R3	S1R4	S1R5	S1R6	S2R1	S2R2	S2R3	S2R4	S2R5	S2R6	S3R1	S3R2	S3R3	S3R4	S3R5	S3R6
OLIGOCHAETA	18	4	49	1	15	2	19	8	7	3	12	25	26	35	6	14	14	34
NEMATODA	37	29	37	30	15	50	20	25	12	43	60	73	96	38	39	60	17	29
PLATYHELMINTHES			1								1							
ECHINODERMATA	2	4	5	8	1	1	8	2	1	4	3	5					2	
ANTHOZOA					1		1						3	6				2
NEMERTEA		1	5	6	10	3		3		1	8	8	2	4	3	8	5	7
SIPUNCULA/PRIAPULA		3	3	3	2	2		1		11	7	11	1	2	3	4		1
BRYOZOA	3				1													
PHORONID																		
HEMICHORDATA																		
CHAETOGNATHA																		
CHORDATA		1	1	4	1							5		3	3	3	12	2
PYCNOGONIDA																		
MOLLUSCA		1	1	6	1		1		1			2	5		1		1	
Total # other taxa per replicate	60	43	102	58	47	58	49	39	21	62	91	129	133	88	55	89	51	75
Taxa per replicate																		
Total Macro Animals	71	93	216	100	66	70	67	72	43	93	354	592	150	117	104	127	129	112

TAXON	40m S4R1	Feb94 S4R2	40m S4R3	Feb94 S4R4	40m S4R5	Feb94 S4R6	Feb94 S5R1	40m S5R2	Feb94 S5R3	40m S5R4	Feb94 S5R5	40m S5R6	40m S6R1	Feb94 S6R2	40m S6R3	Feb94 S6R4	40m S6R5	Feb94 S6R6	Feb94 DHSR1	40m DHSR2	Feb94 DHSR3	40m DHSR4	Feb94 DHSR5	40m DHSR6
OLIGOCHAETA	33	14	7	10	22	26	17	4	29	13	6	29	11	12	21		19	27	28	19	12	3		
NEMATODA	225	109	2	99	63	95	55	18	54	20	38	41	60	57	30	72	42	58	13	46	31	51	51	38
PLATYHELMINTHES	1																							
ECHINODERMATA		2	1	1	2		3		6		3	1	1		2		3			1		1		
ANTHOZOA										17			8	10										
NEMERTEA	1	1	1			2	3	1	8	2	6	2	5	1	1	1		7			2			
SIPUNCULA/PRIAPULA	14	1		1		3	30	17	42	20	20	24	3	2	4	1	7	3	6	16	16	12	7	9
BRYOZOA		5			27		1					1												
PHORONID																								
HEMICHORDATA																								
CHAETOGNATHA																								
CHORDATA	2	6	1	4	3		6	5	20	3	1	4	11	4	1		2	1	2	5	1	4	1	5
PYCNOGONIDA				1																				
MOLLUSCA	1	5				1	3		1	8	2		1			1	2			2		2	4	4
Total # other taxa per replicate	277	143	12	116	117	127	118	45	160	83	76	102	100	86	59	75	75	96	49	89	62	73	63	56
Taxa per replicate																								
Total Macro Animals	345	182	20	167	152	145	312	111	297	195	188	247	181	147	96	129	127	122	102	132	129	149	121	102

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August 1994 40m	Species	S1R1A	S1R2A	S1R3A	S1R4A	S1R5A	S1R6A	S2R1A	S2R2A	S2R3A	S2R4A	S2R5A	S2R6A	S3R1	S3R2	S3R3	S3R4	S3R5	S3R6
	Amaeana accraensis																		
	Amphicteis gunneri			1						1									
	Amphiduros sp. A												1						
	Amphiglena mediterranea									2		3							
	Amphiglena sp. A																		
	Aonides oxycephala												1						
	Aonides sp A																		
	Aricidea catherinae																		
	Aricidea sp. A																		
	Armandia intermedia											1				2			1
	Augeneriella dubia	62	2	39	55	13	72	1	7	6		1		47	15	17		20	7
	Augeneriella sp. A																		
	Axiothella quadrimaculata																		
	Axiothella quadrimaculata																	1	
	Branchiomma nigromaculata																		
	Branchiosyllis exilis																		
	Brania mediodentata																		1
	Brania sp. A																		
	Capitella capitata				2	1				1	1	2		1		5	1	1	2
	Capitella sp. A												3						
	Capitellidae sp. B																		
	Capitellidae sp. D (?)																		
	Caulleriella acicula																		
	Caulleriella bioculatus																		
	Caulleriella capensis																		
	Chloeia flava																		
	Cirratulus acicula																		
	Cirratulus africanus (?)																		
	Cirratulus filiformis																		
	Cossura sp. B											1							
	Dorvillea rubrovittata																		
	Euchone sp. B		11	209	56		477	56	43	282	36	67		4	2	15		9	51
	Eulalia sp																		
	Eunice antennata																		
	Eunice australis																		
	Eunice siciliensis																		
	Eunice vittata																		
	Euthalenessa sp. A														1				
	Exogone longicornis	1			2	1	1	1				3	2			2			2
	Exogone sp. A																		
	Exogone sp. B																		
	Exogone sp. C						1		1						2	1		3	7
	Exogone sp. D																		
	Exogone sp. E																	3	
	Fabricia capensis																		
	Fabricia sp. A	3		8			2	2	3	17		7		1	1	3		5	10
	Glycera tesselata											1							
	Goniada emerita						1												
	Grubeulepsis mexicana																		
	Haplosyllis spongicola																		
	Hesionidae sp. A																		
	Hesionura sp. B																		

Species	S4R1	S4R2	S4R3	S4R4	S4R5	S4R6	S5R1	S5R2	S5R3	S5R4	S5R5	S5R6	S6R1	S6R2	S6R3	S6R4	S6R5	S6R6	DHSR1	DHSR2	DHSR3	DHSR4	DHSR5	DHSR6
Amaeana accraensis																								
Amphicteis gunneri														1	1								1	
Amphiduros sp. A																								
Amphiglena mediterranea													1											
Amphiglena sp. A								1																
Aonides oxycephala								2		4														
Aonides sp. A	1									1	1									1				
Aricidea catherinae																								
Aricidea sp. A								2		1														
Armandia intermedia		2					1	6					2				1			5	1		1	2
Augeneriella dubia	4	7	6		6	61							12	1	1			1	3		1		1	
Augeneriella sp. A																								
Axiothella quadrimaculata		1																						
Axiothella quadrimaculata																								
Branchiomma nigromaculata																								
Branchiosyllis exilis								1																
Brania mediodentata		1	1																					
Brania sp. A																								
Capitella capitata				1		1				1							3							1
Capitella sp. A																								
Capitellidae sp. B		2			1					2							4							
Capitellidae sp. D (?)																								
Caulleriella acicula								1																
Caulleriella bioculatus																								
Caulleriella capensis																								
Chloeia flava														1										
Cirratulus acicula																								
Cirratulus africanus (?)																								
Cirratulus filiformis																								
Cossura sp. B																								
Dorvillea rubrovittata																								
Euchone sp. B						1		3			1		7	70						3				3
Eulalia sp.																							1	
Eunice antennata										1														
Eunice australis										1														
Eunice siciliensis																								
Eunice vittata								1																
Euthalenessa sp. A																								
Exogone longicornis									8								1							
Exogone sp. A																								
Exogone sp. B													2											
Exogone sp. C						4°									1		1	1						1
Exogone sp. D																								
Exogone sp. E	1			1				1									1							
Fabricia capensis																								
Fabricia sp. A	2				2	4		6					3	14	1									
Glycera tesselata																				1				
Goniada emerita							1	2																
Grubeulepsis mexicana																								
Haplosyllis spongicola																							1	
Hesionidae sp. A																								
Hesionura sp. B														1										

August 1994 40m	Species	S1R1A	S1R2A	S1R3A	S1R4A	S1R5A	S1R6A	S2R1A	S2R2A	S2R3A	S2R4A	S2R5A	S2R6A	S3R1	S3R2	S3R3	S3R4	S3R5	S3R6
	Jasmineira caudata	10																	
	Langerhansia cornuta																2		
	Langerhansia sp. A																		
	Laonome sp. A			6	2	1	3	1	2	1		5							
	Laonome sp. C																		
	Lepidasthenia sp.																		
	Linopherus microcephala													5	2	1	2		
	Lumbrineris sp.							2		2			1					2	2
	Lysidice ninetta																		
	Magelona cincta																		
	Magelona sp. A		1	6			2		2	2	1		4			1			
	Maldanidae sp. A					3					1								
	Megalomma intermedium																		
	Micronereis A																		
	Microphthalmus aberrans																		
	Microphthalmus sczelkowii																		
	Microspio granulata															4			
	Myriochele oculata		6	11	4		16	7	11	38	1	12	7		11	16	7		4
	Myriochele pygidialis																		
	Myriochele sp. A								1										
	Naineris sp. A																		
	Neanthes arenaceodonta															1			
	Nematonereis unicornis						1		2										
	Nereididae sp. A																		
	Nereimyra sp. A			3	2	1	1				2			1	1		3	1	1
	Nereis sp. B							3				1		2					1
	Notomastus tenuis		1	2		3	2	1	1	1	1	2	1			2		1	1
	Onuphis geophiliformis															1			
	Ophyrotrocha sp. A		1																
	Oriopsis sp. A																		
	Oriopsis sp. B																		
	Paleonotus sp. B																		
	Palymyra sp. B																		
	Pholoe sp. A																		
	Pholoe sp. F																		
	Phyllochaetopterus verrilli								1										
	Phyllodoce madeirensis			1														2	
	Phyllodoce sp. A																		
	Phyllodocidae sp. B																		
	Phyllodocidae sp. F																		
	Pionosyllis heterocirrata				1					1		1	4	8	7	5	14	9	7
	Pionosyllis spinisetosa	2	2	1	1		4	3	3	3	12	4	2	1	2	4	2		1
	Pionosyllis weismanni																2		
	Pisione africana (?)																5		
	Pisione sp. A																		
	Podarke angustifrons	2	4	2	3	4	1	2	1	6	1	1	6	9	4	6	9	3	6
	Podarke sp. A								1										
	Polycirrus plumosus										1								
	Polydora armata																		

Species	S4R1	S4R2	S4R3	S4R4	S4R5	S4R6	S5R1	S5R2	S5R3	S5R4	S5R5	S5R6	S6R1	S6R2	S6R3	S6R4	S6R5	S6R6	DHSR1	DHSR2	DHSR3	DHSR4	DHSR5	DHSR6
Jasmineira caudata																							1	
Langerhansia cornuta							1	5									1						1	
Langerhansia sp. A																	1							
Laonome sp. A																								
Laonome sp. C						2														1				
Lepidasthenia sp.																								
Linopherus microcephala			1				1	10	2	6		1	2				1		1					
Lumbrineris sp.						1	1	1	1		1		2	1	1			1		2	1		2	1
Lysidice ninetta																								
Magelona cincta																								
Magelona sp. A																								
Maldanidae sp. A		1						3																
Megalomma intermedium			1																					
Micronereis A																								
Microphthalmus aberrans																	1							
Microphthalmus sczelkowii																					1			
Microspio granulata									1							1			1	1				
Myriochele oculata	1	1	1			9		14	12	2	2	1		17	12			2				1	1	2
Myriochele pygidialis																								
Myriochele sp. A																								
Naineris sp. A																							2	
Neanthes arenaceodonta																							1	
Nematonereis unicornis								10		1														
Nereididae sp. A							1			2														
Nereimyra sp. A			4			3		1					2	2	4		1	2	1	1		2	3	
Nereis sp. B									2						1				2	2	1			1
Notomastus tenuis	2	1	1	1	1	2	1	3					1	2		2	1							
Onuphis geophiliformis																								
Ophyrotrocha sp. A																								
Oriopsis sp. A																								
Oriopsis sp. B																								
Paleonotus sp. B																				1				
Palymyra sp. B																								
Pholoe sp. A																								
Pholoe sp. F																								
Phyllochaetopterus verrilli																								
Phyllodoce madeirensis			1					2									1						1	
Phyllodoce sp. A										1														
Phyllodocidae sp. B																								
Phyllodocidae sp. F																								
Pionosyllis heterocirrata	11	14	5	5	4	4	2	11	6	2	24	16	8	3	4	1	6	4	3	6	1	1	4	4
Pionosyllis spinisetosa								1		5				1						3				1
Pionosyllis weismanni								1		3														
Pisione africana (?)			2	3			2		3		2	2					1						2	
Pisione sp. A		2						1																
Podarke angustifrons	9	6	8	3	9	4		3	1	1	7	2	4	4	3	3	7	7	5	14	7	3	5	10
Podarke sp. A																							1	
Polycirrus plumosus																								
Polydora armata																								

August 1994 40m Species	S1R1A	S1R2A	S1R3A	S1R4A	S1R5A	S1R6A	S2R1A	S2R2A	S2R3A	S2R4A	S2R5A	S2R6A	S3R1	S3R2	S3R3	S3R4	S3R5	S3R6
Polydora normalis			4			2		8	6	19	8	11	1					1
Polyophthalmus pictus																		
Prionospio cirrifera	2	1	3	5	4	1	4	2	3	2	10	4		2	2		2	5
Prionospio cirrobranchiata	1				1	1				2				1		1	1	
Prionospio steenstrupi		1	3	1	1	2	3		4		6		2	1				
Progoniada sp. A												1						
Protodorvillea biarticulata			3								1	1		1	1	1		2
Protodorvillea egena																		
Protodorvillea sp. B																		
Protodrillus sp. A																		
Protomistides sp																		
Pseudopotamilla sp. A																		
Pygospio sp. A																		
Questa caudicirra																		
Questa sp. A											1			1	5		1	3
Rhodine sp. A																		
Sabellastarte sanctijosephi																		
Sabellidae sp.																		
Salmacina dysteri																		
Samythella sp. A					1													
Schistomeringos rudolphi					1		1			1			1			2		
Scololepis victoriensis																		
Scyphoproctus djiboutiensis																		
Sigambra parva	1							1			2	1	5		2			
Sphaerodoridium sp. A																		
Sphaerodoropsis sp. C																		
Sphaerosyllis capensis									1		1							
Sphaerosyllis riseri															1			
Sphaerosyllis taylori	2		2		1		1			2	2	2				3	1	3
Spio blakei							1											
Spionidae sp. B																		
Spionidae sp. D																		
Spiophanes bombyx																		
Streptosyllis pettibone																		
Syllidae sp. C																		
Syllinae sp. A																		
Synelmis acuminata	3	8	10	12	4	15	32	2	18	9	14	1	9	7	17		22	8
Synelmis albini																		
Synelmis sp. A																		
Terebellidae sp. A													1	1				
Terebellidae sp. B																		
Tharyx marioni			1															
Typosyllis aciculata																		
Individual Polys per Replicate	89	38	315	146	40	605	121	92	395	92	157	53	98	62	114	54	87	126
Poly Species per Replicate	11	11	19	13	15	19 *	17	18	19	16	25	18 *	16	18	23	14	18	22

Species	S4R1	S4R2	S4R3	S4R4	S4R5	S4R6	S5R1	S5R2	S5R3	S5R4	S5R5	S5R6	S6R1	S6R2	S6R3	S6R4	S6R5	S6R6	DHSR1	DHSR2	DHSR3	DHSR4	DHSR5	DHSR6
Polydora normalis								3																
Polyophthalmus pictus			1				1								1									
Prionospio cirrifera	1				3	4	2	5	6	1	1	1	1	6			3		1	5	2		3	2
Prionospio cirrobranchiata							2	1	1	1					2	1	1		3	2	4	2	5	2
Prionospio steenstrupi			1			1		1						1				1	1	5	4			4
Progoniada sp. A																								
Protodorvillea biarticulata	4		1			3		2				2		1			5			1				
Protodorvillea egena																								
Protodorvillea sp. B														1										
Protodrilus sp. A			2																					
Protomistides sp.																							1	
Pseudopotamilla sp. A								2									27							
Pygospio sp. A																								
Questa caudicirra																								
Questa sp. A		5	1		2						1	3					5							
Rhodine sp. A								29																
Sabellastarte sanctijosephi																								
Sabellidae sp.																								
Salmacina dysteri																								
Semythella sp. A																								
Schistomeringos rudolphi			1							3					2		3							
Scololepis victoriensis								1																
Scyphoproctus djiboutiensis								9																
Sigambra parva	1														1		1	1						3
Sphaerodoridium sp. A																								
Sphaerodoropsis sp. C																								
Sphaerosyllis capensis							1												2				1	
Sphaerosyllis riseri								1												1	2		1	
Sphaerosyllis taylori					2	6		1	2	1			1	1			4		3	10	1		2	1
Spio blakei	1				1									1				1						
Spionidae sp. B																								
Spionidae sp. D																								
Spiophanes bombyx																								
Streptosyllis pettibone																							2	
Syllidae sp. C																								
Syllinae sp. A																								
Synelmis acuminata	11	15	9	3	8	11	6	11	4	1	6	3	9	21	23	23	18	11	20	6	18	4	21	
Synelmis albini						1		4																
Synelmis sp. A								4																
Terebellidae sp. A																				1				1
Terebellidae sp. B						1																		
Tharyx marioni							1																	
Typosyllis aciculata																								
Individual Polys per Replicate	49	58	47	17	39	123	24	166	49	41	46	33	57	150	58	31	99	32	46	72	44	13	65	39
Poly Species per Replicate	13	13	18	7	11	19 *	15	39	13	21	10	9 *	15	20	15	6	25	11 *	13	21	13	6	25	16

Total Number of Species Found During This Sampling	99

S1 sp	S2 sp	S3 sp	S4 sp	S5 sp	S6 sp	DHS sp
32	43	40	37	55	42	41

Shannon-Wiener Diversity Index (SWidx) for this SAMPLING	-1.17

S1 SWidx	S2 SWidx	S3 SWidx	S4 SWidx	S5 SWidx	S6 SWidx	DHS SWidx
0.637	0.87	1.211	1.114	1.422	1.178	1.069

S1 Abund	S2 Abund	S3 Abund	S4 Abund	S5 Abund	S6 Abund	DHS Abund
1233	910	541	333	359	427	279

Tot Abund
4082

AUGUST 1994 40m

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TAXON	Aug94 S1R1A	40m S1R2A	Aug94 S1R3A	40m S1R4A	Aug94 S1R5A	40m S1R6A	40m S2R1A	Aug94 S2R2A	40m S2R3A	Aug94 S2R4A	40m S2R5A	Aug94 S2R6A	Aug94 S3R1	40m S3R2	Aug94 S3R3	40m S3R4	Aug94 S3R5	40m S3R6
OLIGOCHAETA	3	59	28	2	19	35	19		52	10	2		12	19	36	7	13	24
NEMATODA	19	34	21	77	36	17	54	68	65	1	133	69	110	110	160	30	57	218
PLATYHELMINTHES		1						1			1						1	
ECHINODERMATA	2	5	7	3	9	7	4	8	8	4	6	10	2	1	1		1	1
ANTHOZOA				1														
NEMERTEA	2	3	6	4	2	7	2		8	1	4	4	1	1	3		4	6
SIPUNCULA/PRIAPULA	8	1	3	1	3	1	4	3	4	3	6	7	17	2	4	4	2	9
BRYOZOA							1										1	1
PHORONID		1				2												
HEMICHORDATA					1							1						
CHAETOGNATHA																		
CHORDATA						3		3	1		5	2	1	1		9	2	3
PYCNOGONIDA																		
MOLLUSCA		1	1	1	2						7	1	1				1	4

Total # other taxa per replicate	34	105	66	89	72	72	84	83	138	19	164	94	144	134	204	50	82	266
Taxa per replicate																		
Total Macro Animals	123	143	381	235	112	677	205	175	533	111	321	147	242	196	318	104	169	392

d:\123w\dummy\mamcum.wk3

TAXON	40m S4R1	Aug94 S4R2	40m S4R3	Aug94 S4R4	40m S4R5	Aug94 S4R6	Aug94 S5R1	40m S5R2	Aug94 S5R3	40m S5R4	Aug94 S5R5	40m S5R6	40m S6R1	Aug94 S6R2	40m S6R3	Aug94 S6R4	40m S6R5	Aug94 S6R6	Aug94 DHSR1	40m DHSR2	Aug94 DHSR3	40m DHSR4	Aug94 DHSR5	40m DHSR6
OLIGOCHAETA	11	19	30	3	20	40		3	5	14	8		2	38	20	1	10	23		5	6	2	6	11
NEMATODA	34	123	23	56	36	56	33	22	17	28	70		120	93	73	28		23	47	50	32	26	66	39
PLATYHELMINTHES		1																		1	1			
ECHINODERMATA								3											1	4			1	
ANTHOZOA							1																	
NEMERTEA		4			1	11		8	5	7	6			4	4		1				7		1	5
SIPUNCULA/PRIAPULA	1		2		3	9	6	36	2	1	11		10	3	2		3	2	11	8	20	3	4	11
BRYOZOA		1															1						1	
PHORONID		2						2																
HEMICHORDATA																								
CHAETOGNATHA								1																
CHORDATA	3	4	2	2	2	2	9	3	4	6			4	1	3	4	1		3	1	1	7	2	2
PYCNOGONIDA																								
MOLLUSCA			1			1		2	1	1				3		1							5	1
Total # other taxa per replicate	49	154	58	61	62	119	49	80	34	57	95	0	136	142	102	34	16	48	62	69	67	38	86	69
Taxa per replicate																								
Total Macro Animals	98	212	105	78	101	242	73	246	83	98	141	33	193	292	160	65	115	80	108	141	111	51	151	108

Appendix 3.2 Statistical results tables (70m and 40m)

H_1- The abundance of polychaete worms differs between the 70m control site (DH) and the site nearest the outfall (B3) during concurrent samplings.
H_0- The abundance of polychaete worms does not differ between sites DH and B3 (70m) in concurrent sampling periods.

Log transformation; Vmax / Vmin = 21.58 (Homoscedastic)

Results of oneway ANOVA at 95% Confidence Interval ($p \leq 0.05$)

Season	DH	Diff ?	Relation	B3	p value
S	Aug93	S	<	Aug93	0.007
W	Nov93	NS		Nov93	0.914
W	Jan94	NS		Jan94	0.315
S	May94	S	<	May94	0.000
S	Aug94	S	<	Aug94	0.026

Statement: H_1 holds true for all summer samplings. H_0 is supported for winter samplings.

H_1- The number of species of polychaete worms differs between the 70m control site (DH) and the site nearest the outfall (B3) in concurrent sampling periods.
H_0- The number of polychaete species does not differ between sites DH and B3 (70m) in concurrent sampling sessions.

Log transformation; Vmax / Vmin = 13.837 (Homoscedastic)

Results of oneway ANOVA at 95% Confidence Interval ($p \leq 0.05$)

Season	DH	Diff ?	Relation	B3	p value
S	Aug93	NS		Aug93	0.377
W	Nov93	NS		Nov93	0.101
W	Jan94	NS		Jan94	0.228
S	May94	NS		May94	0.140
S	Aug94	NS		Aug94	0.608

Statement: H_0 holds true for all samplings.

H_1- The number of Polychaete individuals will differ between seasons (S and W) at 40m sites.
H_0- The number of Polychaete individuals will not differ seasonally at 40m sites.

Log transformation; Vmax / Vmin = 40.325 (Heteroscedastic)

Results of Kruskal-Wallis at 95% Confidence Interval ($p \leq 0.05$) with tie corrections

W	Diff?	Relation	S	p value
S1	NS		S1	0.078
S2	NS		S2	0.262
S3	S	<	S3	0.011
S4	NS		S4	0.378
S5	S	>	S5	0.037
S6	NS		S6	0.522
DHS	NS		DHS	0.297

Statement: Sites S3 and S5 demonstrated seasonal differences within the scope of this test. The former possessing more worms in S, the latter in W.

H_1- The number of Polychaete species will differ between seasons (S and W) at 40m sites.
H_0- The number of Polychaete species will not differ seasonally at 40m sites.

No data transformation; Vmax / Vmin = 12.349 (Homoscedastic)

Results of oneway ANOVA at 95% Confidence Interval ($p \leq 0.05$)

W	Diff?	Relation	S	p value
S1	NS		S1	0.091
S2	NS		S2	0.346
S3	NS		S3	0.065
S4	NS		S4	0.790
S5	NS		S5	0.630
S6	NS		S6	0.472
DHS	NS		DHS	0.877

Statement: No seasonal differences in species richness, within the scope of this test, was observed

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H_1- The number of Polychaete individuals will differ between 40m sites within the S season (Aug94).

H_0- The number of Polychaete individuals will not differ at 40m sites within the S season (Aug94).

Log transformation; Vmax / Vmin = 17.626 (Homoscedastic)

Results of oneway ANOVA at a 95% Confidence Interval ($p \leq 0.05$)

Station	Diff?	Relation	Station	p value
S1	NS		S2	0.364
	NS		S3	0.576
	NS		S4	0.976
	S	<	S5	0.005
	NS		S6	0.234
	NS		DHS	0.119
S2	NS		S3	0.438
	NS		S4	0.248
	NS		S5	0.262
	NS		S6	0.719
	NS		DHS	0.895
S3	NS		S4	0.566
	S	<	S5	0.000
	NS		S6	0.332
	NS		DHS	0.100
S4	S	<	S5	0.002
	NS		S6	0.196
	NS		DHS	0.084
S5	S	>	S6	0.002
	S	>	DHS	0.000
S6	NS		DHS	0.467

Statement: During Aug 94, S5 had significantly more polychaete individuals than all stations except S2 which was markedly different than the remaining stations.

H_1- The number of Polychaete individuals will differ between 40m sites within the W season (Feb94).
H_0- The number of Polychaete individuals will not differ at 40m sites within the W season (Feb94).

Log transformation; Vmax / Vmin = 17.626 (Homoscedastic)

Results of oneway ANOVA at a 95% Confidence Interval ($p \leq 0.05$)

Station	Diff?	Relation	Station	p value
S1	NS		S2	0.473
	NS		S3	0.454
	NS		S4	0.454
	NS	<	S5	0.101
	NS		S6	0.194
	NS		DHS	0.058
S2	NS		S3	0.283
	S	>	S4	0.031
	S	>	S5	0.036
	NS		S6	0.089
	S	>	DHS	0.015
S3	NS		S4	0.067
	NS		S5	0.082
	NS		S6	0.246
	S	>	DHS	0.026
S4	NS		S5	0.962
	NS		S6	0.508
	NS		DHS	0.713
S5	NS		S6	0.546
	NS		DHS	0.683
S6	NS		DHS	0.303

Statement: During Feb 94, S2 had significantly more polychaete individuals than stations S4, S5 and DHS.

Combined Statement: In general, within the S series stations, S5 and S2 tend to have high worm abundances, while DHS has a uniformly low abundance.

H_1 Station B3 differs from DH (70m) in numbers of meiofaunal polychaetes in concurrent samplings.
H_0 Station B3 does not differ from DH (70m) in number of meiofaunal polychaetes during concurrent samplings.

No data transformations, Vmax/Vmin = 18.91 (Heteroscedastic)

Results of oneway ANOVA at 95% CI ($p \leq 0.05$)

DH	Diff?	Relation	B3	p value
Aug93	S	<	Aug93	0.010
Nov93	S	<	Nov93	0.046
Jan94	NS		Jan94	0.455
May94	NS		May94	0.553
Aug94	NS		Aug94	0.105

Statement: Meiofaunal polychaetes were recorded in greatest number during Aug 93 and Nov 93.

H_1 The number of meiofaunal polychaetes varies seasonally at DH.
H_0 The number of meiofaunal polychaetes does not vary seasonally at DH.

No data transformations, Vmax/Vmin = (Heteroscedastic)

Results of oneway ANOVA at 95% CI ($p \leq 0.05$)

DH	Diff?	Relation	DH	p value
Aug93	NS		Nov93	0.662
	NS		Jan94	0.231
	NS		May94	0.168
	NS		Aug94	0..07
Nov93	NS		Jan94	0.920
	NS		May94	0.584
	NS		Aug94	0.434
Jan94	NS		May94	0.497
	NS		Aug94	0.281
May94	NS		Aug94	0.787

Statement: Meiofaunal polychaete abundances did not show evidence of seasonality at DH (70m).

H_1 The number of meiofaunal polychaetes varies seasonally at B3.
H_0 The number of meiofaunal polychaetes does not vary seasonally at B3.

No data transformations, Vmax/Vmin = (Heteroscedastic)

Results of oneway ANOVA at 95% CI ($p \leq 0.05$)

B3	Diff?	Relation	B3	p value
Aug93	NS		Nov93	0.730
	S		Jan94	0.009
	S		May94	0.004
	NS		Aug94	0.063
Nov93	S		Jan94	0.005
	S		May94	0.000
	NS		Aug94	0.068
Jan94	NS		May94	0.337
	NS		Aug94	0.548
May94	NS		Aug94	0.247

Statement: Meiofaunal polychaete abundances showed evidence of seasonality at B3 (70m). Summer samplings present more meiofaunal worms than winter samplings.

H_1 Abundance of macrofaunal Ophryotrocha sp. A varies seasonally.
H_0 Abundance of macrofaunal Ophryotrocha sp. A does not vary seasonally.

Log transformation, Vmax/Vmin = 6.24 (Homoscedastic)

Results of oneway ANOVA at 95% Confidence Interval ($p \leq 0.05$)

B3	Diff?	Relation	B3	p value
Aug93	NS		Nov93	0.150
	S	>	Jan94	0.015
	S	>	May94	0.043
	S	>	Aug94	0.035
Nov93	NS		Jan94	0.586
	NS		May94	0.516
	NS		Aug94	0.618
Jan94	NS		May94	0.759
	NS		Aug94	0.974
May94	NS		Aug94	0.807

Statement: Ophryotrocha sp. A was particularly abundant in Aug93 and Nov93 samplings.

H_1 The number of macrofaunal nematodes differs between sites B3 and DH (70m) in concurrent samplings.
H_0 The number of macrofaunal nematodes does not differ between sites B3 and DH in concurrent samplings

Log transformation, Vmax / Vmin = 24.19 (Homoscedastic)

Results of oneway ANOVA at 95% Confidence Interval ($p \leq 0.05$)

DH	Diff?	Relation	B3	p value
Aug93	S	<	Aug93	0.012
Nov93	NS		Nov93	0.057
Jan94	S	<	Jan94	0.016
May94	S	<	May94	0.029
Aug94	S	<	Aug94	0.021

Statement: Station B3 consistently presents more nematodes than DH.

H_1 The number of macrofaunal oligochaetes differs between sites B3 and DH in concurrent samplings.

H_0 The number of macrofaunal oligochaetes does not differ between sites B3 in concurrent samplings.

Log transformation, Vmax / Vmin = (Homoscedastic)

Results of oneway ANOVA at 95% confidence interval ($p \leq 0.05$)

DH	Diff?	Relation	B3	p value
Aug93	NS		Aug93	0.974
Nov93	NS		Nov93	0.516
Jan94	S	<	Jan94	0.010
May94	NS		May94	0.168
Aug94	NS		Aug94	0.504

Statement: Only Jan 94 presented a significant difference in oligochaete abundances.

Appendix 4.1 Crusteacean taxa presence

Mamala Bay Study / STATION	1=FIRST	X=RECUR				
TAXA / SAMPLING DATE	Aug-93	Nov-93	Jan-94	May-94	Aug-94	TOTAL
COPEPODA	1	x	x	x	x	5
OSTRACODA - MYODOCOPIDA						
Myodocope sp. A.		1			x	2
Myodocope sp. B.					1	1
Myodocope sp. C.			1			1
OSTRACODA - PODOCOPIDA						
Bairdia kauaiensis			1	x		2
NEBALIACEA						
Nebalia cf. *bipes*				1		1
ISOPODA						
Jaeropsis hawaiiensis				1		1
Metacirolana sp. A.	1					1
Munna acarina				1		1
AMPHIPODA - CAPRELLIDEA						
Metaprotella sandalensis				1		1
AMPHIPODA - GAMMARIDEA						
Amphilochus menehune			1			1
Bemlos kaumanu		1				1
Bemlos sp. A.				1		1
Ericthonius brasiliensis			1			1
Eriopisella sechellensis	1	x	x	x	x	5
Ischyrocerus sp. A.			1			1
Paraphoxus sp. A.				1		1
Photis kapapa				1		1
Seba ekepuu	1					1
DECAPODA - NATANTIA						
Ogyrides sp. A			1			1
DECAPODA - ANOMURA						
Pagurid sp. A.			1			1
TOTAL TAXA / SAMPLE	4	4	9	10	4	
NEW TAXA / SAMPLE	4	2	7	7	1	
CUMULATIVE TAXA / STATION	4	6	13	20	21	
AVERAGE OCCURRENCE						1.47619
ST. DEV / 95 % CONF. INT.					1.2090925	0.517127
AVE. (W/O COPEPODS)						1.3
STD / 95 % (W/O COPEPODS)					0.9233805	0.394929

MAMALA BAY STUDY STATION DHS

Mamala Bay Study / STATION TAXA / SAMPLING DATE	1=FIRST Feb-94	X=RECUR Aug-94	TOTAL
COPEPODA	1	X	2
OSTRACODA - MYODOCOPIDA			
Myodocope sp. A.		1	1
Myodocope sp. B.	1	X	2
Myodocope sp. C.	1	X	2
Sarsiella janiceae	1		1
OSTRACODA - PODOCOPIDA			
Bairdia kauaiensis	1		1
Mutilus cf. oahuensis	1		1
TANAIDACEA			
Apseudes tropicalis		1	1
Leptochelia dubia	1	X	2
Leptochelia sp. A.	1	X	2
Tanaissus sp. A.		1	1
ISOPODA			
Munna acarina		1	1
AMPHIPODA - GAMMARIDEA			
Ericthonius brasiliensis		1	1
Eriopisella sechellensis	1	X	2
Gammaropsis atlantica	1	X	2
Ischyrocerus sp. A.		1	1
Konatopus paao	1	X	2
Leucothoe hyhelia	1		1
Paraphoxus sp. A.	1	X	2
Paraphoxus sp. B			0
Photis kapapa		1	1
DECAPODA - NATANTIA			
Ogyrides sp. A	1	X	2
Peneopsis sp. A.		1	1
TOTAL TAXA / SAMPLE	14	18	
NEW TAXA / SAMPLE	14	8	
CUMULATIVE TAXA / STATION	14	22	

MAMALA BAY STUDY STATION DH

Mamala Bay Study / STATION	1=FIRST X=RECUR					
TAXA / SAMPLING DATE	Aug-93	Nov-93	Jan-94	May-94	Aug-94	TOTAL
ACARI			1			1
COPEPODA		1	x	x	x	4
OSTRACODA - MYODOCOPIDA						
Myodocope sp. A.		1	x	x		3
Myodocope sp. B.		1	x	x	x	4
Myodocope sp. C.		1		x		2
Myodocope sp. D.				1		1
Sarsiella janiceae				1		1
CUMACEA				1		1
TANAIDACEA						
Apseudes tropicalis		1		x		2
Leptochelia dubia	1	x	x	x	x	5
Leptochelia sp. A.	1	x	x		x	4
Tanaissus sp. A.		1	x			2
ISOPODA						
Apanthura inornata	1	x				2
Janira algicola			1			1
Metacirolana sp. A.						
Munna acarina		1	x			2
Pleurocope sp. A.	1					1
Santia sp. A.	1	x				2
AMPHIPODA - CAPRELLIDEA						
Caprella cf subtilis		1				1
AMPHIPODA - GAMMARIDEA						
Ampithoe akuolaka		1				1
Bemlos macromanus		1				1
Bemlos sp. A.		1				1
Ericthonius brasiliensis		1				1
Eriopisella sechellensis	1	x	x	x	x	5
Gammaropsis atlantica		1				1
Ischyrocerus oahu	1				x	2
Ischyrocerus sp. A.	1					1
Konatopus paao		1	x			2
Paraphoxus sp. A.		1		x		2
Photis kapapa		1	x		x	3
Seba ekepuu				1		1
DECAPODA - NATANTIA						
Alpheopsis equalis	1					1
Ambidexter sp. A.		1				1
Processa hawaiiensis		1				1
DECAPODA - ANOMURA						
Pagurid sp. A.		1				1
DECAPODA - BRACHYURA						
Achaeus sp. A.		1				1
TOTAL TAXA / SAMPLE	9	25	12	12	7	
NEW TAXA / SAMPLE	9	20	2	4	0	
CUMULATIVE TAXA / STATION	9	29	31	35	35	
AVERAGE OCCURRENCE						1.642857
ST. DEV / 95 % CONF. INT.					1.150728	0.381229
AVE. (W/O COPEPODS)						1.642857
STD / 95 % (W/O COPEPODS)					1.150728	0.381229

MAMALA BAY STUDY STATION S1

Mamala Bay Study / STATION	1=FIRST	X=RECUR	
TAXA / SAMPLING DATE	Feb-94	Aug-94	TOTAL
COPEPODA	1	X	2
MYSIDACEA	1		1
TANAIDACEA			
Leptochelia dubia	1	X	2
Leptochelia sp. A.		1	1
ISOPODA			
Apanthura inornata	1		1
Cryptoniscus form		1	1
Munna acarina	1		1
Paranthura ostergaardi	1		1
AMPHIPODA - CAPRELLIDEA			
Caprella cf. *subtilis*	1		1
AMPHIPODA - GAMMARIDEA			
Amphilochidae sp. A.	1		1
Bemlos macromanus		1	1
Ericthonius brasiliensis	1		1
Eriopisella sechellensis	1	X	2
Konatopus paao	1	X	2
Leucothoe hyhelia		1	1
Paraphoxus sp. A.	1	X	2
Photis kapapa	1	X	2
DECAPODA - NATANTIA			
Leptochela hawaiiensis	1		1
DECAPODA - BRACHYURA			
Chlorinoides cf. *goldsboroughi*	1		1
TOTAL TAXA / SAMPLE	15	10	
NEW TAXA / SAMPLE	15	4	
CUMULATIVE TAXA / STATION	15	19	

MAMALA BAY STUDY STATION S2

Mamala Bay Study / STATION TAXA / SAMPLING DATE	1=FIRST Feb-94	X=RECUR Aug-94	TOTAL
COPEPODA	1	X	2
OSTRACODA - MYODOCOPIDA			
Myodocope sp. A.	1	X	2
OSTRACODA - PODOCOPIDA			
Bairdia kauaiensis	1	X	2
CUMACEA	1		1
MYSIDACEA	1		1
TANAIDACEA			
Leptochelia dubia	1	X	2
Leptochelia sp. A.		1	1
Tanaissus sp. A.	1	X	2
ISOPODA			
Apanthura inornata		1	1
Munna acarina	1		1
Paranthura ostergaardi	1		1
AMPHIPODA - CAPRELLIDEA			
Caprella cf. *subtilis*	1		1
Metaprotella sandalensis		1	1
AMPHIPODA - GAMMARIDEA			
Amphilochidae sp. A.	1	X	2
Ampithoe akuolaka	1		1
Bemlos macromanus	1		1
Ericthonius brasiliensis	1	X	2
Eriopisella sechellensis	1	X	2
Gammaropsis atlantica	1		1
Konatopus paao	1	X	2
Leucothoe hyhelia	1		1
Paraphoxus sp. A.	1	X	2
Photis kapapa	1	X	2
DECAPODA - NATANTIA			
Leptochela hawaiiensis	1		1
DECAPODA - ANOMURA			
Pagurid sp. A.	1		1
TOTAL TAXA / SAMPLE	22	14	
NEW TAXA / SAMPLE	22	3	
CUMULATIVE TAXA / STATION	22	25	

MAMALA BAY STUDY STATION S3

Mamala Bay Study / STATION	1=FIRST X=RECUR		
TAXA / SAMPLING DATE	Feb-94	Aug-94	TOTAL
COPEPODA	1	X	2
OSTRACODA - MYODOCOPIDA			
Sarsiella janiceae		1	1
OSTRACODA - PODOCOPIDA			
Bairdia kauaiensis	1	X	2
TANAIDACEA			
Leptochelia dubia	1	X	2
ISOPODA			
Apanthura inornata	1	X	2
Metacirolana sp. A.	1		1
Munna acarina	1		1
AMPHIPODA - CAPRELLIDEA			
Caprella cf. *subtilis*	1		1
AMPHIPODA - GAMMARIDEA			
Bemlos macromanus	1	X	2
Elasmopus piikoi	1		1
Ericthonius brasiliensis	1		1
Eriopisa laakona	1		1
Eriopisella sechellensis	1	X	2
Gammaropsis atlantica	1		1
Konatopus paao	1	X	2
Paraphoxus sp. A.		1	1
Photis kapapa		1	1
DECAPODA - NATANTIA			
Ogyrides sp. A		1	1
TOTAL TAXA / SAMPLE	14	11	
NEW TAXA / SAMPLE	14	4	
CUMULATIVE TAXA / STATION	14	18	

MAMALA BAY STUDY STATION S4

Mamala Bay Study / STATION	1=FIRST X=RECUR		
TAXA / SAMPLING DATE	Feb-94	Aug-94	TOTAL
COPEPODA	1	X	2
OSTRACODA - MYODOCOPIDA			
Myodocope sp. A.	1		1
Myodocope sp. B.	1	X	2
OSTRACODA - PODOCOPIDA			
Bairdia hanaumaensis	1	X	2
Bairdia kauaiensis	1	X	2
Mutilus cf. *oahuensis*	1	X	2
TANAIDACEA			
Leptochelia dubia	1	X	2
ISOPODA			
Cryptoniscus form	1		1
Metacirolana sp. A.	1	X	2
Munna acarina	1		1
AMPHIPODA - CAPRELLIDEA			
Caprella cf. *subtilis*	1		1
AMPHIPODA - GAMMARIDEA			
Amphilochidae sp. A.		1	1
Bemlos macromanus	1		1
Ericthonius brasiliensis	1	X	2
Eriopisella sechellensis	1	X	2
Gammaropsis atlantica		1	1
Leucothoe hyhelia		1	1
Paraphoxus sp. A.	1	X	2
Paraphoxus sp. B		1	1
DECAPODA - NATANTIA			
Ogyrides sp. A		1	1
TOTAL TAXA / SAMPLE	15	15	
NEW TAXA / SAMPLE	15	5	
CUMULATIVE TAXA / STATION	15	20	

MAMALA BAY STUDY STATION S5

Mamala Bay Study / STATION	1=FIRST X=RECUR		
TAXA / SAMPLING DATE	Feb-94	Aug-94	TOTAL
COPEPODA	1	X	2
OSTRACODA - MYODOCOPIDA			
Myodocope sp. A.	1		1
Myodocope sp. B.	1		1
Myodocope sp. C.		1	1
Sarsiella janiceae	1		1
OSTRACODA - PODOCOPIDA			
Bairdia hanaumaensis	1		1
Bairdia kauaiensis		1	1
TANAIDACEA			
Leptochelia dubia	1	X	2
Leptochelia sp. A.	1		1
Tanaissus sp. A.	1	X	2
ISOPODA			
Hyssuridae sp. A.		1	1
AMPHIPODA - GAMMARIDEA			
Bemlos macromanus	1	X	2
Ceradocus hawaiiensis		1	1
Eriopisella sechellensis	1	X	2
Gammaropsis atlantica	1	X	2
Konatopus paao	1		1
Maera cf. *hamigera*		1	1
Paraphoxus sp. A.	1	X	2
Paraphoxus sp. B	1	X	2
Seba ekepuu	1		1
DECAPODA - NATANTIA			
Process aequimana		1	1
Processa hawaiiensis	1		1
TOTAL TAXA / SAMPLE	16	14	
NEW TAXA / SAMPLE	16	6	
CUMULATIVE TAXA / STATION	16	22	

MAMALA BAY STUDY STATION S6

Mamala Bay Study / STATION TAXA / SAMPLING DATE	1=FIRST X=RECUR Feb-94	Aug-94	TOTAL
COPEPODA	1	X	2
OSTRACODA - MYODOCOPIDA			
Myodocope sp. B.	1		1
Myodocope sp. C.	1		1
OSTRACODA - PODOCOPIDA			
Bairdia kauaiensis	1	X	2
CUMACEA	1		1
TANAIDACEA			
Leptochelia dubia	1	X	2
Leptochelia sp. A.	1	X	2
Tanaissus sp. A.	1		1
ISOPODA			
Apanthura inornata	1		1
Hyssuridae sp. A.		1	1
Pleurocope sp. A.	1		1
AMPHIPODA - CAPRELLIDEA			
Caprella cf. *subtilis*	1		1
AMPHIPODA - GAMMARIDEA			
Amphilochidae sp. A.	1	X	2
Atylus nani		1	1
Ericthonius brasiliensis	1	X	2
Eriopisella sechellensis	1	X	2
Konatopus paao	1		1
Photis kapapa	1		1
DECAPODA - NATANTIA			
Ambidexter sp. A.	1		1
Leptochela hawaiiensis		1	1
Ogyrides sp. A		1	1
Process aequimana	1		1
TOTAL TAXA / SAMPLE	18	11	
NEW TAXA / SAMPLE	18	4	
CUMULATIVE TAXA / STATION	18	22	

Appendix 4.2 Crusteacean taxa abundance

MAMALA BAY STUDY STATION B3

Mamala Bay Study / STATION	B3-8/93	B3-8/93	B3-8/93	B3-8/93	B3-8/93	
TAXA / REPLICATE	R1	R2	R3	R4	R5	TOTAL
COPEPODA	3	1	1	7	3	15
ISOPODA						
Metacirolana sp. A.				1		1
AMPHIPODA - GAMMARIDEA						
Eriopisella sechellensis	2	2			1	5
Seba sp. A.			3			3
TOTAL TAXA / REP. SAMPLE	2	2	2	2	2	
ABUNDANCE / REP. SAMPLE	5	3	4	8	4	
TOTAL TAXA / STATION						4
TOTAL ABUNDANCE / STATION						24

Mamala Bay Study / STATION	B3-11/93	B3-11/93	B3-11/93	B3-11/93	B3-11/93	
TAXA / REPLICATE	R1	R2	R3	R4	R5	TOTAL
COPEPODA	1	1		1	2	5
OSTRACODA - MYODOCOPIDA						
Myodocope sp. A.		2				2
AMPHIPODA - GAMMARIDEA						
Bemlos kaumanu		2				2
Eriopisella sechellensis	1	6	2	11	4	24
TOTAL TAXA / REP. SAMPLE	2	4	1	2	2	
ABUNDANCE / REP. SAMPLE	2	11	2	12	6	
TOTAL TAXA / STATION						4
TOTAL ABUNDANCE / STATION						33

MAMALA BAY STUDY STATION B3

Mamala Bay Study / STATION	B3-1/94	B3-1/94	B3-1/94	B3-1/94	B3-1/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	TOTAL
COPEPODA	1	1	4	5	7	18
OSTRACODA - PODOCOPIDA						
Bairdia kauaiensis					1	1
AMPHIPODA - GAMMARIDEA						
Amphilochus menehune	1					1
Ericthonius brasiliensis	1		1		1	3
Eriopisella sechellensis	2				6	8
DECAPODA - NATANTIA						
Ogyrides sp. A		1	3			4
DECAPODA - ANOMURA						
Pagurid sp. A.			1			1
TOTAL TAXA / REP. SAMPLE	4	2	4	1	4	
ABUNDANCE / REP. SAMPLE	5	2	9	5	15	
TOTAL TAXA / STATION						7
TOTAL ABUNDANCE / STATION						36

"m" REPLICATES

Mamala Bay Study / STATION	B3-1/94	B3-1/94	B3-1/94	B3-1/94	B3-1/94	
TAXA / REPLICATE	R1m	R2m	R3m	R4m	R5m	TOTAL
COPEPODA	88	46	19	225	213	591
OSTRACODA - MYODOCOPIDA						
Myodocope sp. C.					1	1
ISOPODA						
Munna acarina			1		2	3
AMPHIPODA - GAMMARIDEA						
Ericthonius brasiliensis			1			1
Eriopisella sechellensis		1				1
Ischyrocerus sp. A.					1	1
TOTAL TAXA / REP. SAMPLE	1	2	3	1	4	
ABUNDANCE / REP. SAMPLE	88	47	21	225	217	
TOTAL TAXA / STATION						6
TOTAL ABUNDANCE / STATION						598

MAMALA BAY STUDY STATION B3

Mamala Bay Study / STATION	B3-5/94	B3-5/94	B3-5/94	B3-5/94	B3-5/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	TOTAL
COPEPODA	4		5	1		10
OSTRACODA - PODOCOPIDA						
Bairdia kauaiensis	1			1		2
NEBALIACEA						
Nebalia cf bipes				1		1
TANAIDACEA						
Tanaissus sp. A.	2					2
ISOPODA						
Jaeropsis hawaiiensis	1					1
Munna acarina	1					1
AMPHIPODA - CAPRELLIDEA						
Metaprotella sandalensis	4					4
AMPHIPODA - GAMMARIDEA						
Bemlos sp. A.	1					1
Eriopisella sechellensis				8	5	13
Paraphoxus sp. A.	1				2	3
Photis kapapa	5					5
TOTAL TAXA / REP. SAMPLE	9	0	1	4	2	
ABUNDANCE / REP. SAMPLE	20	0	5	11	7	
TOTAL TAXA / STATION						11
TOTAL ABUNDANCE / STATION						43

Mamala Bay Study / STATION	B3-8/94	B3-8/94	B3-8/94	B3-8/94	B3-8/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	TOTAL
COPEPODA	9	1	3	1	6	20
OSTRACODA - MYODOCOPIDA						
Myodocope sp. A.			1			1
Myodocope sp. B.					1	1
AMPHIPODA - GAMMARIDEA						
Eriopisella sechellensis		1				1
TOTAL TAXA / REP. SAMPLE	1	2	2	1	2	
ABUNDANCE / REP. SAMPLE	9	2	4	1	7	
TOTAL TAXA / STATION						4
TOTAL ABUNDANCE / STATION						23

MAMALA BAY STUDY STATION DHS

Mamala Bay Study / STATION	DHS - 2/94	DHS - 2/94	DHS - 2/94	DHS - 2/94	DHS - 2/94	DHS - 2/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	R6	TOTAL
COPEPODA	1	1		2	1	2	7
OSTRACODA - MYODOCOPIDA							
Myodocope sp. B.			1		3	3	7
Myodocope sp. C.			1		1		2
Sarsiella janiceae				1		1	2
OSTRACODA - PODOCOPIDA							
Bairdia kauaiensis	1		1	4		1	7
Mutilus cf. *oahuensis*						1	1
TANAIDACEA							
Leptochelia dubia	3	5		1	12	5	26
Leptochelia sp. A.		1			1		2
AMPHIPODA - GAMMARIDEA							
Eriopisella sechellensis	1	17		15	7	3	43
Gammaropsis atlantica		1					1
Konatopus paao	1				1		2
Leucothoe hyhelia					5		5
Paraphoxus sp. A.					3	1	4
DECAPODA - NATANTIA							
Ogyrides sp. A		2				1	3
TOTAL TAXA / REP. SAMPLE	5	6	3	5	9	9	
ABUNDANCE / REP. SAMPLE	7	27	3	23	34	18	
TOTAL TAXA / STATION							14
TOTAL ABUNDANCE / STATION							112

Mamala Bay Study / STATION	DHS-8/94	DHS-8/94	DHS-8/94	DHS-8/94	DHS-8/94	DHS-8/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	R6	TOTAL
COPEPODA		7	2			5	14
OSTRACODA - MYODOCOPIDA							
Myodocope sp. A.	1						1
Myodocope sp. B.						2	2
Myodocope sp. C.	1						1
TANAIDACEA							
Apseudes tropicalis							0
Leptochelia dubia	4	8	2	1	5	5	25
Leptochelia sp. A.	1	1					2
Tanaissus sp. A.		3					3
ISOPODA							
Munna acarina					1		1
AMPHIPODA - GAMMARIDEA							
Ericthonius brasiliensis		1	1				2
Eriopisella sechellensis	14	30	2	11	13	10	80
Gammaropsis atlantica		45	1		22		68
Ischyrocerus sp. A.		5					5
Konatopus paao						1	1
Paraphoxus sp. A.		1					1
Photis kapapa		3					3
DECAPODA - NATANTIA							
Ogyrides sp. A						2	2
Peneopsis sp. A.					1		1
TOTAL TAXA / REP. SAMPLE	5	10	5	2	5	6	
ABUNDANCE / REP. SAMPLE	21	104	8	12	42	25	
TOTAL TAXA / STATION							18
TOTAL ABUNDANCE / STATION							212

MAMALA BAY STUDY STATION DH

Mamala Bay Study / STATION	DH - 8/93	DH - 8/93	DH - 8/93	DH - 8/93	DH - 8/93	
TAXA / REPLICATE	R1	R2	R3	R4	R5	TOTAL
TANAIDACEA						
Leptochelia dubia		2	2	1	1	6
Leptochelia sp. A.		1		1		2
ISOPODA						
Apanthura inornata	1					1
Pleurocope sp. A.			1			1
Santia sp. A.				1		1
AMPHIPODA - GAMMARIDEA						
Eriopisella sechellensis					2	2
Ischyrocerus oahu		1				1
Ischyrocerus sp. A.	1		1	1		3
DECAPODA - NATANTIA						
Alpheopsis equalis			1			1
TOTAL TAXA / REP. SAMPLE	2	3	4	4	2	
ABUNDANCE / REP. SAMPLE	2	4	5	4	3	
TOTAL TAXA / STATION						9
TOTAL ABUNDANCE / STATION						18

MAMALA BAY STUDY STATION DH

Mamala Bay Study / STATION	DH-11/93	DH-11/93	DH-11/93	DH-11/93	DH-11/93	
TAXA / REPLICATE	R1	R2	R3	R4	R5	TOTAL
COPEPODA	5	3	1	1	1	11
OSTRACODA - MYODOCOPIDA						
Myodocope sp. A.		1			2	3
Myodocope sp. B.			2	1		3
Myodocope sp. C.				1		1
TANAIDACEA						
Apseudes tropicalis				1		1
Leptochelia dubia	5	18	6	6	8	43
Leptochelia sp. A.	2	1	2	3	8	16
Tanaissus sp. A.		3		1	8	12
ISOPODA						
Apanthura inornata	1					1
Munna acarina			3	3	3	9
Santia sp. A.			3	2	1	6
AMPHIPODA - CAPRELLIDEA						
Caprella cf subtilis					2	2
AMPHIPODA - GAMMARIDEA						
Ampithoe akuolaka					4	4
Bemlos macromanus		2		7	6	15
Bemlos sp. A.			2			2
Ericthonius brasiliensis			3			3
Eriopisella sechellensis		13	7	9	13	42
Gammaropsis atlantica		12	1	1	1	15
Konatopus paao			11		12	23
Paraphoxus sp. A.					1	1
Photis kapapa		7	4	7	20	38
DECAPODA - NATANTIA						
Ambidexter sp. A.		1				1
Processa hawaiiensis				1		1
DECAPODA - ANOMURA						
Pagurid sp. A.			1	1		2
DECAPODA - BRACHYURA						
Achaeus sp. A.					1	1
TOTAL TAXA / REP. SAMPLE	4	10	13	15	16	
ABUNDANCE / REP. SAMPLE	13	61	46	45	91	
TOTAL TAXA / STATION						25
TOTAL ABUNDANCE / STATION						256

MAMALA BAY STUDY STATION DH

Mamala Bay Study / STATION	DH - 1/94	DH - 1/94	DH - 1/94	DH - 1/94	DH - 1/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	TOTAL
ACARI					1	1
COPEPODA		1	11			12
OSTRACODA - MYODOCOPIDA						
Myodocope sp. A.		1	1			2
Myodocope sp. B.					1	1
TANAIDACEA						
Leptochelia dubia	4	4	1	3	4	16
Leptochelia sp. A.	2	4	3	6	12	27
Tanaissus sp. A.		1		1	1	3
ISOPODA						
Janira algicola					1	1
Munna acarina					2	2
AMPHIPODA - GAMMARIDEA						
Eriopisella sechellensis	7	2	2	2		13
Konatopus paao		2	2	3	1	8
Photis kapapa					4	4
TOTAL TAXA / REP. SAMPLE	3	7	6	5	9	
ABUNDANCE / REP. SAMPLE	13	15	20	15	27	
TOTAL TAXA / STATION						12
TOTAL ABUNDANCE / STATION						90

Mamala Bay Study / STATION	DH - 5/94	DH - 5/94	DH - 5/94	DH - 5/94	DH - 5/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	TOTAL
COPEPODA	3	1	1	1	1	7
OSTRACODA - MYODOCOPIDA						
Myodocope sp. A.			1			1
Myodocope sp. B.	1					1
Myodocope sp. C.			1			1
Myodocope sp. D.				1		1
Sarsiella janiceae	1					1
CUMACEA	2					2
TANAIDACEA						
Apseudes tropicalis				1		1
Leptochelia dubia	1					1
AMPHIPODA - GAMMARIDEA						
Eriopisella sechellensis			2			2
Paraphoxus sp. A.	2	1				3
Seba ekepuu	1					1
TOTAL TAXA / REP. SAMPLE	7	2	4	3	1	
ABUNDANCE / REP. SAMPLE	11	2	5	3	1	
TOTAL TAXA / STATION						12
TOTAL ABUNDANCE / STATION						22

MAMALA BAY STUDY STATION DH

Mamala Bay Study / STATION	DH - 8/94	DH - 8/94	DH - 8/94	DH - 8/94	DH - 8/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	TOTAL
COPEPODA			1		1	2
OSTRACODA - MYODOCOPIDA						
Myodocope sp. B.					3	3
TANAIDACEA						
Leptochelia dubia	1			1	5	7
Leptochelia sp. A.			1			1
AMPHIPODA - GAMMARIDEA						
Eriopisella sechellensis		2		4	2	8
Ischyrocerus oahu	1					1
Photis kapapa					2	2
TOTAL TAXA / REP. SAMPLE	2	1	2	2	5	
ABUNDANCE / REP. SAMPLE	2	2	2	5	13	
TOTAL TAXA / STATION						7
TOTAL ABUNDANCE / STATION						24

MAMALA BAY STUDY STATION S1

Mamala Bay Study / STATION	S1 - 2/94	S1 - 2/94	S1 - 2/94	S1 - 2/94	S1 - 2/94	S1 - 2/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	R6	TOTAL
COPEPODA				2			2
MYSIDACEA					1		1
TANAIDACEA							
Leptochelia dubia		1	9	10			20
ISOPODA							
Apanthura inornata			1				1
Munna acarina				1			1
Paranthura ostergaardi				1			1
AMPHIPODA - CAPRELLIDEA							
Caprella cf *subtilis*				1	1		2
AMPHIPODA - GAMMARIDEA							
Amphilochidae sp. A.			5	5			10
Ericthonius brasiliensis		6	13	1			20
Eriopisella sechellensis	6	5	33	85	16	2	147
Konatopus paao	3		3	17	3		26
Paraphoxus sp. A.	2	2	6	10	1		21
Photis kapapa			2	11	1		14
DECAPODA - NATANTIA							
Leptochela hawaiiensis				1			1
DECAPODA - BRACHYURA							
Chlorinoides cf *goldsboroughi*					1		1
TOTAL TAXA / REP. SAMPLE	3	4	8	12	7	1	
ABUNDANCE / REP. SAMPLE	11	14	72	145	24	2	
TOTAL TAXA / STATION							15
TOTAL ABUNDANCE / STATION							268

Mamala Bay Study / STATION	S1 - 8/94	S1 - 8/94	S1 - 8/94	S1 - 8/94	S1 - 8/94	S1 - 8/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	R6	TOTAL
COPEPODA						1	1
TANAIDACEA							
Leptochelia dubia	1		2	10	4	19	36
Leptochelia sp. A.				1			1
ISOPODA							
Cryptoniscus form				1			1
AMPHIPODA - GAMMARIDEA							
Bemlos macromanus			2	1			3
Eriopisella sechellensis	8	7	3	6	22	17	63
Konatopus paao		1		2			3
Leucothoe hyhelia						1	1
Paraphoxus sp. A.		1	3	3		2	9
Photis kapapa	2		3	3			8
TOTAL TAXA / REP. SAMPLE	3	3	5	8	2	5	
ABUNDANCE / REP. SAMPLE	11	9	13	27	26	40	
TOTAL TAXA / STATION							10
TOTAL ABUNDANCE / STATION							126

MAMALA BAY STUDY STATION S2

Mamala Bay Study / STATION	S2 - 2/94	S2 - 2/94	S2 - 2/94	S2 - 2/94	S2 - 2/94	S2 - 2/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	R6	TOTA
COPEPODA					1		
OSTRACODA - MYODOCOPIDA							
Myodocope sp. A.					1		
OSTRACODA - PODOCOPIDA							
Bairdia kauaiensis	2						
CUMACEA				2			
MYSIDACEA				1			
TANAIDACEA							
Leptochelia dubia				3	2	15	2
Tanaissus sp. A.				1			
ISOPODA							
Munna acarina						3	
Paranthura ostergaardi						1	
AMPHIPODA - CAPRELLIDEA							
Caprella cf *subtilis*				1		3	
AMPHIPODA - GAMMARIDEA							
Amphilochidae sp. A.				3	4	1	
Ampithoe akuolaka						1	
Bemlos macromanus				1		6	
Ericthonius brasiliensis	1			70	18		8
Eriopisella sechellensis		3		1	7	16	2
Gammaropsis atlantica				1			
Konatopus paao				1	4	14	1
Leucothoe hyhelia				1			
Paraphoxus sp. A.			1			1	
Photis kapapa					1	5	
DECAPODA - NATANTIA							
Leptochela hawaiiensis				1			
DECAPODA - ANOMURA							
Pagurid sp. A.	1			1			
TOTAL TAXA / REP. SAMPLE	3	1	1	14	8	11	
ABUNDANCE / REP. SAMPLE	4	3	1	88	38	66	
TOTAL TAXA / STATION							2
TOTAL ABUNDANCE / STATION							20

MAMALA BAY STUDY STATION S2

Mamala Bay Study / STATION	S2 - 8/94	S2 - 8/94	S2 - 8/94	S2 - 8/94	S2 - 8/94	S2 - 8/94	
TAXA / REPLICATE	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**TOTAL**
COPEPODA	2	2		1			5
OSTRACODA - MYODOCOPIDA							
Myodocope sp. A.			1		1		2
OSTRACODA - PODOCOPIDA							
Bairdia kauaiensis	1						1
TANAIDACEA							
Leptochelia dubia	8	3	18	1		6	3[illegible]
Leptochelia sp. A.			1				1
Tanaissus sp. A.		1	1				2
ISOPODA							
Apanthura inornata						2	2
AMPHIPODA - CAPRELLIDEA							
Metaprotella sandalensis			2				2
AMPHIPODA - GAMMARIDEA							
Amphilochidae sp. A.			1				1
Ericthonius brasiliensis		3					3
Eriopisella sechellensis	3		17	8		8	3[illegible]
Konatopus paao			4	3			[illegible]
Paraphoxus sp. A.		1				1	2
Photis kapapa			3	1			4
TOTAL TAXA / REP. SAMPLE	4	5	9	5	1	4	
ABUNDANCE / REP. SAMPLE	14	10	48	14	1	17	
TOTAL TAXA / STATION							1[illegible]
TOTAL ABUNDANCE / STATION							10[illegible]

MAMALA BAY STUDY STATION S3

Mamala Bay Study / STATION	S3 - 2/94	S3 - 2/94	S3 - 2/94	S3 - 2/94	S3 - 2/94	S3 - 2/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	R6	**TOTAL**
COPEPODA	1	2	1	1			5
OSTRACODA - PODOCOPIDA							
Bairdia kauaiensis	4		4		2		10
TANAIDACEA							
Leptochelia dubia		1	5	9	18	2	35
ISOPODA							
Apanthura inornata				1			1
Metacirolana sp. A.				1			1
Munna acarina				1			1
AMPHIPODA - CAPRELLIDEA							
Caprella cf *subtilis*					1		1
AMPHIPODA - GAMMARIDEA							
Bemlos macromanus					3		3
Elasmopus piikoi					4		4
Ericthonius brasiliensis		2		3			5
Eriopisa laakona				1			1
Eriopisella sechellensis	1			5	6		12
Gammaropsis atlantica					3		3
Konatopus paao			1				1
TOTAL TAXA / REP. SAMPLE	3	3	4	8	7	1	
ABUNDANCE / REP. SAMPLE	6	5	11	22	37	2	
TOTAL TAXA / STATION							14
TOTAL ABUNDANCE / STATION							83

MAMALA BAY STUDY STATION S3

Mamala Bay Study / STATION	S3 - 8/94	S3 - 8/94	S3 - 8/94	S3 - 8/94	S3 - 8/94	S3 - 8/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	R6	TOTAL
COPEPODA	2	15	3		4	8	32
OSTRACODA - MYODOCOPIDA							
Sarsiella janiceae					1		1
OSTRACODA - PODOCOPIDA							
Bairdia kauaiensis		3	2		1	3	9
TANAIDACEA							
Leptochelia dubia	12	12	22		8	27	81
ISOPODA							
Apanthura inornata			2				2
AMPHIPODA - GAMMARIDEA							
Bemlos macromanus				1			1
Eriopisella sechellensis	3	8	23		8	5	47
Konatopus paao			2		1	2	5
Paraphoxus sp. A.				2	1		3
Photis kapapa	2					1	3
DECAPODA - NATANTIA							
Ogyrides sp. A		1					1
TOTAL TAXA / REP. SAMPLE	4	5	6	2	7	6	
ABUNDANCE / REP. SAMPLE	19	39	54	3	24	46	
TOTAL TAXA / STATION							11
TOTAL ABUNDANCE / STATION							185

MAMALA BAY STUDY STATION S4

Mamala Bay Study / STATION	S4 - 2/94	S4 - 2/94	S4 - 2/94	S4 - 2/94	S4 - 2/94	S4 - 2/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	R6	TOTAL
COPEPODA	5	2		8	7		22
OSTRACODA - MYODOCOPIDA							
Myodocope sp. A.				1			1
Myodocope sp. B.				1	1		2
OSTRACODA - PODOCOPIDA							
Bairdia hanaumaensis				1	3	4	8
Bairdia kauaiensis		4	3	2	3	2	14
Mutilus cf. *oahuensis*	1						1
TANAIDACEA							
Leptochelia dubia	1	2		3	1		7
ISOPODA							
Cryptoniscus form				1			1
Metacirolana sp. A.					1		1
Munna acarina							0
AMPHIPODA - CAPRELLIDEA							
Caprella cf *subtilis*					2		2
AMPHIPODA - GAMMARIDEA							
Bemlos macromanus					1		1
Ericthonius brasiliensis	4	8	1	6	16		35
Eriopisella sechellensis	3	3	1	2	7		16
Paraphoxus sp. A.	2	1		14			17
TOTAL TAXA / REP. SAMPLE	6	6	3	10	10	2	
ABUNDANCE / REP. SAMPLE	16	20	5	39	42	6	
TOTAL TAXA / STATION							15
TOTAL ABUNDANCE / STATION							128

MAMALA BAY STUDY STATION S4

Mamala Bay Study / STATION	S4 - 8/94	S4 - 8/94	S4 - 8/94	S4 - 8/94	S4 - 8/94	S4 - 8/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	R6	TOTAL
COPEPODA	3	2	4			5	14
OSTRACODA - MYODOCOPIDA							
Myodocope sp. B.			2				2
OSTRACODA - PODOCOPIDA							
Bairdia hanaumaensis		1	8			1	10
Bairdia kauaiensis			1			4	5
Mutilus cf. *oahuensis*			1				1
TANAIDACEA							
Leptochelia dubia			4			36	40
ISOPODA							
Metacirolana sp. A.			1				1
AMPHIPODA - GAMMARIDEA							
Amphilochidae sp. A.				1			1
Ericthonius brasiliensis		1	83	7	8	9	108
Eriopisella sechellensis	3	2	2	2		9	18
Gammaropsis atlantica			1				1
Leucothoe hyhelia			2				2
Paraphoxus sp. A.	4	5	8	3	7	1	28
Paraphoxus sp. B		1	2				3
DECAPODA - NATANTIA							
Ogyrides sp. A					1		1
TOTAL TAXA / REP. SAMPLE	3	6	13	4	3	7	
ABUNDANCE / REP. SAMPLE	10	12	119	13	16	65	
TOTAL TAXA / STATION							15
TOTAL ABUNDANCE / STATION							235

Mamala Bay Study / STATION	S5 - 2/94	S5 - 2/94	S5 - 2/94	S5 - 2/94	S5 - 2/94	S5 - 2/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	R6	TOTAL
COPEPODA	17	1	2	11	2	8	41
OSTRACODA - MYODOCOPIDA							
Myodocope sp. A.	1		1				2
Myodocope sp. B.					1		1
Sarsiella janiceae	1						1
OSTRACODA - PODOCOPIDA							
Bairdia hanaumaensis				1			1
TANAIDACEA							
Leptochelia dubia	22	1	51	1	1	3	79
Leptochelia sp. A.	2		1				3
Tanaissus sp. A.	7		7	2		1	17
AMPHIPODA - GAMMARIDEA							
Bemlos macromanus	2						2
Eriopisella sechellensis	4	4	16	14	7	4	49
Gammaropsis atlantica	2						2
Konatopus paao	9	1	5	2		1	18
Paraphoxus sp. A.	2		11	2	6		21
Paraphoxus sp. B			1		1		2
Photis kapapa					2		2
DECAPODA - NATANTIA							
Processa hawaiiensis			1				1
TOTAL TAXA / REP. SAMPLE	11	4	10	7	7	5	
ABUNDANCE / REP. SAMPLE	69	7	96	33	20	17	
TOTAL TAXA / STATION							16
TOTAL ABUNDANCE / STATION							242

Mamala Bay Study / STATION	S5 - 8/94	S5 - 8/94	S5 - 8/94	S5 - 8/94	S5 - 8/94	S5 - 8/94	
TAXA / REPLICATE	R1	R2	R3	R4	R5	R6	TOTAL
COPEPODA	3	9			4	1	17
OSTRACODA - MYODOCOPIDA							
Myodocope sp. C.				1			1
OSTRACODA - PODOCOPIDA							
Bairdia kauaiensis				1			1
TANAIDACEA							
Leptochelia dubia	5	4		5			14
Tanaissus sp. A.	4	1					5
ISOPODA							
Hyssuridae sp. A.	1	1					2
AMPHIPODA - GAMMARIDEA							
Bemlos macromanus				1			1
Ceradocus hawaiiensis	2						2
Eriopisella sechellensis	2	1	2				5
Gammaropsis atlantica		1					1
Maera cf. *hamigera*	1						1
Paraphoxus sp. A.	13	5		1			19
Paraphoxus sp. B		1					1
DECAPODA - NATANTIA							
Process aequimana				2			2
TOTAL TAXA / REP. SAMPLE	8	8	1	6	1	1	
ABUNDANCE / REP. SAMPLE	31	23	2	11	4	1	
TOTAL TAXA / STATION							14
TOTAL ABUNDANCE / STATION							72

MAMALA BAY STUDY STATION S6

Mamala Bay Study / STATION TAXA / REPLICATE	S6 - 2/94 R1	S6 - 2/94 R2	S6 - 2/94 R3	S6 - 2/94 R4	S6 - 2/94 R5	S6 - 2/94 R6	TOTAL
COPEPODA	2		2	7	7		18
OSTRACODA - MYODOCOPIDA							
Myodocope sp. B.						1	1
Myodocope sp. C.				1			1
OSTRACODA - PODOCOPIDA							
Bairdia kauaiensis			2	1			3
CUMACEA				1			1
TANAIDACEA							
Leptochelia dubia	5	7	2	8	13		35
Leptochelia sp. A.		1		1			2
Tanaissus sp. A.				1			1
ISOPODA							
Apanthura inornata						1	1
Pleurocope sp. A.				1			1
AMPHIPODA - CAPRELLIDEA							
Caprella cf *subtilis*					1		1
AMPHIPODA - GAMMARIDEA							
Amphilochidae sp. A.				2			2
Ericthonius brasiliensis				16			16
Eriopisella sechellensis	5	3			2	2	12
Konatopus paao		3			2		5
Photis kapapa			1	2	1		4
DECAPODA - NATANTIA							
Ambidexter sp. A.					1		1
Process aequimana		1					1
TOTAL TAXA / REP. SAMPLE	3	5	4	11	7	3	
ABUNDANCE / REP. SAMPLE	12	15	7	41	27	4	
TOTAL TAXA / STATION							18
TOTAL ABUNDANCE / STATION							106

MAMALA BAY STUDY STATION S6

Mamala Bay Study / STATION TAXA / REPLICATE	S6 - 8/94 R1	S6 - 8/94 R2	S6 - 8/94 R3	S6 - 8/94 R4	S6 - 8/94 R5	S6 - 8/94 R6	TOTAL
COPEPODA	10	38	3			2	5
OSTRACODA - PODOCOPIDA							
Bairdia kauaiensis		5					
TANAIDACEA							
Leptochelia dubia	10	55					6
Leptochelia sp. A.		1					
ISOPODA							
Hyssuridae sp. A.		1					
AMPHIPODA - GAMMARIDEA							
Amphilochidae sp. A.		6					
Atylus nani		1					
Ericthonius brasiliensis		65					6
Eriopisella sechellensis	10	16	4	2	1		3
DECAPODA - NATANTIA							
Leptochela hawaiiensis						1	
Ogyrides sp. A			2	3		1	
TOTAL TAXA / REP. SAMPLE	3	9	3	2	1	3	
ABUNDANCE / REP. SAMPLE	30	188	9	5	1	4	
TOTAL TAXA / STATION							1
TOTAL ABUNDANCE / STATION							23

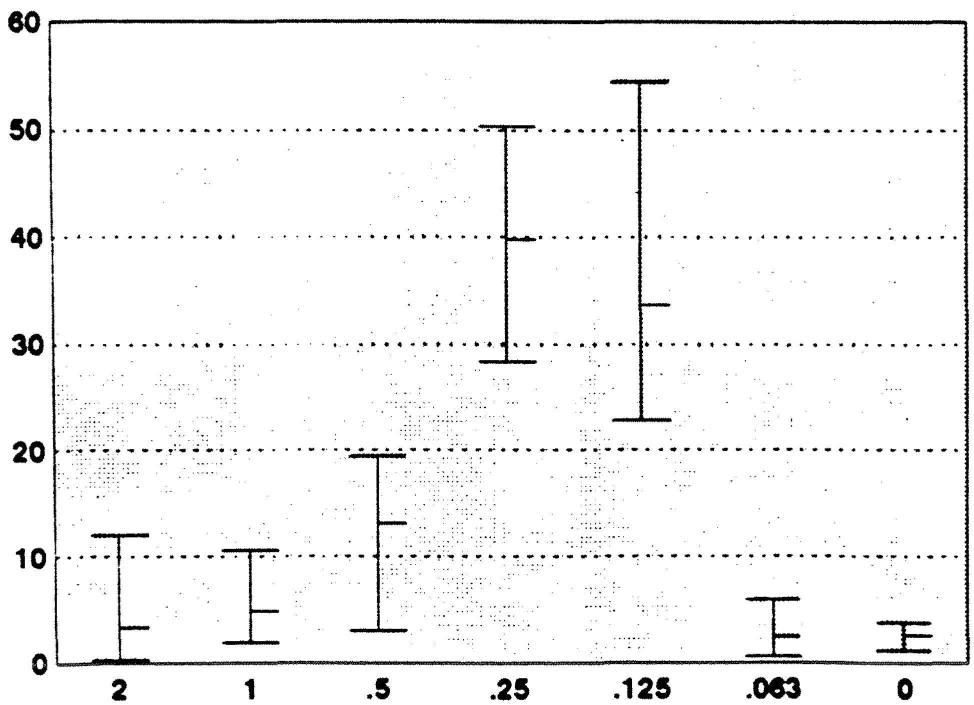
APPENDIX 5 SEDIMENT GRAIN SIZE COMPOSITION

SEDIMENT CALCULATIONS

GRAIN SIZE	STA:	B3	
	MONTH:	MAY	
	YEAR:	1994	

Phi	mm	#	R1	R2	R3	R4	R5	AVG
-2--1	2	10	12.1	1.2	2	0.9	0.3	3.3
-1-0	1	18	10.6	3.7	4.6	3.6	1.9	4.88
0-1	.5	35	17.5	3	19.5	18.9	6.9	13.16
1-2	.25	60	28.9	50.3	46	45.7	28.3	39.84
2-3	.125	120	22.9	40	24.7	26.5	54.5	33.72
3-4	.063	230	4.2	0.6	1.2	0.6	6	2.52
4-5	<.063	PAN	3.8	1.2	2	3.8	2.1	2.58
			100	100	100	100	100	100
		% MUD	3.8	1.2	2	3.8	2.1	
		% SAND	96.2	98.8	98	96.2	97.9	

MAMALA BAY PROJECT
SEDIMENT GRAIN SIZE ANALYSIS- B3 MAY 94



APPENDIX 6.1 CHN ANALYSES

CHN Protocol

Combust for 4 hours at 600^{o}C:
- aluminum foil drying boats (~4 x 4cm)
- aluminum foil weigh boats (4 x 12 x 4mm)
- glass storage vials
- aluminum foil covers for storage vials
- aluminum wrappers (~3 x 4cm)

Dry sediment overnight at 60^{o}C
Grind into fine powder and store in glass vials

Weigh out between 19.000-20.000 mg into weigh boats, record weight
Successive sulfurous acid trials until no more bubbling observed
- wet first with drop of distilled water
- dry at 60^{o}C between trials

Dry overnight at 60^{o}C

Using forceps, place weigh boat on aluminum foil wrapper
Crimp weigh boat shut (be careful not to spill)
Roll wrapper around weigh boat
Crimp wrapper ends in towards center
Fold rolled, crimped wrapper in half
Compress into small pellet
Place in labeled petri dish

Fold four empty weigh boats for blanks
Fold eight Acetanilide standards (0.100-4.000 mg)

Run machine (Perkin-Elmer Elemental CHN Analyzer Model 2400)

Record N signals with average blank values subtracted
Run a regression for standards and calculate mg N/g dry weight.

APPENDIX 6.2 NITROGEN VALUES FOR ALL REPLICATED SAMPLES

SAMPLE	SITE	DATE RUN	Wt (mg)	N signal	Blk	mg N / g dry wt
1A	DHS1 8/94	4/10/95	19.856	136	52	0.629
1B	DHS1 8/94	4/10/95	19.003	135	51	0.647
1C	DHS1 8/94	4/10/95	19.995	134	50	0.604
2A	DHS2 8/94	4/10/95	19.230	132	48	0.607
2B	DHS2 8/94	4/10/95	19.234	131	47	0.596
2C	DHS2 8/94	4/10/95	19.017	131	47	0.602
3A	DHS3 8/94	4/10/95	19.413	134	50	0.622
3B	DHS3 8/94	4/10/95	19.910	132	48	0.586
3C	DHS3 8/94	4/10/95	19.579	130	46	0.575
4A	DHS4 8/94	4/10/95	19.401	127	43	0.548
4B	DHS4 8/94	4/10/95	19.422	129	45	0.569
4C	DHS4 8/94	4/10/95	19.295	129	45	0.572
5A	DHS5 8/94	4/10/95	19.891	130	46	0.566
5B	DHS5 8/94	4/10/95	19.669	131	47	0.583
5C	DHS5 8/94	4/10/95	19.910	130	46	0.565
6A	DHS6 8/94	4/10/95	19.561	138	54	0.660
6B	DHS6 8/94	4/10/95	19.754	138	54	0.653
6C	DHS6 8/94	4/10/95	19.895	143	59	0.701
7A	S3R1 8/94	4/10/95	19.291	133	49	0.615
7B	S3R1 8/94	4/10/95	19.056	137	53	0.666
7C	S3R1 8/94	4/10/95	19.953	133	49	0.595
8A	S3R2 8/94	4/10/95	19.448	140	56	0.685
8B	S3R2 8/94	4/10/95	19.435	141	57	0.696
8C	S3R2 8/94	4/10/95	19.658	137	53	0.646
9A	S3R3 8/94	4/10/95	19.933	133	49	0.596
9B	S3R3 8/94	4/10/95	19.803	135	51	0.620
9C	S3R3 8/94	4/10/95	19.335	136	52	0.646
10A	S3R4 8/94	4/24/95	19.811	176	44	0.667
10B	S3R4 8/94	4/24/95	19.016	196	64	0.911
10C	S3R4 8/94	4/24/95	19.068	181	49	0.747
11A	S3R5 8/94	4/24/95	19.032	171	39	0.631
11B	S3R5 8/94	4/24/95	19.037	209	77	1.050
11C	S3R5 8/94	4/24/95	19.761	169	37	0.595
12A	S3R6 8/94	4/24/95	19.488	162	30	0.527
12B	S3R6 8/94	4/24/95	19.599	177	45	0.684
12C	S3R6 8/94	4/24/95	19.634	171	39	0.620
13A	S3R1 2/94	4/24/95	19.208	192	60	0.859
13B	S3R1 2/94	4/24/95	19.001	163	31	0.554
13C	S3R1 2/94	4/24/95	19.772	169	37	0.595
14A	S3R2 2/94	4/24/95	19.828	217	85	1.091
14B	S3R2 2/94	4/24/95	19.831	167	35	0.573
14C	S3R2 2/94	4/24/95	19.428	180	48	0.722
15A	S3R3 2/94	4/24/95	19.846	177	45	0.676
15B	S3R3 2/94	4/24/95	19.710	164	32	0.545
15C	S3R3 2/94	4/24/95	19.952	169	37	0.590
16A	S3R4 2/94	4/24/95	19.964	163	31	0.528
16B	S3R4 2/94	4/24/95	19.113	168	36	0.605
16C	S3R4 2/94	4/24/95	19.423	180	48	0.722
17A	S3R5 2/94	4/24/95	19.153	162	30	0.539
17B	S3R5 2/94	4/24/95	19.622	168	36	0.589
17C	S3R5 2/94	4/24/95	19.560	156	24	0.465
18A	S3R6 2/94	4/24/95	19.757	159	27	0.492
18B	S3R6 2/94	4/24/95	19.988	161	29	0.506
18C	S3R6 2/94	4/24/95	19.862	157	25	0.468
19A	DHS1 2/94	4/24/95	19.333	171	39	0.630
19B	DHS1 2/94	4/24/95	19.602	165	33	0.558
19C	DHS1 2/94	4/24/95	19.880	160	28	0.499
20A	DHS2 2/94	4/24/95	19.695	167	35	0.577
20B	DHS2 2/94	4/24/95	19.846	154	22	0.438

SAMPLE	SITE	DATE RUN	Wt (mg)	N signal	Blk	mg N / g dry wt
20C	DHS2 2/94	4/24/95	19.962	159	27	0.486
21A	DHS3 2/94	4/24/95	19.751	154	22	0.440
21B	DHS3 2/94	4/24/95	19.856	149	17	0.386
21C	DHS3 2/94	4/24/95	19.072	145	13	0.358
22A	DHS5 2/94	4/24/95	19.997	143	11	0.321
22B	DHS5 2/94	4/24/95	19.593	148	16	0.380
22C	DHS5 2/94	4/24/95	19.467	145	13	0.351
23A	DHS6 2/94	4/24/95	19.296	148	16	0.386
23B	DHS6 2/94	4/24/95	19.529	145	13	0.350
23C	DHS6 2/94	4/24/95	19.212	158	26	0.495
24A	DHR1 2/94	4/24/95	19.603	142	10	0.317
24B	DHR1 2/94	4/24/95	19.379	226	94	1.212
24C	DHR1 2/94	4/24/95	19.722	144	12	0.336
25A	DHR3 2/94	4/24/95	19.441	148	16	0.383
25B	DHR3 2/94	4/24/95	19.840	152	20	0.417
25C	DHR3 2/94	4/24/95	19.488	146	14	0.361
26A	DHR3 2/94	4/24/95	19.133	145	13	0.368
26B	DHR3 2/94	4/24/95	19.784	146	14	0.356
26C	DHR3 2/94	4/24/95	19.774	141	9	0.304
27A	DHR4 2/94	4/24/95	19.682	148	16	0.378
27B	DHR4 2/94	4/24/95	19.682	148	16	0.378
27C	DHR4 2/94	4/24/95	19.591	142	10	0.317
28A	DHR5 2/94	5/11/95	19.180	145	18	0.371
28B	DHR5 2/94	5/11/95	19.249	141	14	0.327
28C	DHR5 2/94	5/11/95	19.834	142	15	0.328
29A	B3R1 2/94	5/11/95	19.708	148	21	0.393
29B	B3R1 2/94	5/11/95	19.477	145	18	0.366
29C	B3R1 2/94	5/11/95	19.944	145	18	0.570
30A	B3R2 2/94	5/11/95	19.994	145	18	0.356
30B	B3R2 2/94	5/11/95	19.422	147	20	0.388
30C	B3R2 2/94	5/11/95	19.212	145	18	0.371
31A	B3R3 2/94	5/11/95	19.257	153	26	0.456
31B	B3R3 2/94	5/11/95	19.695	142	15	0.330
31C	B3R3 2/94	5/11/95	19.933	157	30	0.482
32A	B3R4 2/94	5/11/95	19.604	150	23	0.416
32B	B3R4 2/94	5/11/95	19.156	160	33	0.534
32C	B3R4 2/94	5/11/95	19.488	152	25	0.440
33A	B3R5 2/94	5/11/95	19.047	169	42	0.635
33B	B3R5 2/94	5/11/95	19.607	170	43	0.628
33C	B3R5 2/94	5/11/95	19.477	170	43	0.632
34A	DHR1 8/94	5/11/95	Didn't drop			
34B	DHR1 8/94	5/11/95	19.315	224	97	1.217
34C	DHR1 8/94	5/11/95	19.653	174	47	0.668
35A	DHR2 8/94	5/11/95	19.810	177	50	0.694
35B	DHR2 8/94	5/11/95	19.581	174	47	0.671
35C	DHR2 8/94	5/11/95	19.195	177	50	0.717
36A	DHR3 8/94	5/11/95	19.020	177	50	0.723
36B	DHR3 8/94	5/11/95	19.020	179	52	0.745
36C	DHR3 8/94	5/11/95	19.812	179	52	0.715
37A	DHR4 8/94	5/11/95	19.491	179	52	0.727
37B	DHR4 8/94	5/11/95	19.552	183	56	0.767
37C	DHR4 8/94	5/11/95	19.121	177	50	0.719
38A	DHR5 8/94	5/11/95	19.063	178	51	0.732
38B	DHR5 8/94	5/11/95	19.119	179	52	0.741
38C	DHR5 8/94	5/11/95	19.722	190	63	0.834
14D	S3R2 2/94	5/11/95	19.420	145	18	0.367
14E	S3R2 2/94	5/11/95	19.421	144	17	0.560
14F	S3R2 2/94	5/11/95	19.422	150	23	0.420
27A	DHR4 2/94	5/11/95	19.608	144	17	0.353
27B	DHR4 2/94	5/11/95	19.781	143	16	0.339
27C	DHR4 2/94	5/11/95	19.407	143	16	0.346

SAMPLE	SITE	DATE RUN	Wt (mg)	N signal	Blk	mg N / g dry wt
K1A	Khi1 4/95	5/11/95	19.425	266	139	1.658
K1B	Khi1 4/95	5/11/95	19.542	266	139	1.648
K1C	Khi1 4/95	5/11/95	19.907	271	144	1.670
K2A	Khi2 4/95	5/11/95	19.225	251	124	1.514
K2B	Khi2 4/95	5/11/95	19.557	254	127	1.520
K2C	Khi2 4/95	5/11/95	19.559	255	128	1.530
K3A	Khi3 4/95	5/11/95	19.998	160	33	0.512
K3B	Khi3 4/95	5/11/95	19.858	157	30	0.484
K3C	Khi3 4/95	5/11/95	19.442	171	44	0.644