AN ASSESSMENT OF HUMAN IMPACTS ON BENTHIC INVERTEBRATE COMMUNITIES, WITH AN EMPHASIS ON POLYCHAETES

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ABSTRACT

Various human activities such as trampling through shallow waters and organic enrichment can alter benthic invertebrate communities. To examine the impact of human activities to shallow-water invertebrate communities on Oahu's south shore, sediment samples were collected from depths of 0.1 m, 1.0 m, and 3.0 m, from an area frequently perturbed by humans, and an area that experiences little or no human activity. Multiple samples were collected from six stations, and all invertebrates were identified and preserved in ethanol. The members of the class Polychaeta were identified to family, and grouped in guilds based on motility and trophic categories. Overall, the stations that experience human perturbation displayed less taxa abundance, were predominantly composed of nematodes (an indicator of organic enrichment), and had very few amphipods (a crustacean sensitive to disturbance). The polychaete communities at stations frequently visited by humans were dominated by detritivores, and contained low numbers of suspension-feeding and tubicolous individuals and families, indicating perturbation. In contrast, the stations that experience little or no human activities yielded higher taxa abundance, high individual tallies, were composed mostly of amphipods, and displayed higher percentages of suspension-feeding and tubicolous polychaetes. Since the grain size of each sample site was the only physical parameter taken into consideration, a more thorough study must be performed to conclusively tie human activities to alterations in benthic invertebrate communities.

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Introduction

The shallow reef-flats of Oahu's southern shore support a very large and diverse invertebrate community (Bailey-Brock, 1979). Using Magic Island beach (a popular beach park in Honolulu) as a study site, this study will investigate the impacts of human activity on shallow-water organisms, with an emphasis on polychaete communities. Processes such as trampling by bathers through shallow waters and organic pollution can dramatically alter the composition of benthic macrofauna. The invertebrate community of Magic Island beach will be compared to an invertebrate community (with presumably similar physical characteristics) that experiences little or no human perturbations. I hypothesize that the invertebrate community that is frequently visited by humans will display less taxa richness, contain species that indicate organic enrichment, and lack species that are sensitive to habitat disturbance.

An Overview of the of Hawaii's Invertebrates

Many different invertebrates live in the intertidal zone of Hawaii, performing various ecological roles in the coastal ecosystem. Some invertebrates are very resilient to environmental change, whereas other species are sensitive to alterations. Either way, the coastal invertebrate population has changed in the course of human activity.

When examining a benthic macrofaunal community, several species may be targeted as "indicators," when a certain species is found in high abundance when compared to another. If indicators are present, this may signify the overall health of a community. For example, a diverse amphipod community is associated with unpolluted and less disturbed habitats when found in high abundance. Therefore, a decline in the amphipod to polychaete ratio can indicate anthropogenic pollution (Nikitik and Robinson, 2003). The phylum Nematoda and the polychaete, *Capitella capitata* are associated with organic enrichment when found in high abundance. A high nematode to copepod ratio is a strong indicator of organic pollution (Shiells and Anderson, 1985).

The Class Polychaeta

Of the approximately 9,000 species of annelids, more than 8,000 are polychaetes (Rouse and Pleijel, 2001). They are an ecologically diverse group containing predators, scavengers, deposit feeders, and suspension feeders. Along with different feeding strategies, these worms possess different degrees of mobility, ranging from active predators to tube-builders that trap food particles with mucus or specialized structures (Meksumpun and Meksumpun, 1999). Polychaetes usually have a well-developed head, with eyes, antennae, and sensory palps. They have peritoneal gonads that may be visible as swellings during the breeding season, and their gametes exit from the coelom when they spawn.

Polychaetes play essential ecological roles, serving on one hand as predators of small invertebrates, and on the other as food for fish and large invertebrates (Martin et al., 2000). Polychaetes also play a vital role in the coastal process of bioturbation. Through activities such as digging burrows, ingesting materials, and shuffling along the soft bottom, polychaetes help to oxygenate sediments, enhance organic decomposition, and distribute nutrients in the habitat (Sherman and Coull, 1980).

Human Impacts to Shallow Coastal Waters

Oahu’s southern beaches are world renowned for their beauty, and attract visitors from all over the world. However, with thousands of beach-goers tromping through the shallow coastal waters, invertebrate communities can be harmed in multiple ways. For example, the work of Boucot (1981) examines the compaction of sediments by large mammals, and the damaging affects to bioturbators. The compression of mudflats or other soft-bottom environments can lead to decreases in tube-dwelling invertebrates and larval survival. Trampling through the shallow waters also stirs up motile invertebrates, which can remain suspended in the water column and are easily preyed upon by small fish (Bailey-Brock et al., 2003). Together, the frequent trampling and disturbance of shallow-water habitats can greatly alter invertebrate communities.

Another affect humans have on invertebrate communities can occur through organic pollution. Limiting nutrients such as phosphorus and nitrogen from fertilizers can be transported to coastal waters via runoff. As organic enrichment of coastal waters increases, benthic communities commonly experience a shift in composition, wherein the percentage of suspension-feeders declines and the percentage of detritivores increases (Widdicombe and Austin, 2001). Organic pollution can severely alter the invertebrate composition of an ecosystem, and continued enrichment can lead to eutrophication, wherein the community collapses (Probert, 1984). Indicator species of organic pollution have been discussed above.

A Description of Magic Island

Magic Island beach is at the end of a man-made peninsula on the southern shore of Oahu. It was created in late 1950s by reclaiming 30 acres of shallow reef, and was originally intended to serve as grounds for an amusement park (Clark, 1977). Today, it is one of the largest recreational parks in Honolulu. The beach area is approximately 300 meters long, and the interior pool slopes to depths of 4 meters. Five retaining walls protect the sand from being eroded by strong summer swells, thereby creating a calm lagoon. Due to its gentle water conditions, Magic Island beach serves as a popular swimming and bathing spot for many beach-goers. On weekends, the small beach can experience up to 500 beach-goers walking through its waters each day (Goldsberry et al., 2002). In contrast, the conditions outside Magic Island's protected lagoon experience much more wave activity, and much less human turbulence. The western retaining wall forms a cliff embankment, and is only occasionally perturbed by surfers.

Methods

The aim of this experiment is to compare invertebrate communities from an area of high human activity to an area that experiences little or no human perturbations. Since this research only examines the benthic macrofauna community and the grain size at each sample station, it is important to note that other physical parameters such as wave activity and water chemistry, salinity, and temperature are not addressed, and could alter invertebrate communities. These physical parameters are disregarded for this research project, but should be examined to gain more conclusive findings sometime in the future.

Stations

In order to compare polychaete (as well as overall invertebrate) community compositions in areas of high human activity with areas of little or no human activity, multiple sediment samples were collected from various places inside and outside the cove of Magic Island (Figure 1). Stations #5, #1, and #2 (with depths of 0.1 m, 1.0 m and 3.0 m, respectively) are inside the cove, which serves as a popular swimming and bathing area for many beach-goers. Similarly, Stations #6, #3, and #4 (with depths of 0.1 m, 1.0 m, and 3.0 m, respectively) are outside the cove, and experience very little human activity, as well as natural tidal and wave activity. Samples were collected from Stations

#1 through #4 on October 7th and December 3rd, 2003. 0n February 5th, 2004, two replicate samples were collected from the same stations again. To examine invertebrate communities of even shallower waters, Stations #5 and #6 were added, and two replicates of each were collected on February 5th as well. All together, twenty samples from sixstations were collected from the waters of Magic Island between October of 2003 and February of 2004. Figure 1 displays an aerial view of Magic Island, with major features of all six sample locations labeled.

Figure 1: An aerial view of Magic Island with all six sample stations and major features labeled.

Collection and Elutriation

All sediment samples were collected by hand while wading in shallow water or free-diving. Containers 7.6 cm in diameter were used to collect between 400- and 600-cm^3 of surface sediment from each site. All samples were immediately preserved in calciumbuffered 10% formalin and dyed with Rose Bengal. Also at each station, approximately 100 cm^3 of sediment was collected and refrigerated for an analysis of grain size composition, also known as the process of granulometry. After samples were preserved and dyed for 24 hours or more, the sediments were elutriated at the University of Hawaii Bilger Hall. During the process of elutriation, samples were washed with water multiple times and pored through a 0.50-mm mesh sieve. All invertebrates retained on the sieve were stored in 70% ethanol.

Sorting and Identification

Using dissecting microscopes, all invertebrates were separated from the remaining sediment and stored in vials of ethanol. Afterwards, general invertebrate identifications were performed, wherein the invertebrates were divided into their lowest taxonomic level. Some invertebrates were only identified to phylum, such as Platyhelminthes, Nematoda, and Nemertea. Other phyla were separated further to class, such as Echinodermata (classes Echinoidea and Holothuroidea) and Mollusca (class Bivalvia). The class Crustacea (phylum Arthropoda) was further divided to order, such as amphipods, copepods, and isopods. Finally, the phylum Annelida was separated into classes (Oligochaeta and Polychaeta), and polychaetes were further divided into a number of families. In order to properly identify some oligochaetes and the families of polychaetes, specimens were mounted on slides in glycerol and examined with compound microscopes. All identifications were performed in Dr. Julie Bailey-Brock's wormlab located at the University of Hawaii Edmondson Hall. Polychaete identifications were performed using several dichotomy keys, particularly Day (1967). Identification checks were performed by wormlab researchers.

Granulometry

In order to compare grain sizes from each sample site, 30- to 50-cm^3 of sediment was filtered through six mesh sieves of decreasing sizes (2-mm, 1-mm, 0.50-mm, 0.25-mm, 0.125-mm, and 0.063, respectively). Approximately 5 liters of water was run through the sieves, and then 500-mL of the water was funneled through a Whatman filter (with a pore size of 7 microns) to determine the particulate volume (slurry volume). The six sieves and filter were placed in a large oven and kept consistently at 80° C for 24-30 hours. Afterwards, the sediments from each sieve were weighed and recorded.

Data Entry

All data collected were entered and examined using Microsoft Excel. Invertebrate totals were tallied, and overall abundance and taxa richness were compared. The most abundant polychaete families from each station were listed. In order to study the polychaete community composition more closely from an ecological aspect, the families were categorized based on their feeding and motility modes as adapted from Fauchald and Jumars (1979), and as used in Swartz et al. (2003). Four basic feeding methods were defined: detrivores, omnivores, carnivores, and suspension-feeders, and three motility methods: motile, discretely motile, and tubicolous. Polychaete communities were compared based on overall abundance, family richness, and trophic and motility categories.

Results

Invertebrate Composition

The invertebrates collected from the six stations included polychaetes, oligochaetes, nematodes, platyhelminths, echinoderms, anthozoans, hydrozoans, nemerteans, hemichordates, mollusks, sipunculans, a priapulid species, a pycnogonid species, amphipods, copepods, cumaceans, decapods, isopods, ostracods, and tanaids. From the stations, a grand total of 4,972 specimens were counted and identified representing 46 taxa. All invertebrates collected in each sample are presented in Table 1.

Of the specimens identified, the taxa of crustaceans (amphipods, copepods, cumaceans, decapods, isopods, ostracods, and tanaids all combined), nematodes, polychaetes, oligochaetes, and nemerteans comprise 98.7% of the all invertebrates sampled (yielding 45.6%, 25.7%, 24.2%, 2.5%, and 1.8%, respectively). Figure 2 depicts the invertebrate composition of all samples.

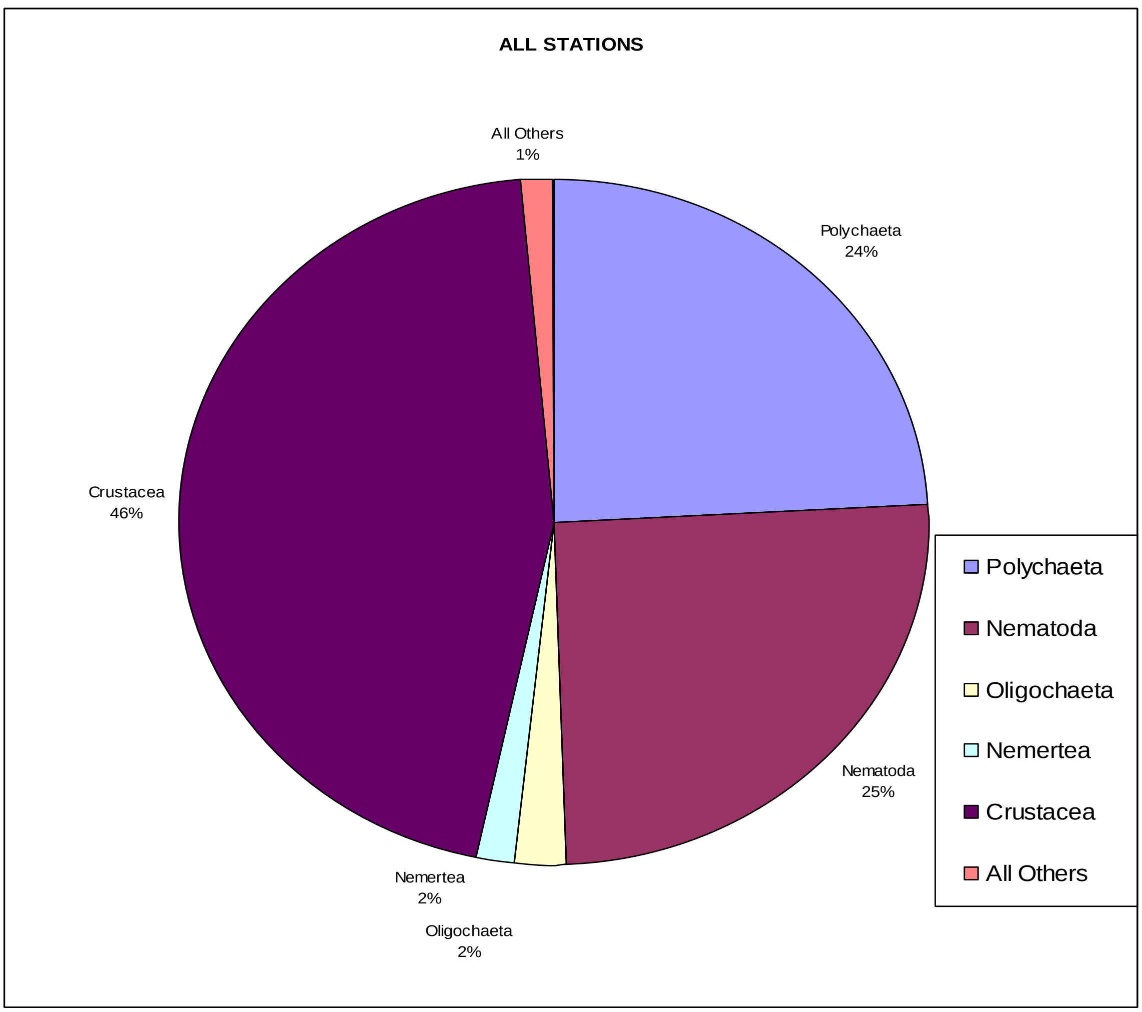

Figure 2: The percentages of major invertebrate taxa identified from all stations.

The sampled stations varied greatly in regards to total invertebrate abundance, composition, and taxa richness. Station #3 yielded the most taxa (36) and the most invertebrates (2,020 total, or an average of 505.0 per sample). Crustaceans were the dominant taxa at this station composing 77.1% of all invertebrates, followed by polychaetes (12.5%), nematodes (4.3%), oligochaetes (2.1%), and nemerteans (1.9%). Samples from Station #6 presented the second most taxa (26) and average abundance (306.5). It followed the same order as Station #3, being comprised of 46.5% crustaceans, 32.1% polychaetes, 17.3% nematodes, 2.4% oligochaetes, and 0.5 % nemerteans. Station #2 yielded 1,164 invertebrates (291.0 per sample) and 24 taxa (both the third highest), with a majority being nematodes (60.2%), followed by crustaceans (21.9%), polychaetes (12.5%), oligochaetes (3.3%), and nemerteans (0.8%). Station #5 had the next highest mean number of invertebrates (223.5), but the least taxa richness (12). It was comprised almost completely of polychaetes (89.7%), with some nematodes (8.3%), and crustaceans (1.1%). 505 invertebrates (average of 126.3) from 22 different taxa were collected from Station #1. It had a similar composition as Station #2, with 45.5% nematodes, 24.6% crustaceans, 23.8 % polychaetes, 4.0% nermerteans, and 1.6% oligochaetes. Finally, the least number of invertebrates (223, or 55.8 per sample) and second lowest taxa richness (18) were collected from Station #4, whereat nematodes composed 43.0%, followed by polychaetes (38.1%), nemerteans (7.6%), crustaceans (6.7%), and oligochaetes (3.6%). The invertebrate compositions of each station are presented in Figure 3.

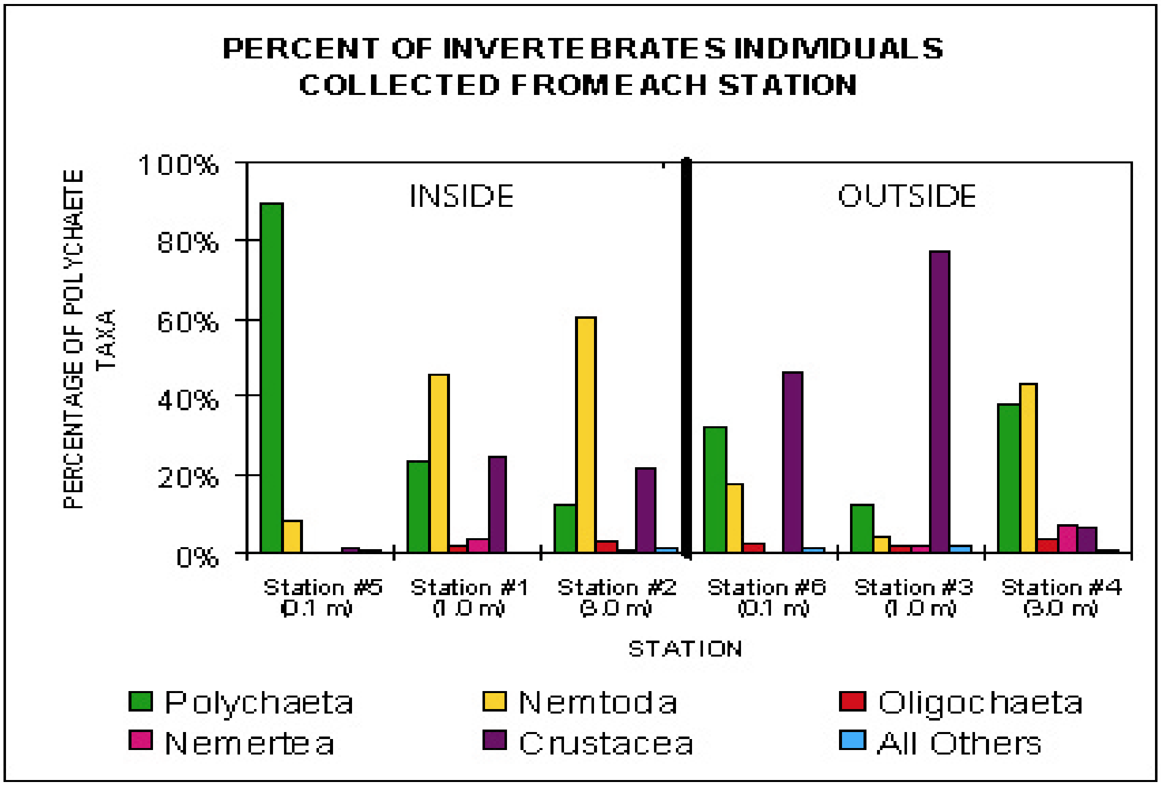

Figure 3: The percentages of most abundant taxa identified from each station.

Polychaete Composition

Table 2 depicts all the polychaetes collected from each station. A total of 1,201 polychaetes representing 25 different families were collected and identified. They comprised 24.2% of the total invertebrate abundance of all samples. The highest mean sample of polychaetes was Station #5 (200.5 individuals), followed in decreasing order of abundance by Station #6 (98.5 individuals), Station #3 (63.3 individuals), Station #2 (36.3 individuals), Station #1 (30.0 individuals), and Station #4 (21.3 individuals). The maximum number of families found occurred at Station #3 (with 17), followed in decreasing order by Station #6 (with 13), Stations #1 and #2 (both with 12), Station #4 (with 10), and Station #5 (with 5).

Six families represented 89.1% of the polychaete individuals collected from the Magic Island stations (Table 3). Overall, syllids were the most abundant family collected,

TABLE 3: DOMINANT POLYCHAETE SPECIES FOR EACH STATION							
Station	**Dominant Species**			**Trophic**	**Motility**		**Percentof Polycheates**
Station #1	1)	*Saccocirridae*		D	M		42.5
	2)	*Syllidae*		O	M		24.2
	3)	*Hesionidae*		C	M		10.0
Station #2	1)	*Oweniidae*		D	T		40.0
	2)	*Syllidae*		O	M		29.0
	3)	*Chaetopteridae*		S	T		13.1
Station #3	1)	*Syllidae*		O	M		56.1
	2)	*Spionidae*		D	DM		11.5
	3)	*Cirratulidae*		D	M		9.5
Station #4	1)	*Syllidae*		O	M		74.1
	2)	*Oweniidae*		D	T		8.2
	3)	*Hesionidae*		C	M		4.7
Station #5	1)	*Saccocirridae*		D	M		57.6
	2)	*Protodrilidae*		D	M		40.9
	3)	*Spionidae*		D	DM		1.0
Station #6	1)	*Protodrilidae*		D	M		41.6
	2)	*Syllidae*		O	M		27.4
	3)	*Oweniidae*		D	T		8.1
	3)	*Saccocirridae*		D	M		8.1
TOTALS for all stations	1)	*Syllidae*		O	M		27.6
	2)	*Saccocirridae*		D	M		25.5
	3)	*Protodrilidae*		D	M		20.6
	4)	*Oweniidae*		D	T		7.2
	5)	*Chaetopteridae*		S	T		4.1
	5)	*Spionidae*		D	DM		4.1

comprising 27.6% of all polychaetes identified, followed in decreasing order by saccocirrids (25.5%), protodrilids (20.6%), oweniids (7.2%), chaetopterids (4.1%), and Spionids (4.1%). The families Syllidae, Spionidae, and Cirratulidae were found at all stations.

The composition of the samples as a whole is misleading, in that none of the six stations display the values listed above. The dominant polychaete family varied greatly over the six stations. Syllids were the most abundant family at Stations #4 (74.1%) and #3 (56.1%), and among the most abundant families at Stations #2 (29.0%), #6 (27.4%), and #1 (24.2%). Saccocirridae was the most abundant at Stations #5 (57.6%) and #1 (42.5%), and among the most abundant at Station #6 (8.1%). Protodrilids composed a majority of polychaetes collected at Station #6 (41.6%), and the second most abundant at Station #5 (40.9%). Oweniids were the most abundant family at Station #2 (40.0%), and among the most at Stations #4 (8.2%) and #6 (8.1%). Chaetopterids were among the most abundant at Station #2 (13.1%), but rare or absent at all other stations. Spionids were found in all samples, but only found in high abundance at Stations #3 (11.5%) and #5 (1.0%). Finally, the families of Hesionidae (10.0% of Station #1 and 4.7 % of Station #4) and Cirratulidae (9.5% of Station #3) were among the most abundant at three stations, but rare or completely absent everywhere else. Table 3 displays the most dominant polychaete families per station and overall.

Polychaete Trophic categories

In order to further examine the polychaetes collected from each station, the families were divided into their respective trophic groups. The four polycheate trophic categories include detritivores, omnivores, carnivores, and suspension-feeders. A comparison of the percent of polychaete individuals in these four trophic groups is given for each station (Figure 4) Similarly, the percent of polychaete families from each trophic category is compared for each station (Figure 5).

Detritivores: Deposit-feeders were present at all stations, and the most dominant type of trophic category at four of the six, including Stations #5, #6, #1, and #2 (with 98.8%, 62.8%, 60.0%, and 55.9%, respectively). Composition percentages and individual abundance of detritivores were highest at Station #5 (98.8% of all polychaetes and 400 individuals) and lowest at Station #4 (12.9% and 11 individuals). The number of deposit-feeding families ranged from 10 (Station #3) to 3 (Station #4), and percentages of all polychaete families represented by detritivores ranged from 80.0% (Station #5) to 30.0% (Station #4). The most abundant deposit-feeders were the Saccocirridae, which listed as the most abundant family at Stations #5 (57.6% of polychaetes collected) and #2 (42.5%), as well as the third most abundant at Station #6 (8.1%). Other abundant detritivores included the families Protodrilidae (41.6% of Station #6 and 40.9% of Station #5), Oweniidae (40.0% of Station #2, 8.2% of Station #4, and 8.1% of Station #6), Spionidae (11.5% of Station #3 and 1.0% of Station #5), and Cirratulidae (9.5% of Station #3).

Omnivores: Omnivores were the most abundant trophic category at Stations #4 (74.1%) and #3 (56.5%), and the second most abundant at Stations #2, #6, #1, and #5 (29.7, 28.6%, 25.8%, and 0.2%, respectively). The abundance of omnivore individuals ranged from 143 (Station #3) to 1 (Station #5). At least one omnivore family was represented at each of the stations, and their percentage of all polychaete families ranged from 20.0% (Station #5) to 10.0% (Station #4). The only abundant omnivore family was

the Syllidae, which was one of the most abundant polychaete families at Stations #4 (74.1%), #3 (56.1%), #2 (29.0%), #6 (27.4%), and #1 (24.2%).

Carnivores: Carnivorous polychaetes were absent from Stations #2 and #1, and the lowest composition and abundance of polychaetes was at Stations #3 (2.0%, and 5 individuals), #4 (7.1%, and 6 individuals) and #6 (1.5%, and 3 individuals). Station #1 had the highest number of carnivores with 17 worms present (or 14.2% of polychaetes collected). Carnivore families per station ranged from none at Stations #2 and #1 to 3 (Stations #3 and #4), and the percent of family composition varied from none present to 30.0% (Station #4). Hesionids were the only carnivorous family listed among the most abundant (10.0% of Station #1 and 4.7% of Station #4).

Suspension: Suspension-feeding polychaetes were never the most abundant trophic category, and were absent from Stations #1 and #5. Where found, suspension-feeders ranged from 14.5% (Station #2) to 5.9% (Station #4) of all polychaetes. Of stations with suspension-feeders, totals were greatest at Station #3 with 23, and lowest at Station #4 with 5. Three suspension-feeding families were collected at Stations #4 and #2, comprising 25.0% and 30.0% of polychaetes collected respectively. Chaetopterids were the only family found in abundance of the trophic group, comprising 13.1% of Station #2.

Polychaete Motility Categories

In order to further examine the polychaetes collected from each station, the families were divided into their respective motility categories. The three polychaete motility methods include motile, tube-dwelling, and discretely motile. A comparison of the percent of polychaete individuals using these three motility methods is given for each station (Figure 6) Similarly, the percent of polychaete families in each motile category is compared for each station (Figure 7).

Motile: Motile polychaetes were the most abundant form of motility at Stations #5 (99.0% of all polychaetes), #1 (88.3%), #6 (83.2%), #4 (81.2%), and #3 (76.7%), and the second most abundant at Station #2 (42.8%). Total individuals ranged from 397 (Station #5) to 62 (Station #2). Station #3 contained the highest number of motile families with 11 (comprising 64.7% of total), and Stations #4 and #5 contained the lowest (each with 4 families represented). The dominant motile families included syllids (74.1% of Station #4, 56.1% of Station #3, 29.0% of Station #2, 27.4% of Station #6, 24.2% of Station #1), saccocirrids (57.6% of Station #5, 42.5% of Station #1, and 8.1% of Station #6), protodrilids (41.6% of Station #6 and 40.9% of Station #5), cirratulids (9.5% of Station #3), and hesionids (10.0% of Station #1 and 4.7% of Station #4).

Tubicolous: Tubicolous polychaetes were the most abundant form at Station #2, with 79 individuals comprising 54.7% of all polychaetes collected there. Only Station #5 lacked tube-builders. Of the stations with tubicolous polychaetes, individual values ranged from 79 (Station #2) to 2 (Station #1). Stations #2 and #4 each contained 4 families of tubicolous polychaetes, and the percentage of tube-builders ranged from zero to 40.0% (Station #4). Tallying among the most abundant families were the tube-building oweniids (40.0% of Station #2, 8.2% of Station #4, and 8.1% of Station #6) and chaetopterids (13.1% of Station #2).

Discretely Motile: Discretely motile polychaetes were found at every station, but were never the most abundant of the three motility groups, and were the least abundant at Stations #5, #6, #2, and #4 (with percentages of 1.0%, 1.5%, 2.8%, and 4.7%,

respectively). Individuals collected ranged from 32 (Station #3) to 3 (Station #6). Station #3 had the highest number of discretely motile families with 3, and Stations #5 and #6 had the lowest with 1. Percentages of discretely motile families ranged from 20.0% (Stations #4 and #5) to 7.7% (Station #6). The only dominant discretely motile family was the Spionidae (11.5% of Station #3 and 1.0% of Station #5).

Granulometry Results

Between 34.663g (Station #1) and 49.707g (Station #2) of well-mixed sediment from each station were examined by grain size. Figure 8 depicts the grain size percentage of each station. The largest percentage at each station was 0.5 mm (ranging from 36.8% of Station #6 to 63.5% of Station #1). The grain size of 0.25 mm was the second highest

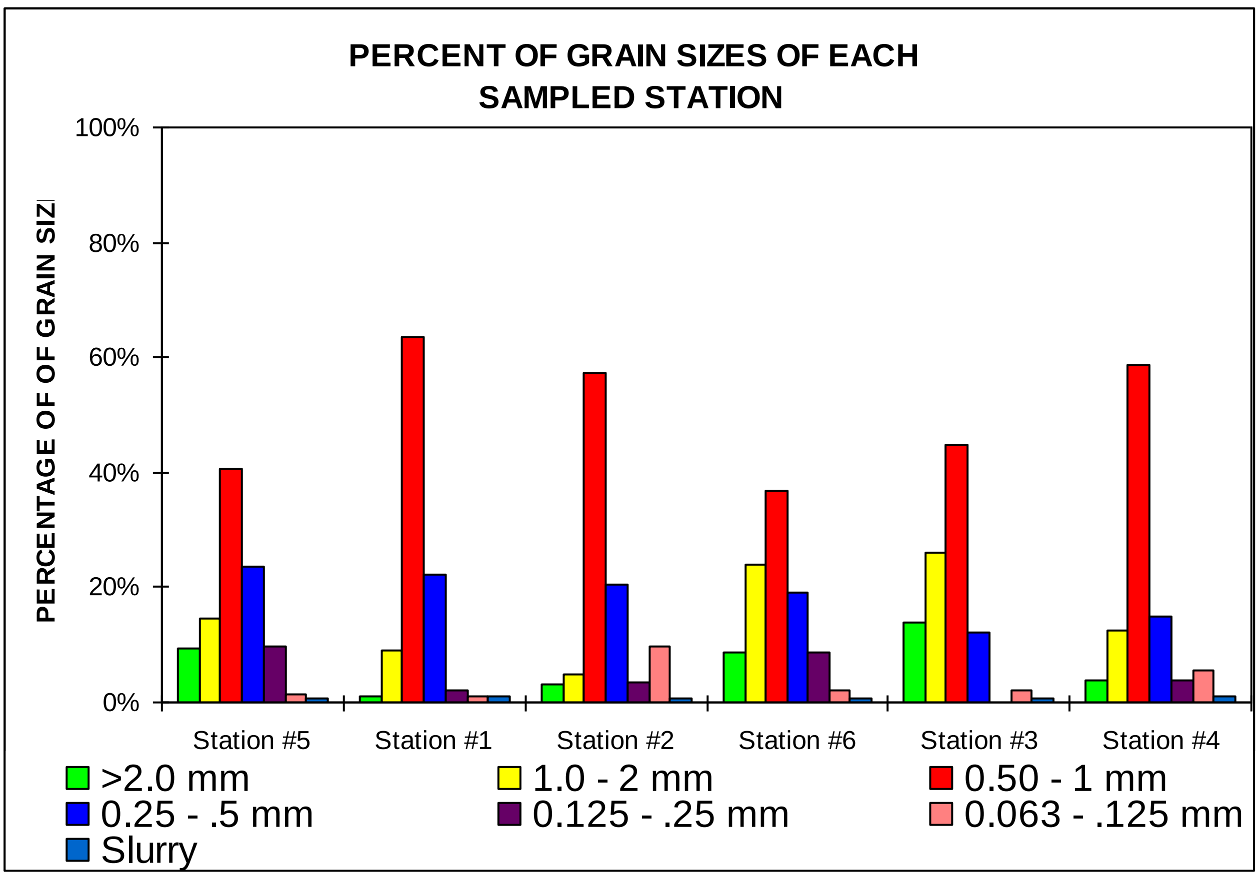

Figure 8: The percentage of grain sizes found at each station.

percentage of all station but Station #3 (ranging from 12.2% of Station #3 to 23.7% of Station #5). The sediment at Station #3 was somewhat larger, with 13.8 % greater than 2.0 mm and 26.2% greater than1.0 mm, particularly when compared to Station #1. 0.25 mm was slightly larger at Stations #2, #5, and #6 (comprising 9.9%, 9.7%, and 8.7% of the sediment sampled, respectively). Slurry volume and 0.063 mm sediment composed a small percentage of the sediment sampled at each station.

Discussion

Analysis of the results indicates that many implications as to the human effects on invertebrate and polychaete communities are apparent. Table 4 displays the most evident findings that indicate the effects human perturbations on soft-bottom benthic communities. The stations located inside Magic Island's lagoon are shaded, and arranged next to the unperturbed station of equal depth. This figure also displays some inconsistencies of the sampled stations when evaluating Station #4.

TABLE 4: Most Evident Findings

	Station 5 (0.1 m)	Station 6 (0.1 m)	Station 1 (1.0 m)	Station 3 (1.0 m)	Station 2 (3.0 m)	Station 4 (3.0 m)
Average individuals per Sample	223.0	306.5	126.3	505.0	291.3	55.8
Number of Taxa	12	26	22	36	24	18
Most abundant Taxa	Polychaeta 89.7%	Crustacea 46.5%	Nematoda 45.5%	Crustacea 77.1%	Nematoda 60.2%	Nematoda 43.0%
Average Polchaetes per Sample	200.5	98.5	30.0	63.3	36.3	21.3
Polychaete Families	5	13	12	17	12	10
Most abundant Families	Saccocirridae 57.6%	Protodrilidae 41.6%	Saccocirridae 42.5%	Syllidae 56.1%	Oweniidae 40.0%	Syllidae 74.1%
Percent of Tubicolous	0%	15.3%	1.7%	10.7%	54.5%	14.1%

Comparisons between Stations of 0.1 m Depth

Based on the information presented in Table 4, Station #6 appears much healthier than Station #5. Station #5 exhibited only 12 taxa, which is less than half of the taxa found at

Station #6. Crustaceans comprised almost half of the total individuals found at Station #6, which is an indicator of an unperturbed habitat (Nikitik and Robinson, 2003). In contrast, amphipods were virtually absent from Station #5, with 2 individuals from all samples. Station #6 also averaged more individuals per sample with 306.5, nearly 40% more than Station #5.

Station #5 was almost completely composed of polychaetes (89.7% of all individuals collected). However, only 5 polychaete families were represented, and the families Saccocirridae and Protodrilidae dominated (compiling 57.6% and 40.9% of all polychaetes, respectively). The large quantity of saccocirids found at Station #5 is possibly due to the adaptation of a saccocirid that may benefit from highly perturbed environments. As described by Bailey-Brock et al (2003), Saccocirrids can attach themselves to a grain of sand that acts as a weight belt, allowing them to resettle quickly to the bottom. Other polychaetes may remain suspended in the water column for longer periods, becoming easy prey for small fish. Station #5 is also completely lacking tubicolous polychaetes. Without any tube-builders and very few burrowing crustaceans, it appears that bioturbation from benthic invertebrates is minimal at this station. Station #5 was also lacking suspension-feeders, and was composed of 80% detritivores, which is an indicator of organic enrichment (Widdicombe, 2001). In contrast to Station #5, Station #6 had 13 families of polychaetes; nearly three times as many as Station #5. Of the families present, 3 were tube-builders comprising 15.3% of all polychaetes collected. Station #6 also had 2 suspension-feeding families, comprising 7.1% of the polychaete community. Based on low taxa richness, overall individual tallies, and the complete absence of tubicolous and suspension-feeding polychaetes, the impacts of human activities to benthic communities of 0.1m depth are clear.

Comparisons between Stations of 1.0 m Depth

When evaluating the stations of 1.0m depth, the impact of human activities is still very apparent. Station #1 has 61% the taxa richness of Station #3. Likewise, Station #3 averaged 505 total individuals per sample, a 4-to-1 ratio to Station #1. Station #3 was dominated by crustaceans, which composed 77.1% of the benthic community. In contrast, a majority of Station #1 was nematodes (45.5%), which serves as an indicator of organic enrichment.

The polychaete composition suggests human impacts to Station #1 as well. Only 12 polychaete families were collected from Station #1, whereas 17 were collected from Station #3. Like Station #5, Station #1 was absent of suspension-feeders, and only presented 2 tubicolous individuals (1.7% of all polychaetes collected). Unlike Station #1, Station #3 had 23 suspension-feeders, comprising 9.1% of polychaetes collected at this station. Similarly, tube-building worms comprised over 10% of all polychaetes. With a greater abundance of taxa, overwhelming amphipod dominance, and a larger proportion of suspension-feeding and tubicolous polychaetes, these data imply that Station #3 is relatively unperturbed when compared to Station #1. Like the stations at 0.1m depth, the 1.0m stations clearly illustrate human impacts.

Comparisons between Stations of 3.0 m Depth

Unlike stations at 0.1m and 1.0m depths, the two stations at 3.0m depth do not exhibit the same pattern, in that Station #4 does not appear unperturbed. Station #2 averaged 291.3 individuals per sample, consisting of 24 different taxa. In contrast, Station #4 only averaged 55.8 individuals from 18 taxa, both the lowest of any station. Station #2 was dominated by nematodes, with 701 individuals comprising 60.2% of all invertebrates. Although high in nematodes, Station #2 still had 255 crustaceans, 72 of which were amphipods (a 10-to-1 nematode/amphipod ratio). Station #4 was dominated by nematodes as well (43.0% of all invertebrates). Station #4 presented a similar nematode/amphipod ratio of 12-to-1. Such high nematode/amphipod ratios indicate organic enrichment at both sample sites.

When evaluating the polychaete composition, both stations appear equally perturbed. Station #2 has slightly more families with 12 compared to 10 found at Station #4. Station #2 is largely composed of tube-builders (54.5%), and displayed a relatively large percent of suspension-feeders (14.5%). Since this station is at 3m depth, it is not exposed the human trampling experienced by stations at .01m and 1.0m depth. Because of this, tubicolous polychaetes can grow without human disturbance. Station #4 averaged the least number of polychaetes with 21.3 per sample, a majority of which were syllids (74.1%). Tubicolous and suspension-feeding polychaetes were found at this station, but in low abundance (14.1% and 5.9%, respectively). The low abundance and taxa richness of Station #4 could be attributed to other factors than human impact. For example, with its location near the retaining wall, this station can experience abnormally high wave disturbance, and thereby limiting the invertebrate community. Regardless of the cause, no evidence supports that the station inside Magic Island’s lagoon is more perturbed than the station outside.

Implications of Granulometry Results

As shown in Figure 8, the grain size of the sample sites outside Magic Island is slightly larger when compared to the stations inside. This physical difference could influence the invertebrate community. Ecosystems with smaller grain size are more likely to become tightly packed, which can limit the availability of oxygen (Boucot, 1981). Since most of the invertebrates discussed in this study depend on oxygen, the stations inside Magic Island may display less individuals and taxa abundance, regardless of human activity. Likewise, ecosystems with larger grain size (0.5 mm and above) can stay oxygenated more easily, and thus support a larger invertebrate community. However, according to the work of Amjad and Gray (1981), grain size parameters had no influence when examining the copepod to nematode ratio when studying the impacts of organic pollution. The role of grain size in determining the benthic invertebrate community is not entirely clear. In order to properly assess the human impacts to a shallow-water invertebrate community, the physical parameters of the ecosystem must be examined more closely.

Conclusion

Oahu's southern beaches are some of the most popular in the world, and experience thousands of beach-goers daily. As demonstrated by this study, this frequent human activity can affect the benthic invertebrate community. With the exception of Station #4, it appears that the invertebrate community inside Magic Island's lagoon is perturbed when compared to outside stations of equal depths. The invertebrate community has become less diverse, nematode dominant, and virtually absent of suspension-feeding and tubicolous polychaetes, due to human activities. In contrast, the stations that are rarely disturbed by humans exhibited over twice the number of taxa, were amphipod dominant, and possessed a relatively high percentage of suspension-feeding and tubicolous polychaetes. These are characteristics of an unperturbed habitat. Since the only physical characteristic examined was the sediment particle size at each station, parameters such as wave activity and water salinity and temperature must be considered before conclusively associating human activity to alterations in benthic invertebrate communities. Similarly, the role of the Saccocirridae in shallow waters environments isn't clearly known, but it is possible that they actually benefit from frequent habitat disturbance. Although more research should be performed, the results gathered from this project support a correlation between invertebrate community alterations as a result of human disturbance.

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