A SURVEY OF SELECTED CORAL AND FISH ASSEMBLAGES NEAR THE WAIANAE OCEAN OUTFALL, OCTOBER 1990

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ABSTRACT

Coral growth and fish abundance were monitored at two stations in the marine environment vicinity of the Waianae Wastewater Treatment Plant for any possible effects of sewage effluent inshore and down coast of the outfall diffuser discharge. One station, the sunken ship *Mahi*, was located 1.2 km south of the zone of initial dilution and was chosen for the abundance of fishes and corals nearby. The second station, located 0.8 km directly offshore from the WWWTP and 8 to 10 m east of the outfall pipe, was chosen to monitor effects of direct shoreward movement of sewage effluent of corals and fish abundance and diversity. No comparison of the stations was made since they are unique and have no spatial controls. Since this was the first of a five-year study, no comparisons could be made except for fish abundance, compared to that of 1988. Results showed no significant difference in the presence or absence of fish species when compared, and the carbonate sand sediments near coral were clean and white. A more detailed investigation is needed to discover direct effects of sewage effluent on water columns, sediment, and biological indicators.

INTRODUCTION

This report is part of the ongoing effort by the City and County of Honolulu (CCH) to monitor the marine environment in the vicinity of ocean outfalls off Oʻahu, Hawaiʻi.

On 20 October 1990, the principal investigator and the CCH oceanographic team completed a survey of selected stations near the Waianae ocean outfall. The Waianae Wastewater Treatment Plant (WWWTP) discharges approximately 2 mgd of primary effluent 1.8 km offshore at a depth of approximately 34 m (Fig. 1). This survey was the first of five annual studies designed to monitor any possible effects of sewage effluent on corals and fishes inshore and down coast of the outfall diffuser discharge.

SURVEY STATIONS

Station W2

Station W2 is located 1.2 km south of the zone of initial dilution (ZID) of the Waianae outfall diffuser (Fig. 1). This station is the sunken ship *Mahi*, whose aft deck lies at a depth of 22 m. The aft deck of the ship was chosen as a control monitoring station because of the abundance of corals growing on the horizontal deck platform and the aggregations of fishes attracted to it. The ship lies in an area normally devoid of bottom relief and hard substrata. The wreck is also important as a tourist site because Oʻahu commercial dive shops take many tourists there for scuba sightseeing.

Station WW

Station WW is located 0.5 km directly offshore from the WWWTP, 8 to 10 m east of the outfall pipe and surrounding armor rock, at a depth of 8 m (Fig. 1). The station was chosen to monitor any possible effects of direct shoreward movement of sewage effluent on coral cover and fish assemblage abundance and diversity in the area.

The substratum at this station is hard carbonate limestone, to which corals attach and grow. Because of the structural relief provided by the nearby outfall pipe and armor rock, many fishes congregate here.

METHODS AND MATERIALS

The sampling methodology used in this study generally followed the recommendations of Swartz (1978), Reed (1980), and U.S. Environmental Protection Agency guidelines (U.S. EPA

1987). This report does not compare stations since stations WW and W2 are unique and have no spatial controls.

Corals

At Station W2, four haphazardly chosen permanent markings (I-IV) were made on the aft deck platform with underwater markers. A 0.75-m^2 quadrat was placed at each mark (with the number in the upper-lefthand corner), and photographs were taken of the corals growing on the deck platform with a camera mounted at a fixed focal length. Two other fixed quadrat positions were chosen: the stern grating and the stern hatch cover. These positions were chosen because the grating and cover are permanent and easily recognizable features of the deck.

At Station WW, two 25-m permanent transect lines (telephone wire) were laid 12 m apart. On each transect, permanent marker buoys were secured to the lines at three locations (5–6 m apart) where corals were present. Photographs of the bottom at the designated positions were made of the quadrats (the permanent-marker numbers were in the upper-lefthand corner). This is essentially the belt quadrat technique used by Dodge et al. (1982) and Ott and Sinclair (1977).

Color photographs (3 by 5 in.) of all permanent quadrats at both stations (six at each station) were analyzed by estimating percentage of live coral cover and actual coral surface area, using a grid overlay (300 squares = 0.75 m^2; 1 square = 25 cm^2). Results were checked with a planimeter. At several quadrat sites, large, intact, live coral heads were designated for monitoring to estimate rates of coral growth. Photographs will be compared annually over a five-year period for changes in coral cover, composition, and color.

Permanent transects with permanent, randomly selected quadrats were used instead of randomly laid transects to estimate temporal changes in coral cover. Because of the extremely patchy distribution and coral abundance (per unit area) on this coast, a prohibitively large number of random replicate transects would be necessary to validly test for statistical differences in mean coral cover at different times. In some cases, the use of inferential statistical analysis may not be valid at the same location and over different periods because the assumption of independent sampling may be violated. In the future, paired comparison t-tests will be used to test the null hypothesis that the mean difference in coral cover for each quadrat from time t1 to time t2 is zero or positive (Daniel 1987). This test is not sensitive to moderate deviations from normality; is not affected by the assumption of independence, since only differences are tested; does not consider equality of variances, since only one variable is involved; and eliminates a maximum number of sources of extraneous variation by making pairs similar with respect to as many variables as possible (Daniel 1987). If the data are seriously skewed from a normal distribution, the nonparametric paired sign test will be used for analysis.

Fish Counts

At station WW, fishes were counted along the two 25-m transect lines, looking 3 m to each side of the lines. On the deck of the sunken ship (Sta. W2), permanent wire transect lines were not laid because many tourist divers visit the wreck. A diver swimming the length of the deck's center line (approximately 25 m) counted fishes from the center line to the port railing (approximately 7 m). The starboard railing (25 m) was used as the second transect. Fishes were counted and identified from the starboard railing to the center line of the deck (approximately 7 m). Diurnally active fishes are counted reasonably well by transecting, but the most common species are usually underestimated and cryptic fishes are poorly represented (Brock 1982).

Since at Station WW there were no previous fish counts along the permanent transects, no comparisons can be made until the 1991 annual survey. However, at Station W2, previous fish counts on the deck of the *Mahi* were made recently (Russo 1988) along the same center-line transect. Therefore, comparisons for this transect were made for the periods 1988 and 1990. In the future, fish assemblages for all transects at both stations will be compared, as were the center-line transects for this study, using the techniques described below.

Similarity in relative species abundance during the two periods was analyzed using the Bray-Curtis similarity index. Differences in species composition between periods, based on data on fish species presence or absence, were tested using Cochran's nonparametric Q-test (Siegel 1956; Green 1979).

Dominance during each period was calculated as the number of species accounting for 75% of the total abundance. To quantify variations in species composition between the two periods, a turnover rate (percentage) was calculated according to Ogden and Ebersole (1981). Turnover rate = 0.5 (d/nj + g/nk) ∞ 100, where d is the number of species lost from t1 to t2, g the number gained, nj the number of species at time t1, and nk the number of species at time t2.

RESULTS

Coral cover (percentage and actual area) at permanent quadrats for both Stations WW and W2 is summarized in Table 1. Estimates of coral cover by grid overlay and planimeter differed by < 1.2%. Grid-overlay estimates were used in this report.

Since these were the first permanent quadrats laid for the five-year study, no direct comparisons could be made for previous periods. The mean total coral cover (per quadrat, n = 6) was 18.8% at station WW and ranged from 2.7 to 33.7%; at Station W2, the mean was 22.7% and ranged from 14.9 to 42.2%. The coral species *Pocillopora meandrina* dominated the coral cover at Station W2, and *Porites lobata* dominated at Station WW (Tab. 1). Water clarity was good (12–15 m), and carbonate sand sediments at Station WW were clean and white. Figures 2, 3, 4, and 5 depict the permanent quadrats.

Fish counts at both stations are shown in Tables 2 and 3. On the center-line transect (175 m^2) of Station W2, comparisons were made with counts made by Russo (1988) (180 m^2). From 1988 to 1990, 7 species were lost and 4 species gained. The turnover rate was 21%. In 1988, 11 species accounted for 75% of the total abundance; in 1990, 3 species dominated. If the relatively large number of the snapper *L. kasmira* (95) were left out of the dominance calculation for 1990, the number of dominant species would increase to 6.

Based on the presence or absence of species, the similarity index comparing fish counts from 1988 with those from 1990 was 0.66. There was no significant difference in the presence or absence of fish species between the two periods (Q = 0.89, df = 1, n.s.).

In 1990, the butterfly fish *Chaetodon miliaris*, the wrasse *Thallassoma duperrey*, and the snapper *Lutjanus kasmira* were the most dominant fish species. In 1988, the surgeonfishes *Ctenochaetus strigosus* and *Acanthurus thompsoni*, the butterfly fish *C. miliaris*, and the wrasse *T. duperrey* were most dominant. An aggregation (30) of the snapper (*L. kasmira*) was seen in 1988 near the ship, but it was not counted since it was beyond the transect.

At Station WW, a total of 86 fishes (mean = 43/transect) were counted (both transects combined), represented by 12 species. At Station W2, a total of 58 fishes (12 species) werecounted on the starboard railing, while on the center-line transect, the abundance was 200 (24 species). In January 1988, total fish abundance on the center line was 106, representing 26 species.

DISCUSSION

Off the Waianae coast, coral cover is dominated by the two species *Pocillopora meandrina* and *Porites lobata* (Reed et al. 1977). This dominance of the two species existed before and after the commencement of discharge of the modified Waianae outfall. The outfall pipe, which discharged wastes into < 20 m prior to 1977, was modified and extended to discharge into the 33-m isobath approximately 1 km offshore. In the summer of 1975, Reed et al. (1977) reported coral cover range to be 8 to 12% between the 6- and 12-m isobath offshore from the WWWTP (transect C in their study) and within 50 m of the present Station WW. In this study, coral cover was found to range from approximately 3 to 22% in the same area. There were no apparent shifts in either coral species dominance or range of cover from 1975 to 1990. The clean sand sediments and good horizontal water visibility may indicate no large influx of sewage effluent to the inshore survey station (Sta. WW).

In 1975, total fish abundance offshore from the WWWTP (at 6–12 m depths) varied between 18 and 95 (numbers adjusted to a 175-m^2 area) (Reed et al. 1977). In 1990 at the 8-m isobath in the same area (Sta. WW), total fish abundance varied from 36 to 50 per 175-m^2 transect area.

From 1988 to 1990, there were no significant differences in fish species composition or turnover rate on the ship *Mahi*. The Bray-Curtis similarity index was relatively high (.66) for the two periods.

The two survey stations will be monitored annually over a five-year period for changes in the coral cover and fish diversity and abundance. Changes in the biological indicators near an impact area may be the result of (1) natural environment fluctuations, or (2) impact from other than natural causes. A steady pattern of decreased fish abundance and diversity and coral cover over five years may indicate possible impact effects. In this case, a closer and more detailed investigation of the possible effect of sewage effluent on water column, sediment, and biological indicators should be implemented. Studies of water-column turbidity, dissolved organic carbon, sediment and water column biological oxygen demand, total volatile solids, oxidation-reduction potential of surrounding sediments, and bioaccumulation of selected fish species must be analyzed to detect possible outfall effects.

Sewage discharge may potentially impact coral-reef communities by nutrient enrichment, sedimentation, and/or toxicity (Tetra Tech 1983). Generally, sedimentation seems to be less important to coral-reef stress than nutrient enrichment or toxicity (Smith et al. 1981; Walker and Ormond 1982). At the Sand Island outfall, < 1% of the effluent particulate matter reaches the local sediments (Dollar 1980).

The sedimentation rate at Sand Island is approximately 0.036 mg/cm/day; slight to moderate sedimentation rates range from 1 to 20 mg/cm/day (Dodge et al. 1974; Ott 1975; Loya 1976; Randall and Birkeland 1978; Lasker 1980). At Waianae, the sedimentation rate (worst-case scenario) was reported to be 0.003 mg/cm/day (Tetra Tech 1983). Most hard corals are capable of cleaning moderate amounts of sediment from their surfaces (Hubbard and Pocock 1972; Lasker 1980). The coral genera *Pocillopora* and *Porites* are sensitive to low to moderate sedimentation rates (Tab. 5; Tetra Tech 1983). The immediate impact of sedimentation on hard corals is a decrease in coral cover and diversity.

Toxicity effects on corals may be caused by chemicals found in sewage effluent. Very few studies of the effects of chemicals on corals have been done in Hawaii (Davis 1971). Most of the information on effluent chemical impact on coral reefs has covered short-term effects. Concentrations of major chemicals (PCB, pesticides, hydrocarbons) are considered low in Hawaiian outfall effluent (Tetra Tech 1987).

Nutrient enrichment of coral-reef communities can have several effects (Tetra Tech 1983). At low levels, benthic algae may proliferate without affecting corals (Kinsey and Domm 1974). At higher levels, filamentous blue-green algae and the green alga *Dictyospaeria cavernosa* may become abundant near outfall discharge (Banner 1974; Walker and Ormond 1982). This algal growth can inhibit coral cover growth and diversity. Also, other opportunistic species (bryozoans and tunicates) may replace coral or overgrow coral recruits in highly enriched environments (Birkeland 1977; Kinsey and Davies 1979).

Presently, there are no indications that onshore or down-coast movement of sewage effluent is taking place near the WWWTP, and circumstantial evidence implies little or no effect from the outfall on fish and coral communities. Coral species dominance has not changed since 1975, sediments are clean, and water clarity is good. Also, fish community structure is essentially similar to other communities in areas around the Hawaiian Islands with similar substrata. When compared to the results of extensive surveys done by Hobson (1984), fish species richness, species composition, and abundance are very similar to those of typical Hawaiian subtidal biotopes. Numbers and species of fish seen in the WWWTP area in 1975 are similar to those recorded in 1990. Fishes normally intolerant of moderate to heavy sewage pollution (e.g., *Forcipiger flavissimus*, *Dascyllus albisella*, and *Chaetodon multicinctus*) were seen at both stations. This is an initial study, and only after analysis of a series of annual surveys can direct and significant evidence confirming or denying outfall effects begin to become clear.

REFERENCES CITED

Banner, A.H. 1974. Kaneohe Bay, Hawaii: Urban pollution and a coral reef ecosystem. *Proc. 2nd Int. Coral Reef Sympos.* 2:685-702.

Birkeland, C. 1977. The importance of rate of biomass accumulation in early successional stages of benthic communities to the survival of coral recruits. *Proc. 3rd Int. Coral Reef Sympos.* 1:15-21.

Brock, R.E. 1982. A critique of visual census methods for assessing coral reef populations. *Bull. Mar. Sci.* 32:13-20.

Daniel, W.W. 1987. *Biostatistics: A foundation for analysis in health science*. New York: Wiley and Sons.

Davis, K.K. 1971. The levels of residual chlorine in Kaneohe Bay, Hawai'i and the effects of residual chlorine on coral planulae. Master's thesis (Oceanography), University of Hawaii at Manoa, Honolulu.

Dodge, R.E.; Aller, R.C.; and Thomson, J. 1974. Coral growth related to resuspension of bottom sediments. *Nature* 247:574-577.

Dodge, R.E.; Logan, A.; and Antonius, A. 1982. Quantitative reef assessment studies in Bermuda: a comparison of methods and preliminary results. *Bull. Mar. Sci.* 32:745-760.

Dollar, S. 1980. Ecological response of benthic communities to relaxation of sewage stress off Sand Island, Oahu. In *Environmental Survey Techniques for Coastal Water Assessment Conference Proceedings*, pp. 113-151. Water Resources Research Center and Sea Grant, University of Hawaii at Manoa, and Hawaii Water Pollution Control Association, Honolulu.

Green, R.H. 1979. *Sampling design and statistical methods for environmental biologists.* New York: Wiley-Interscience.

Hobson, E.S. 1984. The structure of reef fish communities in the Hawaiian Island Archipelago. In *Proc., N. W. Hawaiian Island Symposium, MR* 84-01: 57-70, Sea Grant College Program, University of Hawaii at Manoa, Honolulu.

Hubbard, J., and Pocock, Y. 1972. Sediment rejection by recent scleractinian corals: A key to paleo-environmental reconstruction. *Geol. Rundsch.* 61:598-626.

Kinsey, D.W., and Davies, P.J. 1979. Effects of elevated nitrogen and phosphorus on coral reef growth. *Limnol. and Oceangr.* 24: 935-940.

Kinsey, D.W, and Domm, A. 1974. Effects of fertilization on coral reef environments—primary production studies. *Proc. 2nd Int. Coral Reef Sympos.* 1:49-66.

Lasker, H.R. 1980. Sediment rejection by reef corals. *J. Exp. Mar. Biol. Ecol.* 47:77-87.

Loya, Y. 1976. Effects of water turbidity and sedimentation on the community structure of Puerto Rican corals. *J. Exp. Mar. Biol. Ecol.* 26:450-466.

Ogden, J.C., and Ebersole, J.P. 1981. Scale and community structure of coral reef fishes: A long term study of large artificial reefs. *Mar. Ecol. Prog.* Ser. 4: 97-103.

Ott, B. 1975. Community patterns on a submerged barrier reef at Barbados, West Indies. *Int. Rev. Ges. Hydrobiol.* 60:719-736.

Ott, B., and Sinclair, A.N. 1977. Cluster analysis definition of species ecological groups for a submerged barrier reef in Barbados, West Indies. *Int. Rev. Ges. Hydrobiol.* 62:41-51.

Randall, R.H., and Birkeland, C. 1978. Guam's reefs and beaches. Part II. sedimentation studies at Fouha Bay and Ylig Bay. *Tech. Rep.* No. 47, University of Guam Laboratory. 77 pp.

Reed, S.A. 1980. Sampling and transecting techniques on typical reef substrates. In *Environmental Survey Techniques for Coastal Water Assessment Conference Proceedings*, pp. 71-89. Water Resources Research Center and Sea Grant, University of Hawaii at Manoa, and Hawaii Water Pollution Control Association, Honolulu.

Reed, S.A.; Kay, E.A; and Russo, A. 1977. Survey of benthic coral reef ecosystems, fish populations, and micromollusks in the vicinity of the Waianae ocean sewer outfall, Oahu, Hawai'i. *Tech. Rep.* No. 104, Water Resources Research Center, University of Hawaii at Manoa, Honolulu.

Russo, A.R. 1988. "Fish community structure in the vicinity of the Waianae ocean outfall, Oahu, Hawaii." Spec. Rep. 1:22:88. Water Resources Research Center, University of Hawaii at Manoa, Honolulu.

Siegel, S. 1956. *Nonparametric Statistics for Behavorial Science*. New York: McGraw Hill.

Smith, S.; Kimmerer, W.J; Laws, E.; Brock, R; and Walsh, T. 1981. Kaneohe Bay sewage diversion experiment: Perspectives on ecosystem responses to nutritional perturbation. *Pac. Sci.* 35:279-395.

Swartz, R.C. 1978. Techniques for sampling and analyzing the marine benthos. Doc. No. 600/3-789-030, U.S. Environmental Protection Agency, Corvallis Environmental Research Laboratory, Corvallis, Oregon.

Tetra Tech. 1983. Ecological impacts of sewage discharges on coral reef communities. EPA 430 9-83-010. Prepared for U.S. Environmental Protection Agency, Office of Water Program Operations (Sept.).

______. 1987. Technical review of the Waianae Wastewater Treatment Plant: Updated section 301(h) application for modified secondary treatment requirements for discharge into marine waters. Prepared for U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. 1987. *Quality assurance and quality control (QA/QC) for 301(h) monitoring programs: Guidance on field and laboratory methods*. EPA 430/9-86-004, Office of Marine and Estuarine Protection, U.S. Environmental Protection Agency. 267 p.

Walker, D.I., and Ormond, R.F. 1982. Coral death from sewage and phosphate pollution at Aquaba, Red Sea. *Mar. Poll. Bull.* 13:21-25.

TABLE 1.CORAL COVER IN SELECTED QUADRATS NEAR WAIANAE OCEAN OUTFALL, OCTOBER 1990

STATION WW	%	AREA (cm²)	STATION WW	%	AREA (cm²)
Transect A			**Transect B**		
Quadrat A *Pocillopora meandrina* *Porites lobata*	8.6 22.2	643.8 1 667.5	Quadrat 2B *P. lobata*	34.2	2 562.5
Total	30.8	2 311.3	Quadrat 3B *P. meandrina*	4.0	300.0*
Quadrat 3A *P. meandrina* *P. lobata*	1.0 19.8	71.3 1 485.0	Quadrat B *P. lobata*	16.7	1 225.0
Total	20.8	1 556.3			
Quadrat 5A *P. meandrina* *P. lobata*	1.3 1.3	97.5 97.5			
Total	2.6	195.0			
STATION W2	%	AREA (cm²)	STATION W2	%	AREA (cm²)
Quadrat I *P. meandrina* *P. lobata*	30.3 0.8	2 275.0 56.3	Quadrat IV *P. meandrina* *P. lobata*	16.8 1.6	1 256.2 118.8
Total	31.1	2 331.3	Total	18.4	1 043.8
Quadrat II *P. meandrina* *P. lobata*	12.8 2.9	956.3 218.8	Quadrat Stern Grating *P. meandrina* *P. lobata*	15.8 4.2	1 287.5 306.3
Total	15.7	1 175.1	Total	20.0	1 493.8
Quadrat III *P. meandrina* *P. lobata*	10.1 3.8	756.3 287.5	Quadrat Stern Hatch *P. meandrina* *P. lobata*	11.0 2.1	825.0 156.3
Total	13.9	1 043.8	Total	13.1	981.3

*Designated coral head area = 230 cm².
†Designated coral head area = 290 cm².
‡Designated coral head area = 350 cm².

TABLE 2. FISH ABUNDANCE AT STATION WW TRANSECTS, NEAR WAIANAE OCEAN OUTFALL, O‘AHU, HAWAI‘I, OCTOBER 1990

TAXON	TRANSECT A*	TRANSECT B*
Acanthuridae (Surgeon fishes)		
Acanthurus nigoris	3	0
A. triostegus	4	1
A. thompsoni	3	0
Balistidae (Trigger fishes)		
Melichthys vidua	1	1
Rhinecanthus rectangulus	2	3
Chaetodontidae (Butterfly fishes)		
Chaetodon multicinctus	0	2
Labridae (Wrasses)		
Thallassoma duperrey	15	9
Mullidae (Goat fishes)		
Mulloidicthys auriflamma	1	4
Parupeneus porphyreus	11	3
Monacanthidae (File fishes)		
Pervagor spilosoma	5	0
Pomacentridae (Damsel fishes)		
Chromis sp.	2	10
Dasycllus albisella	3	3
Total	50	36
Total No. Species	11	9

*Nos./175 m^2.

TABLE 3. FISH ABUNDANCE AT STATION W2 TRANSECTS, NEAR WAIANAE OCEAN OUTFALL, O‘AHU, HAWAI‘I, 1990 AND 1988

TAXON	DECK STBD RAILING* 1990	DECK CENTER LINE* 1990	DECK CENTER LINE* 1988†
Acanthuridae			
(Surgeon fishes)			
Acanthurus nigoris	0	2	2
A. olivaceua	0	0	2
A. thompsoni	2	1	9
Ctenochaetus strigosus	0	0	11
Naso hexacanthus	1	3	3
N. literatus	0	2	2
Zanclus cornutus	1	1	2
Zebrasoma flavescens	0	0	2
Aulostomidae			
(Trumpet fishes)			
Aulostomus chinesis	0	1	0
Balistidae			
(Trigger fishes)			
Melichthys vidua	0	0	3
Rhinecanthus rectangulus	0	2	1
Sufflamen brusa	1	2	4
Chaetondontidae			
(Butterfly fishes)			
Chaetodon kleini	2	3	6
C. miliaris	16	50	21
C. ornatissimus	0	1	2
Forcipeger flavissmus	1	4	2
Cirrhitidae			
(Hawk fishes)			
Paracirrhites forsteri	1	3	0
Diodontidae			
(Spiny puffer)			
Diodon holocanthus	0	1	2
Labridae (Wrasses)			
Coris gaimardi	0	0	1
Coris sp.	0	1	1
Labroides phthirophagus	1	1	1
Thallassoma duperrey	8	12	9
Lutjanidae (Snappers)			
Lutjanus kasmira	20	95	0

Monacanthidae (File fishes) *Pervagor spilosoma*	0	3	6
Mullidae (Goat fishes)			
Mulloidicthus auriflamma	0	0	5
Parupeneus multifasciatus	0	1	1
P. porphyreus	0	1	1
Muraenidae (Eels)			
Gymnothorax meleagris	0	1	0
Tetradontidae (Puffers)			
Canthigastor cinctus	0	1	1
Total	58	200	107
Total No. Species	12	24	27

*Nos./175 m^2.

†Provided for comparison.