HAWAU-S-93-004 C2

AN ANALYSIS OF THE FISH COMMUNITIES ALONG THE BARBERS POINT DEEP OCEAN OUTFALL, O'AHU, HAWAI'I, USING REMOTE VIDEO—1992 DATA

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PROJECT REPORT PR-94-02

August 1993

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PREPARED FOR
City and County of Honolulu
Department of Wastewater Management
Project Completion Report
for
"The Assessment of the Impact of Ocean Sewer Outfalls on the Marine Environment off Oahu, Hawaii"
Project No.: C59390
Project Period: 21 February 1990–31 December 1994
Principal Investigator: Roger S. Fujioka

WATER RESOURCES RESEARCH CENTER
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ABSTRACT

Because the diffuser of the Barbers Point deep ocean outfall lies below safe diving depths, a remotely controlled video camera system was used to determine the status of the marine fish communities and selected diurnally exposed macroinvertebrate species resident to the diffuser. Video reconnaissance was completed over the entire 533-m diffuser length. Three visual "transects," which "sampled" approximately 31% of the total diffuser length, were established on the diffuser pipe. Video sampling of the diffuser fish communities was carried out on 12 January 1992. Twenty-two fish species (928 individual fish) having an estimated standing crop ranging from 13 to 51 g/m^2 (mean 35 g/m^2) were censused. In this census one "new" fish species was encountered for every 8.9 m^2 of substratum sampled, and one fish was seen for every 0.4 m^2. After future data collections are made, comparisons between annual surveys will be possible.

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INTRODUCTION

In recent years controversy has arisen regarding the impact that sewage effluent from the Honouliuli Wastewater Treatment Facility may have on marine communities resident to the receiving waters. The Barbers Point deep ocean outfall, which has been operational since 1982, currently releases roughly 25 mgd (1.10 m^3/s) of primary treated sewage through a 2 670-m-long pipe with a diffuser situated at a depth of 61 m offshore of 'Ewa Beach, O'ahu, Hawai'i. The diffuser is comprised of reinforced concrete pipe of three diameters: 147 m of 1.98-m-diameter pipe having 40 discharge ports that are 8.67 cm in diameter on the shoreward end of the diffuser, 183 m of 1.68-m-diameter pipe equipped with 50 ports that are 9.09 cm in diameter in the central part, and 212 m of 1.22-m-diameter pipe outfitted with 58 ports that are 9.50 cm in diameter at the seaward end. At the terminus of the diffuser are two 15.24-cm-diameter ports. In all, there are 148 ports (two per pipe section) spread along the 533 m length of the diffuser. The diffuser rests on a gravel pad and has some ballast rock placed at the junctures between sections as well as along both sides of each pipe section up to the midline (springline). Fishes and invertebrates have taken up residence along most of the length of the deep ocean outfall. This study has been undertaken in an attempt to semiquantitatively ascertain the impacts that may be occurring to the communities resident to the diffuser. This report presents a synopsis of the data from the first annual sampling effort carried out on 12 January 1992.

MATERIALS AND METHODS

Because the fish and diurnally exposed macroinvertebrate communities of interest to this study reside in waters below safe diving depths, a remotely controlled video camera system was used. There are a number of drawbacks as well as positive aspects to using a video camera system to visually census fishes and diurnally exposed macroinvertebrates. The drawbacks include problems with camera resolution, making species and size identifications difficult, and the problem of adequately controlling the camera to focus-in on rapidly fleeing fishes, adding further difficulty to identification problems. On the positive side, a permanent record of the organisms in the path of the camera is obtained. An additional benefit to using a video system is that it eliminates the need for diving to great depths.

There are some well-known problems with using visual census methods to assess coral reef fish populations, regardless of whether a camera or diver is in the water conducting the census. One of these is the simple frightening of wary fishes on the approach of the diver or camera. Another is the underestimation of cryptic species such as moray eels (family Muraenidae) and nocturnal species such as squirrelfishes (family Holocentridae) and bigeyes or 'āweoweo (family Priacanthidae). This problem is compounded in areas of high relief and coral coverage that affords numerous shelter sites. Species lists and abundance estimates are more accurate for areas of low relief, although some fishes with cryptic habits or protective coloration, such as scorpionfishes or nohu (family Scorpaenidae) and flatfishes (family Bothidae), might still be missed. Another problem is the reduced effectiveness of the visual census technique in turbid water. This is compounded by the difficulty of counting fishes that move quickly or are very numerous. Additionally, bias related to the experience of the census taker should be considered in making comparisons between surveys. Despite these problems, the visual census technique carried out by divers is probably the most accurate, nondestructive assessment method currently available for counting diurnally active fishes (Brock 1982). Use of a remotely controlled video system to obtain census data compounds many of the above problems, but it is probably one of the most cost-effective methods available for assessing fish communities at depths below safe diving limits.

Other than exposed sessile species (corals in shallow water and some sponges in deeper waters), most tropical marine invertebrates are cryptic, remaining under shelter until darkness when they emerge to feed. Only a few motile macroinvertebrates remain fully exposed during the day; among these are some holothurian (sea cucumber) and echinoid (sea urchin) species. Problems with species identification preclude the enumeration of most diurnally exposed invertebrates. Identification of holothurians is based on skin spicule configuration, and spicules are also used for identification of sponges. Thus, in this study, the identification and enumeration of exposed macroinvertebrates are confined to large arthropods (spiny lobsters) and sea urchins, and educated guesses are made as to species of holothurians present along the Barbers Point diffuser pipe.

The video "transect" of fish and macroinvertebrate populations resident to the diffuser pipe along predetermined transects was undertaken by the Oceanographic Team of the Department of Wastewater Management, City and County of Honolulu. In general, the video camera traveled from 0.5 to 1.5 m above the diffuser pipe, occasionally moving to the right or left side (and down) to survey the substratum alongside the pipe. The camera usually viewed a path from about 1.5 to 3 m in width. For data analysis purposes, we assumed that the camera path was approximately 2 m in width and attempted to count only fishes and invertebrates seen in this path. At times, the camera would tilt up (toward the horizon) to allow a viewing ahead down the pipe. Visibility under these circumstances ranged from about 1 m (in a discharge plume) to about 8 m, which is approximately the length of one pipe section. Because the camera grossly underestimates the number of fishes and invertebrates, we counted everything in the arbitrary 2-m-wide path, regardless of whether it was encountered directly below the camera (as when viewing from above) or several meters ahead (as when the camera is in a horizontal position).

The fish census involved not only the counting of populations but also the estimating of lengths of all fishes for later use in calculating standing crop. The standing crop of all fishes was estimated by use of linear regression techniques (Ricker 1975). Commencing about 30 years ago, species-specific regression coefficients have been developed by the author and others at the University of Hawaii, the Naval Undersea Center (see Evans 1974), and the Hawaii Division of Aquatic Resources from weight and body length measurements of captured fishes; for many species, sample sizes were in excess of a hundred individuals.

RESULTS

The January 1992 videotape covered the entire 533-m length of the diffuser; it was viewed several times to determine where representative "transects" could best be established. Three transect sites selected as being representative sections of the diffuser pipe were sampled for this study using the visual census technique. These transects were established using known points on the pipe and counting sections of pipe from those points. Establishing transects at known points ensures that these same sites can again be sampled in subsequent annual surveys, thus making data comparable.

Transect 1 commences at the outfall terminus and continues shoreward for 36.5 m, Transect 2 is situated near the middle of the diffuser and is 80 m long, and Transect 3 commences at the shoreward end of the diffuser (where the pipe emerges from the armor rock cap and discharge ports are evident) and continues for 51 m in a seaward direction. In total, these transects "sampled" 31% of the total diffuser length. The location of each transect is shown in Figure 1.

Collectively, approximately 336 m^2 of substratum were sampled. The results of all fish censuses are presented in Table 1, and the data for each transect are discussed below. In tallying the number of species seen on a given transect, all fishes that could not be positively assigned to a given species were lumped into groups such as "labrid unidentified"; in the tally of species, each of these groups were counted as being comprised of a single species, even though more than one species may have been in the group.

Sampling at Transect 1, which comprised five sections of 1.22-m-diameter pipe (Figure 1), was conducted in a shoreward direction. This transect sampled 73 m^2 of substratum at a depth of 61 m and noted 11 species of fishes (294 individuals) with an estimated biomass of

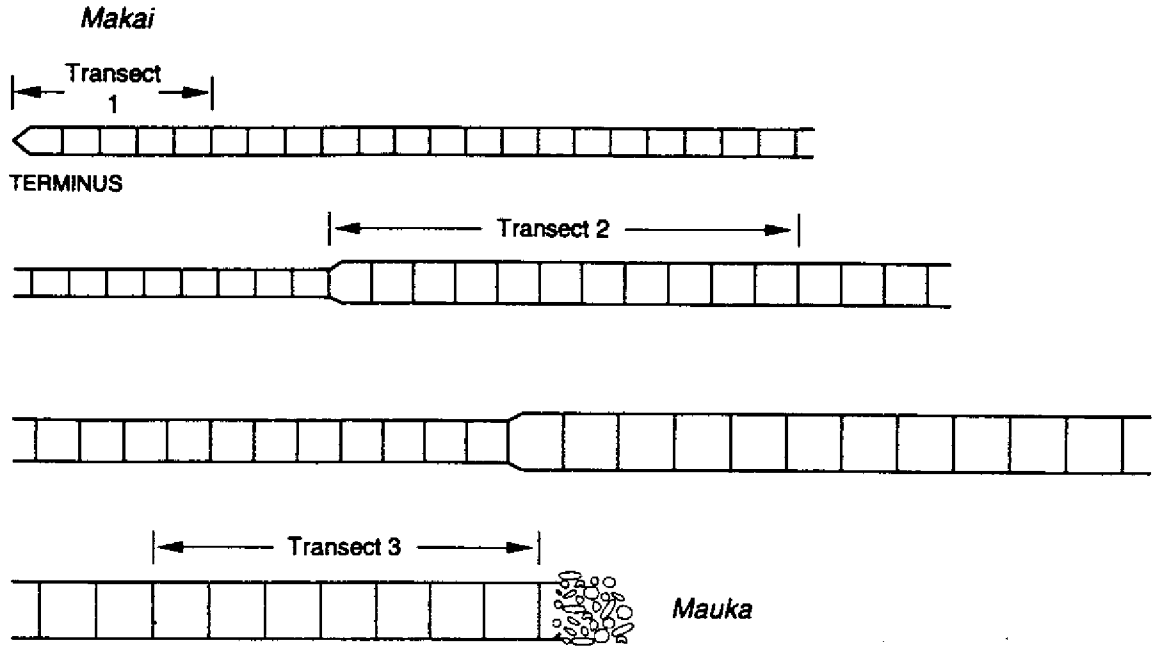

Figure 1. Rough schematic of the 533-m-long Barbers Point deep ocean outfall diffuser pipe showing the approximate locations of three fish census transects (Transects 1 through 3) surveyed by a remotely controlled video recording system on 12 January 1992. Transects are numbered, and the length of diffuser pipe covered by each is shown with arrows. Transect 1 covers 5 of 29 sections of 1.22-m-diameter pipe. Transect 2 covers 11 of 25 sections of 1.68-m-diameter pipe, and Transect 3 covers 7 of 20 sections of 1.98-m-diameter pipe. Each of the 74 pipe sections is 7.20 m in length. (Drawing not to scale)

13 g/m^2 (Table 1). This amounts to one new fish species encountered for every 6.6 m^2 of substratum sampled, or one fish seen for every 0.2 m^2. Of the species that could be identified, the most abundant on this transect were *Lutjanus* sp. (probably juvenile *L. kasmira* or ta'ape), comprising 86% of the fishes censused on this transect, and damselfishes or *Chromis* sp. (probably *C. hanui* or *C. agilis,* or both). In terms of standing crop, the juvenile *Lutjanus* sp. contributed 57% and the *Acanthurus olivaceus* or na'ena'e accounted for 22%.

Five identifiable macroinvertebrate species were seen in the boundaries of Transect 1. These species are the cushion starfish or *Culcita novaeguineae* (one individual), the wana or *Diadema setosum* (three individuals), the serrated sea urchin or *Chondrocidaris gigantea* (one individual), the spotted sea cucumber or *Bohadschia vitiensis* (one individual), and the black sea cucumber or *Holothuria atra* (two individuals).

Transect 2 commences 212 m down from the beginning of the diffuser pipe in about 61 m of water and continues for 80 m along the pipe from that point (Figure 1). This transect sampled 11 sections of the 1.68-m-diameter diffuser pipe, or 161 m^2 of substratum. Thirteen species of fishes were censused (Table 1); this translates to one new species seen for every

Table 1. Family and Species of Fishes Censused on Three Transects Along the 533-m-long Diffuser Pipe of the Barbers Point Deep Ocean Outfall as Delineated by Use of a Remotely Controlled Video Camera System on 12 January 1992. Areas Sampled on the Three Transects Varied: 73 m^2 for Transect 1, 161 m^2 for Transect 2, and 102 m^2 for Transect 3.

Family and Species	Transect 1	Transect 2	Transect 3
CARANGIDAE			
Caranx melampygus		1	
LUTJANIDAE			
Lutjanus kasmira	7		
Lutjanus sp. (?)	254	341	125
MULLIDAE			
Parupeneus multifasicatus		8	10
CHAETODONTIDAE			
Chaetodon sp.			3
POMACANTHIDAE			
Holocanthus arcuatus			1
Centropyge potteri		4	
POMACENTRIDAE			
Chromis hanui	8	12	6
Chromis sp.	11	34	51
LABRIDAE			
Thalassoma duperrey (?)		2	7
Pseudojuloides cerasinus	1		
Anampses chrysocephalus	2		
Labrid unidentified	4	3	6
ACANTHURIDAE			
Acanthurus dussumieri		1	2
A. olivaceus	2		2
A. xanthopterus			3
Naso unicornis	2		
ZANCLIDAE			
Zanclus cornutus		2	3
BALISTIDAE			
Sufflamen fraenatus		3	
MONACANTHIDAE			
Cantherhines sandwichiensis	1		
TETRAODONTIDAE			
Arothron hispidus		1	
CANTHIGASTERIDAE			
Canthigaster jactator	2	1	2
Total Number of Species	11	13	13
Total Number of Individuals	294	413	221
Estimated Biomass (g/m^2)	13	41	51

12.4 m^2 of substratum sampled. In total, 413 individual fishes were counted, or one fish was seen for every 0.4 m^2 sampled. The most common species of fishes seen were *Lutjanus kasmira, Chromis hanui,* and the manybar goatfish or moano (*Parupeneus multifasciatus*). Important species by weight include a single blue crevally or 'ōmilu (*Caranx melampygus*—42% of the total weight), the bridled triggerfish or humuhumu mimi (*Sufflamen fraenatus*—24%), juvenile *Lutjanus* sp. (11%), and the smooth puffer or kēkē (*Arothron hispidus*—10%). The biomass of fishes on Transect 2 was estimated to be 41 g/m^2.

The macroinvertebrate census carried out on Transect 2 resulted in 4 species and 13 individuals encountered: 9 *Holothuria atra,* 2 *Bohadschia vitiensis,* 1 *Diadema setosum,* and 1 *Culcita novaeguineae.*

Approximately 197.5 m from the end of Transect 2 (or 490 m from the outfall terminus), Transect 3 was established (Figure 1). It terminates 51 m away, where the diffuser ports end and the pipe is covered with armor stone. Comprised of the seven most landward sections of the 1.98-m-diameter diffuser pipe, this transect, which is located at a depth of about 61 m, sampled 102 m^2 of substratum. Thirteen species of fishes were seen during the census, or one new fish species was seen for every 7.8 m^2 of substratum sampled. The number of individual fishes encountered on this transect was 221; this translates to one fish per 0.5 m^2 of substratum sampled. Again, the most abundant fish species on this transect appeared to be juvenile *Lutjanus kasmira,* which made up 53% of the total number of fishes censused. Other common species seen include *Chromis* sp. (again probably *C. hanui* or *C. agilis,* or both) and *Parupeneus multifasciatus.* The standing crop of fishes was estimated to be 51 g/m^2, of which 43% was comprised of 3 yellowtail surgeonfish or pualu (*Acanthurus xanthopterus*), 21% of 1 *Acanthurus olivaceus,* and 8% of 10 *Parupeneus multifasciatus.*

Five species of macroinvertebrates (22 individuals) were censused on Transect 3. These species include 11 *Bohadschia vitiensis,* 3 *Holothuria atra,* 5 *Chondrocidaris gigantea,* 2 *Culcita novaeguineae,* and 1 *Diadema setosum.*

Physical characteristics and survey results for the three transects censused in the January 1992 video tape are summarized in Table 2. In general, these data are similar to those obtained at the Sand Island diffuser using the same methods (Brock 1992*a*, 1992*b*, 1993). This study focuses on addressing the question "Is there change occurring in the fish and diurnally exposed macrobenthos at the Barbers Point diffuser through time?" However, until additional census data are available, statistical analysis cannot be done.

Table 2. Summary of the Physical Characteristics of Three Transects Carried Out at Various Points Along the 533-m Barbers Point Deep Ocean Outfall Diffuser. Included are Summary Data from the Fish and Invertebrate Censuses Carried Out at Each Transect Location in January 1992. Grand Means are Presented in the Far Right Column.

Parameter	Transect			Grand Mean
	1	2	3	
Transect length (m)	36.5	80	51	55.8
Area sampled (m^2)	73	161	102	112
No. of fish species	11	13	13	12
No. of fish individuals	294	413	221	309
No. of m^2 sampled/new fish species	6.6	12.4	7.8	8.9
No. of m^2 sampled/individual fish	0.2	0.4	0.5	0.4
Fish biomass (g/m^2)	13	41	51	35
No. of invertebrate species	5	4	5	5
No. of invertebrate individuals	8	13	22	14

DISCUSSION

The identification of a number of fish species in this study was not difficult because of their size (adult palani or *Acanthurus dussumieri* and *A. xanthopterus*), color (*Parupeneus multifasciatus*, masked angelfish or *Holocanthus arcuatus*, and kihikihi or *Zanclus cornutus*), extreme abundance (*Lutjanus kasmira*), or diurnal habits. Despite this, a number of the fishes were difficult or impossible to identify because of (1) poor camera resolution, (2) rapid movement of the individual fishes to cover, (3) small size, or (4) fishes being on the periphery of the camera's field of view. Some of these fishes were small *Chromis* sp. (probably *C. hanui* or *C. agilis*), small *Lutjanus* sp. (probably juvenile *L. kasmira*), and small wrasses (family Labridae; possibly *Cheilinus bimaculatus*, *Pseudocheilinus* spp., *Thalassoma* spp., or *Pseudojuloides cerasinus*). In terms of abundance, these unidentified fishes were important; but, in general, they contributed little to the biomass estimates because of their small size.

In the 1992 census the estimated standing crop of fishes ranged from 13 to 51 g/m^2, and the mean was 35 g/m^2. On each of the three transects, just a few individual large fish contributed heavily to the biomass estimates. A major part of the standing crop included *Acanthurus olivaceus* on Transect 1, *Sufflamen fraenatus* on Transect 2, and *Acanthurus xanthopterus* as well as *A. olivaceus* on Transect 3. Goldman and Talbot (1975) suggested that a reasonable maximum biomass of coral reef fish is about 200 g/m^2. Space and cover are important agents governing the distribution of coral reef fishes (Sale 1977). Similarly, the standing crop of fishes on a reef is correlated with the degree of vertical relief. Thus, Brock (1954) using visual techniques on Hawaiian reefs estimated the standing crop of fishes to range from 4 g/m^2 on sand flats to a maximum of 186 g/m^2 in an area of considerable vertical relief. The large variation seen in standing crop of fishes on coral reefs is tied to the structural diversity of the habitat (Risk 1972). Some authors (Risk 1972; Gladfelter and Gladfelter 1978; Brock et al. 1979; Ogden and Ebersole 1981; Anderson et al. 1981; Shulman et al. 1983; Shulman 1984; Eckert 1985; Walsh 1985; Alevizon et al. 1985) viewed reef structure as an important factor in determining the species composition of coral reef fish communities. Thus some evidence suggests that both the biomass and species composition are influenced by the complexity of the local topography.

The substratum in the vicinity of the Barbers Point outfall diffuser appears to be a sandy plain. Sand habitats typically support a low diversity of fish species and biomass (i.e., biomass ranging from 0.5 to 20 g/m^2; Brock 1954; Brock et al. 1979; Brock and Norris 1989). The deployment of the diffuser pipe on a gravel pad with ballast stone placed up to the midline of the pipe as well as at the ends of most pipe sections provides additional local topographical structure, which has probably influenced the development of the fish community. Because of the small graded sizes used, the ballast stone and gravel pad provide only small-scale shelter. Small-scale shelter favors species that are either small as adults or juveniles of larger species. The average size of the fishes censused in this survey supports this contention. Thus the presence of a few adult fishes of species that attain some size (up to 30 cm) will add substantially to the biomass estimates.

If present in the field of view, larger or more colorful fishes are more easily identified than small fishes. Most of the fishes censused in this study were small, and the accuracy of censusing is less with fishes of this size. As with large fishes, only large invertebrates may be seen with enough detail to allow identification and censusing. The identification of *Bohadschia vitiensis* and *Holothuria atra* is tentative because accurate identification requires examination of skin spicules with a microscope. Despite the problems mentioned above, the remotely controlled video system provides a semiquantitative measure of the fish communities and some macroinvertebrate species resident to the Barbers Point deep ocean outfall diffuser.

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