AN ANALYSIS OF THE FISH COMMUNITIES ALONG THE SAND ISLAND DEEP OCEAN OUTFALL USING REMOTE VIDEO II. 1991 DATA

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ABSTRACT

Because the diffuser of the Honolulu 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 resident near the diffuser. Five visual "transects" were carried out; approximately 41 percent of the total diffuser length (1,036 m) was recorded with the camera system. In total at least 27 species of fishes were seen (1,785 individuals) having an estimated standing crop ranging from 8 to 106 g/m^2. The 1990 video census covered only the terminal 183 m of the diffuser whereas in 1991 a number of transects were spread out along the entire diffuser length, thus the data between years are not directly comparable. In 1990 one "new" fish species was seen for every 22.9 m^2 sampled and one fish was seen every 5.6 m^2; in 1991 one "new" species was seen in every 13.1 m^2 sampled and one fish was seen every 0.7 m^2. Although not directly comparable, these data suggest that the abundance and numbers of species of fishes increased on the diffuser between the two surveys. It is, however, suspected that better control of the video camera in the 1991 survey effort resulted in a better survey and higher counts. Further sampling will provide the data to resolve this question.

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PURPOSE

In recent years controversy has arisen regarding the impact that sewage effluent from the Sand Island Wastewater Treatment Facility may have on marine communities resident in the receiving waters. The present outfall has been operational since December 1976 and releases primary treated sewage at a depth of 68–73 m. The outfall was constructed in 1974–1975 and is comprised of 3,222 m of 2.1 m diameter reinforced concrete pipe terminating in a 1,036 m long diffuser. The diffuser is made up of reinforced concrete pipe of three diameters: 490 m of 2.1 m pipe, 271 m of 1.7 m pipe and terminating in 275 m of 1.2 m pipe. It lies in water from 68 to 73 m in depth, and there are 282 ports along the length of the diffuser that range from 7.6 to 9 cm in diameter. The diffuser rests on a gravel pad and has some ballast rock placed at the junctions between sections. Fishes 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 fish communities resident near the discharge port areas of the outfall. This report presents a synopsis of the data from the second annual sampling effort on 22 August 1991.

MATERIALS AND METHODS

Because the fish 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 in conducting a visual census of fishes. On the positive side, a permanent record of the fishes in the path of the camera is obtained, and there is no risk to divers involved. The negative aspects of using a remotely controlled video system to perform a census of fishes include problems with resolution that make species and size identifications difficult, and problems of adequately controlling the camera to "focus in" on rapidly fleeing fishes which further exacerbates identification difficulties.

There are some well-known shortcomings associated with the use of visual census methods to assess coral reef fish populations whether a camera or diver is used. One of these is the frightening of wary fishes on the approach of the diver or camera. Other problems with the visual census technique include the underestimation of cryptic species such as moray eels (Family Muraenidae) and nocturnal species such as squirrelfishes (Family Holocentridae), bigeyes or aweoweos (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 the nohus (Family Scorpaenidae) and the flatfishes (Family Bothidae), might still be missed. Obviously the effectiveness of the visual census technique is reduced in turbid water and species of fishes which move quickly and/or are very numerous may be difficult to count. Additionally, bias related to the experience of the census taker should be considered in making comparisons between surveys. In spite of these problems, the visual census technique carried out by divers is probably the most accurate nondestructive assessment method presently available for diurnally active fishes (Brock 1982). Obviously, 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 depths below safe diving limits.

This study utilized a remote controlled video system to visually assess the fish populations resident near the diffuser pipe. The video "transect" was undertaken by the Oceanographic Team of the Division 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 of the pipe. The camera usually viewed a path from about 1.5 to 3 m in width. For purposes of data analysis, we assumed that the camera path was approximately 2 m in width and attempted to count only fishes seen in this path. At times, the camera would tilt up (towards the horizontal) and would allow a viewing ahead down the pipe. Visibility under these circumstances ranged from about 1 m (in a discharge plume) to about 8 m (approximately the length of one pipe section). Because the camera grossly underestimated the fish community, we counted everything in the arbitrary 2 m wide path whether it was encountered directly below the camera (as viewing from above) or several meters ahead (as when the camera was in a horizontal position).

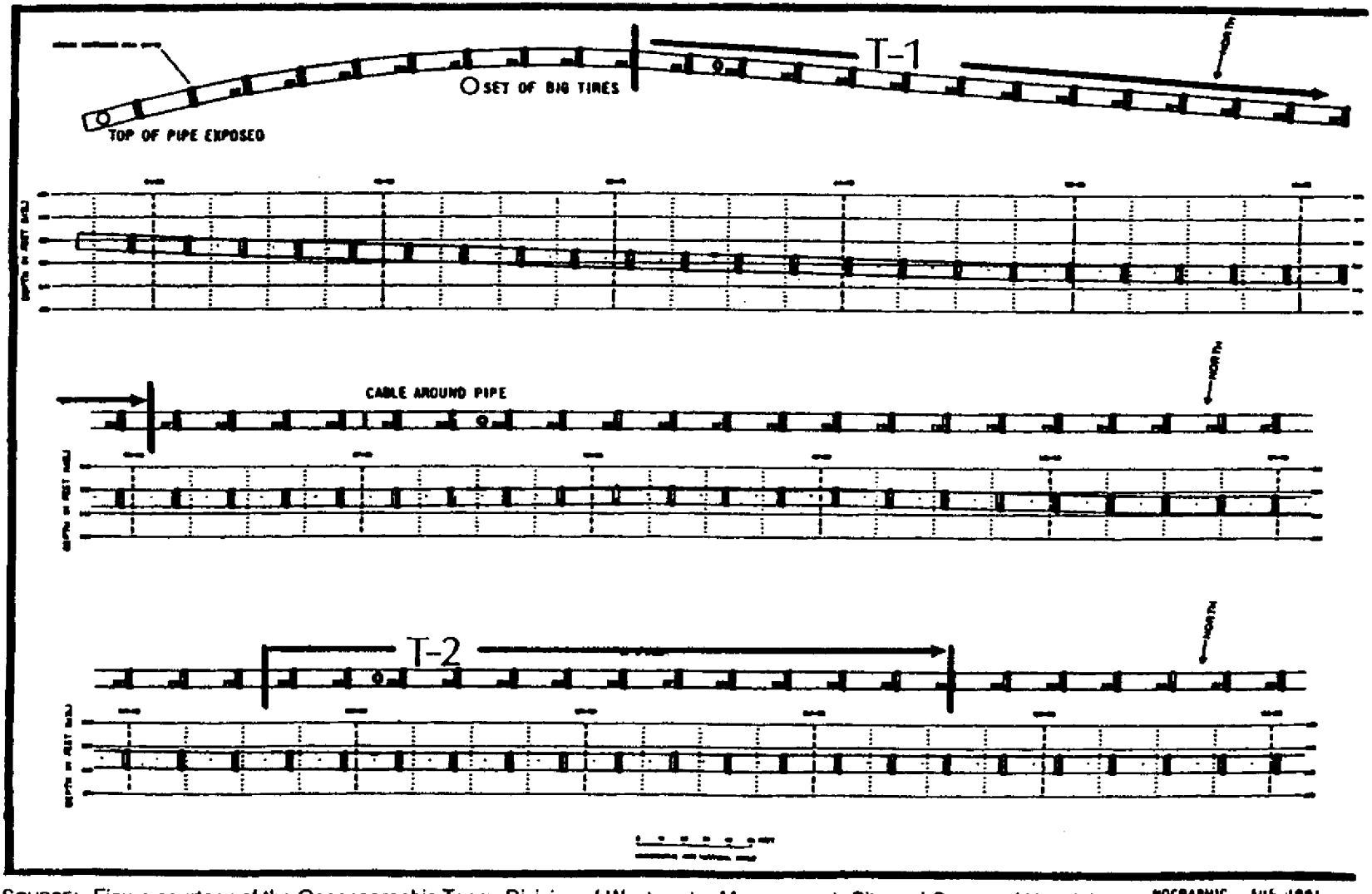
Not only were fishes counted but the lengths of all fishes were estimated for later use in calculating standing crop. The standing crop of all fishes was estimated by use of linear regression techniques (Ricker 1975). Species specific regression coefficients have been developed over the last thirty years by the author and others at the University of Hawaii, the Naval Undersea Center (see Evans 1974), and the Hawaii State Division of Aquatic Resources, through capturing, weighing and measuring fishes. For many species, sample sizes were in excess of a hundred individuals.

RESULTS

In the 22 August 1991 reconnaissance, the camera commenced just shoreward of the first discharge port on the diffuser and recorded the fish community for the entire diffuser length (a distance of approximately 1,036 m). The tape was viewed several times to determine where representative "transects" could be best taken. Since the 1991 survey sampled the entire diffuser, five sites were selected as being representative of a section of the diffuser pipe and these sites were sampled. The location of each "transect" is shown in Figure 1. Transects ranged from 44 m to 110 m in length. In total, approximately 848 m^2 of substratum were sampled in this survey. The results of all fish censuses are presented in Appendix A and each transect is discussed below.

Transect T-1 commenced 58 m down from the beginning of the diffuser pipe and continued for approximately 95 m along the pipe towards the terminus (Fig. 1). This transect sampled 13.5 sections of the 2.1 m diameter diffuser pipe. The depth at the top of the diffuser pipe at the start of the transect was approximately 68.5 m (225 feet) and about 70.1 m (230 feet) at the end. Twelve species (169 individuals) were noted in this transect and the biomass was estimated to be 32 g/m^2. This amounts to one new species encountered for every 15.8 m^2 of substratum sampled, or one individual fish seen every 1.1 m^2. Of the species that could be identified, the most abundant fishes on this transect were the damselfishes (*Chromis hanui* and *Chromis* sp., probably *C. hauni* and/or *C. agilis*), the barred filefish or 'o'ili (*Cantherhines dumerili*), and the eye-stripe surgeonfish or palani (*Acanthurus dussumieri*). Unidentified wrasses were also common in this transect; 41 percent of the fishes counted fell into this category. In terms of standing crop, the eye-stripe surgeonfish or palani (*Acanthurus dussumieri*), yellowfin surgeonfish or pualo (*Acanthurus xanthopterus*), barred filefish or 'o'ili (*Cantherhines dumerili*), and the stripebelly puffer or keke (*Arothron hispidus*) contributed most heavily to the biomass of fishes present on this transect.

The second transect (T-2) commenced 355 m down from the beginning of the diffuser pipe in about 71 m (233 feet) of water and ended 91 m down the pipe from that point (Fig. 1) in approximately 71.3 m (234 feet) of water (depths to the top of pipe). This transect sampled 12.5 sections of the 2.1 m diameter diffuser pipe. Thirteen species of fishes were counted (App. A) which translates to one new species seen every 14 m^2 of substratum sampled. In total, 217 individual fishes were counted or one fish for every 0.8 m^2 surveyed. The most common species of fishes seen were the brightly colored sea bass (*Pseudanthias thompsoni*), the damselfish (*Chromis* sp., probably *C. hanui* and/or *C. agilis*), and the smalltail wrasse (*Pseudojuloides cerasinus*). Again, unidentified wrasses were common, comprising 23 percent of the total number of fishes seen. Important species by weight were the barred filefish or 'o'ili



SOURCE: Figure courtesy of the Oceanographic Team, Division of Wastewater Management, City and County of Honolulu. NOGRAPHIC AUG 1991
NOTE: Transects are numbered and the length of diffuser pipe covered by each is shown by an arrow.

Figure 1. Schematic of 1,036 m long Honolulu Deep Ocean Outfall Diffuser Pipe showing approximate locations of five fish census transects tken from a remotely controlled video recording system, 22 August 1991

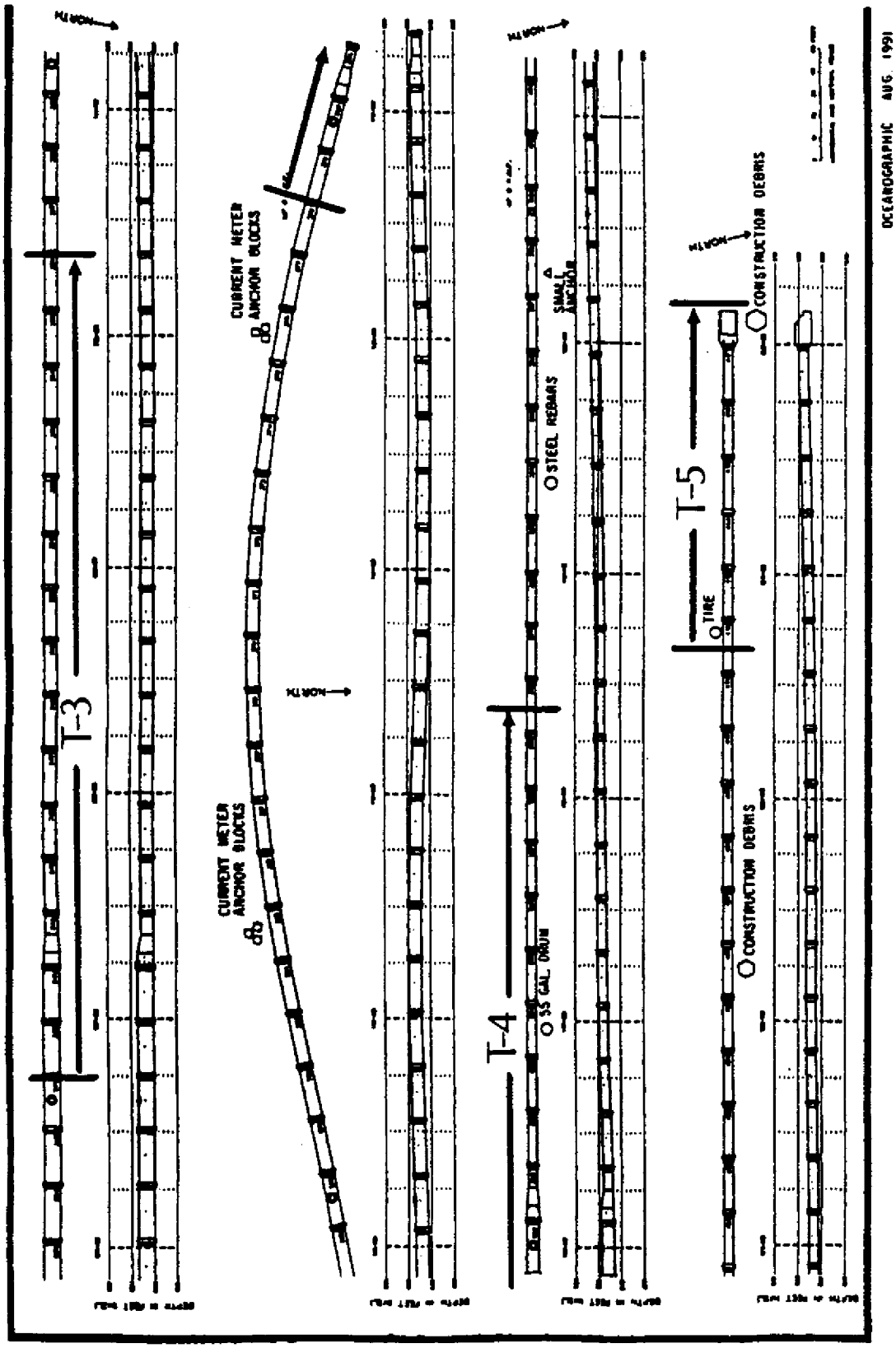


Figure 1.—Continued

(*Cantherhines dumerili*), the stripebelly puffer or keke (*Arothron hipidus*), and the unidentified wrasses. The biomass of fishes on T-2 was estimated to be 8 g/m^2.

Seventy-three meters from the end of transect T-2 the third transect (T-3) was established (see Fig. 1). The water depth at the beginning of the transect was 71.3 m (234 feet) to the top of the pipe, and the transect terminated 110 m away in 71.9 m (236 feet) of water. Transect T-3 included 2.5 sections of the 2.1 m diameter diffuser and 12.5 sections of the 1.7 m diameter diffuser pipe. Fourteen species of fishes were seen on this transect or one new fish species in every 15.7 m^2 of substratum sampled. The number of individual fishes encountered in this transect was 1,045 individuals or one fish per 0.2 m^2. The most abundant fish species on this transect was juvenile bluelined snapper or taape (*Lutjanus kasmira*) which made up 66 percent of the total number of fishes counted. Other common species included the brightly colored sea bass (*Pseudanthias thompsoni*), the smalltail wrasse (*Pseudojuloides cerasinus*), the damselfish (*Chromis* sp., probably *C. hanui* and/or *C. agilis*), and the unidentified wrasses. The standing crop of fishes was estimated to be 55 g/m^2. Sixty-one percent of this biomass was comprised of the bluelined snapper or taape (*Lutjanus kasmira*). Other species contributing heavily to the biomass of fishes on transect T-3 included the barred filefish or ‘o‘ili (*Cantherhines dumerili*) and the group of unidentified wrasses (Family Labridae).

Transect T-4 was established 161 m towards the diffuser terminus from the end point of transect T-3 at a depth of approximately 70.7 m (232 feet, depth to the top of the pipe). Transect T-4 sampled about 84 m of the diffuser pipe and ended at a depth of 70.1 m (230 feet). This transect covered 2.5 sections of the 1.7 m diameter pipe and 9 sections of the 1.2 m diameter diffuser pipe. In total 11 species of fishes (147 individuals) were seen in the video transect at this station. Equating these figures to the area sampled, one new fish species was seen in every 12 m^2 and one individual fish was encountered in every 1.1 m^2 sampled. The most abundant fishes on transect T-4 were the brightly colored sea bass (*Pseudanthaias thompsoni*), the damselfishes (*Chromis hanui* and *Chromis* sp.), and the unidentified wrasses (Family Labridae). The standing crop of fishes at T-4 was estimated to be 10 g/m^2. The species contributing most heavily to this biomass were the barred filefish or ‘o‘ili (*Cantherhines dumerili*), the unidentified wrasses (Family Labridae), and the stripebelly puffer or keke (*Arothron hispidus*).

Transect (T-5) covered the final 44 m of the diffuser pipe and the terminus. This transect sampled 5.5 sections of pipe and the diffuser terminus. It started at a depth of about 71 m (233 feet to top of pipe) and ended at a depth of approximately 69.5 m (228 feet) at the top of the diffuser terminus. Eleven species of fishes (207 individuals) were encountered in the census. In terms of area sampled, one new species of fish was seen for every 8 m^2 sampled and one individual fish was encountered in every 0.4 m^2 sampled. The most abundant species included

the brightly colored sea bass (*Pseudanthias thompsoni*), the damselfish (*Chromis* sp., probably *C. hanui* and or *C. agilis*), and unidentified wrasses (Family Labridae). The biomass of fishes at this station was estimated to be 106 g/m^2. The standing crop estimate was high due to the presence of a large yellowmargin moray eel or puhi paka (*Gymnothorax flavimarginatus*) which comprised 58 percent of the total weight of fishes seen at station and to two large tableboss or 'a'awa (*Bodianus bilunulatus*) which contributed 19 percent of the total biomass of fishes encountered.

The data from the five transects are summarized in Table 1 and may be compared to the information obtained from the analysis of the 1990 video transect carried out only on the last 183 m of the diffuser (Brock 1992). In the 1990 study 16 species of fishes or one "new" species was seen for every 22.9 m^2 sampled, and 67 individual fishes were encountered or one fish for every 5.6 m^2 sampled. The standing crop of fishes was estimated to be 17 g/m^2. Based on the criteria used (i.e., biomass, number of square meters sampled to encounter a new species or an individual fish) the fish communities of the diffuser pipe have increased since the 1990 survey. It is suspected that better control of the video camera in the 1991 survey effort has resulted in a better survey and higher counts, and that the increase seen over the 1990 survey is an artifact of the improved methodology. At this point the data do not lend themselves to statistical analysis.

DISCUSSION

The identification of a number of species of fishes in this study was not difficult because of their size (e.g., the adult 'a'awa [*Bodianus bilunulatus*] or palani [*Acanthurus dussumieri*]), color (the kihikihi [*Zanclus cornutus*]), extreme abundance (taape [*Lutjanus kasmira*]), or diurnal habits. However, a number of fishes were difficult or impossible to identify because of poor camera resolution, rapid movement of the individual fishes to cover, or having the fishes on the periphery of the field of view. Some of these fishes were small damselfishes (probably *Chromis hanui* or *C. agilis*) and small wrasses (Family Labridae; possibly *Cheilinus bimaculatus, Pseudocheilinus* spp., or *Pseudojuloides cerasinus*). In terms of abundance, these unidentified fishes were important but, in general, contributed little to the biomass estimates because of their small size.

The estimated standing crop of fishes ranged from 8 to 106 g/m^2 and the mean was 42 g/m^2. The high standing crop (106 g/m^2) encountered at Station 5 was due to a large resident yellowmargin moray eel or puhi paka (*Gymnothorax flavimarginatus*) and two tablebosses or 'a'awa (*Bodianus bilunulatus*) that wandered through the path of the video

TABLE 1. SUMMARY OF CHARACTERISTICS OF FIVE TRANSECTS CARRIED OUT AT VARIOUS POINTS ALONG 1,036 m HONOLULU DEEP OCEAN OUTFALL DIFFUSER

PARAMETER	TRANSECT NUMBER					GRAND MEAN
	1	2	3	4	5	
Transect Length (m)	95	91	110	84	44	85
Area Sampled (m^2)	190	182	220	168	88	170
No. of Species	12	13	14	11	11	12
No. of Individuals	169	217	1,045	147	207	357
No. m^2 Sampled per New Spp.	15.8	14	15.7	12	8	13.1
No. m^2 Sampled per Individual	1.1	0.8	0.2	1.1	0.4	0.7
Biomass (g/m^2)	32	8	55	10	106	42

NOTE: Data from the fish censuses was carried out at each transect location; grand means are presented in the far right column.

camera. If these three fishes are removed from the biomass estimate, the standing crop is 24 g/m^2 which would change the grand mean standing crop estimate to 26 g/m^2. Goldman and Talbot (1975) have 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; and Alevizon et al. 1985) have 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 Honolulu outfall diffuser appears to be a sandy plain. Sand habitats typically support a low diversity of fish species and biomass (with standing crops in the range of 0.5 to 20 g/m^2 [Brock 1954; Brock et al. 1979]). The addition of the diffuser pipe situated on a gravel pad with some ballast stone placed at the ends of most pipe sections provided 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. Indeed, the average size of the fishes seen in this survey supports this contention. Additionally many of the larger fishes seen (especially the palani - *Acanthurus dussumieri*) were in the vicinity of known areas of topographical relief such as the set of large tires near the start of the diffuser pipe, the discarded 55-gallon drum or the construction debris. The accuracy of the census is lower with smaller fishes.

Despite the problems above, the remotely controlled video system provides a semiquantitative measure of the fish community resident to the Honolulu deep ocean outfall diffuser.

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APPENDIX CONTENTS

Table

A. Family and Species of Fishes Identified and Counted on Five Transects Along 1,036 m Long Diffuser Pipe of Honolulu Deep Water Outfall as Delineated by Use of a Remotely Controlled Video Camera System, 22 August 1991 13

APPENDIX TABLE A. FAMILY AND SPECIES OF FISHES IDENTIFIED AND COUNTED ON FIVE TRANSECTS ALONG 1,036 m LONG DIFFUSER PIPE OF HONOLULU DEEP WATER OUTFALL AS DELINEATED BY USE OF A REMOTELY CONTROLLED VIDEO CAMERA SYSTEM, 22 AUGUST 1991

FAMILY AND SPECIES	TRANSECT NUMBER				
	1	2	3	4	5
MURAENIDAE					
Gymnothorax flavimarginatus					1
SERRANIDAE					
Pseudanthais thompsoni		18	44	18	87
APOGONIDAE					
Apogon kallopterus ?			1		
LUTJANIDAE					
Lutjanus kasmira			690		
MULLIDAE					
Parupeneus multifasicatus	1	4	10	3	1
CHAETODONTIDAE					
Chaetodon multicinctus		1			
C. kleini ?		3			
Chaetodon sp.	5	3			
Heniochus acuminatus ?				1	
POMACANTHIDAE					
Holocanthus arcuatus		1			1
POMACENTRIDAE					
Chromis hanui	41			23	
C. verator ?			1		
Chromis sp.	31	118	91	30	64
LABRIDAE					
Bodianus bilunulatus			1	1	3
Thalassoma duperrey ?	1				
Thalassoma sp.			1		
Pseudojuloides cerasinus	4	11	19		
Labrid unidentified	69	50	175	62	41
ACANTHURIDAE					
Acanthurus dussumieri	5				1
A. xanthopterus	2				
Acanthurus sp.		4	3		
ZANCLIDAE					
Zanclus cornutus				5	5
BALISTIDAE					
Sufflamen fraenatus	1				2
MONACANTHIDAE					
Cantherhines dumerili	7	2	6	2	1

APPENDIX TABLE A.—*Continued*

FAMILY AND SPECIES	TRANSECT NUMBER				
	1	2	3	4	5
TETRAODONTIDAE					
Arothron hispidus	2		2	1	
A. meleagris ?		1			
CANTHIGASTERIDAE					
Canthigaster jactator ?		1			
C. coronata			1	1	
Total No. of Species	12	13	14	11	11
Total No. of Individuals	169	217	1,045	147	207
Biomass (g/m^2)	32	8	55	10	106

NOTE: Areas sampled on the five transects varied; transect 1 sampled 190 m^2, transect 2 sampled 182 m^2, transect 3 sampled 220 m^2, transect 4 sampled 168 m^2, and transect 5 sampled 88 m^2. The body of the table contains the numbers of each fish species censused. The foot of the table contains the totals and an estimate of biomass for each transect.