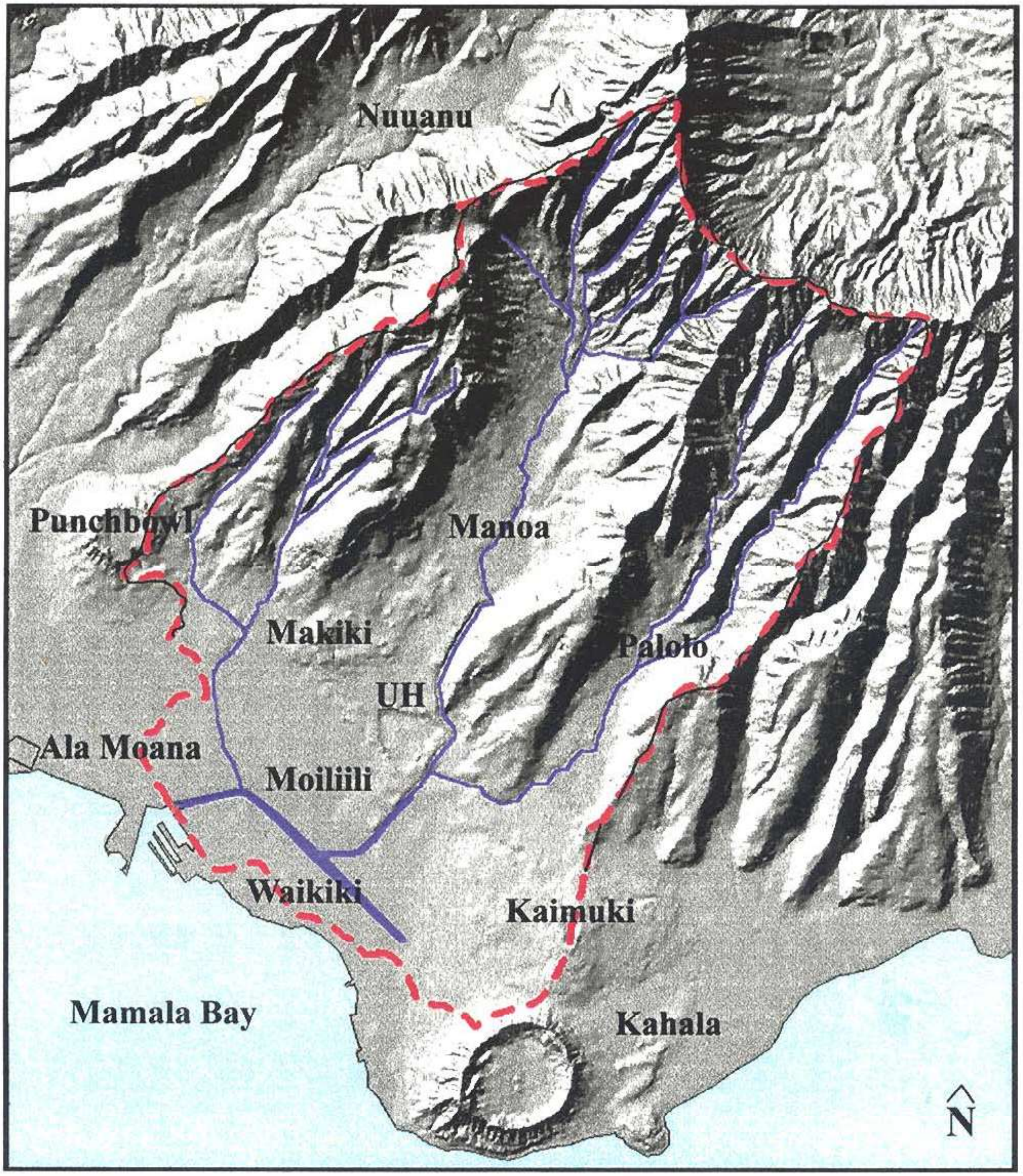

Ala Wai Canal Watershed Water Quality Improvement Project - April 1998

MANAGEMENT & IMPLEMENTATION PLAN -- VOLUME II
TECHNICAL APPENDICES

Prepared by: The Steering Committee, City and County of Honolulu, State of Hawai'i

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APPENDIX D

FISHERS STUDIES

Fishing Practices of the Ala Wai Canal

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Jacquelin Miller at the Environmental Center at
the University of Hawaii at Manoa
August 1997

Fishing Practices of the Ala Wai Canal

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ABSTRACT

The Ala Wai Canal is a 3,100 m long man-made tropical estuary designed to control the flooding of the Manoa, Palolo, and Makiki Streams on the south shore of the island of Oahu. Because of its location in a metropolitan area, it is an ideal area to study the effects of *urbanization on a marine environment.*

The present study of the Ala Wai Canal displays people of Chinese, Japanese, Lao, Filipino, Caucasian, Polynesian, and mixed or unknown ancestry to have consumed their catches from the Ala Wai Canal during May and June of 1997. The most abundantly consumed species included tilapia, Hawaiian Swimming Crab, and the Blue Pincer Crab. Over half of the English speaking fishers ate their catch, while non-English speaking fishers which made up only a small percentage of the fishers at the Ala Wai Canal, mostly consumed their catches.

Because of the presence of various carcinogens in the Ala Wai Canal, the organisms that inhabit there pose a health hazard to the people ingesting them. It is therefore recommended to post signs along the Ala Wai Canal that prevents fishing and to regularly enforce this decree. In addition, pamphlets could be printed out in different languages that would communicate the hazards of ingesting organisms in the canal to non-English speaking fishers.

The results of this study provide the data of fishing practices for management recommendations to provide the people of Hawaii with an aesthetic value and a safe recreational fishing environment at the Ala Wai Canal.

I. INTRODUCTION

The Ala Wai Canal was created by the United States Army Corps of Engineers in 1927 in the area of Waikiki on the island of Oahu in Hawai`i (Fig. 1) which had once been a marshland with taro patches, fish and duck ponds, and rice fields (Fig. 2, 3) (Laws et. al. 1994; Glenn and McMurtry 1995). According to Pinkham, the President of the Board of Health in the State of Hawaii in 1906, the area of Waikiki was a health hazard because it was "low and partly covered with water (and) incapable of effective draining in an unsanitary and dangerous condition (Pinkham 1906)." In addition, Pinkham claimed that the district was "incapable of reclamation by any expenditure within the means of private owners (Pinkham 1906)", but if the state should receive rights to the land, then Waikiki would be made "into an absolutely sanitary, beautiful and unique district (and would) add immensely to the reputation of Honolulu at home and abroad (Pinkham 1906)."

Consequently, the Hawaiian Dredging Company began its construction in 1921 and completed it in 1928 creating a 3,100 m long canal that varies in width from 51 to 83 m located presently behind the Waikiki metropolis (Fig. 1) (Glenn and McMurtry 1995). The Ala Wai Canal extends about 750 m from the base, behind the Waikiki library, bends at a 55 degree angle, and continues for another 2,350 m emptying into the ocean (Fryer 1995; Glenn and McMurtry 1995). In addition, the Ala Wai Yacht Harbor was later built on the eastern side of the mouth of the Ala Wai Canal (Glenn and McMurtry 1995).

In order to drain Waikiki for development, the waters from Manoa, Palolo, and Makiki streams feeding the Waikiki marshes were diverted to the Ala Wai Canal which empties into the ocean (Glenn and McMurtry 1995). Then, as Waikiki rose from the marshlands, this area was stabilized by laying dredged coral blocks creating a suitable environment for development , and the canal was then lined with basalt blocks (Glenn and McMurtry 1995).

In addition, the Manoa and Palolo streams were combined, and this unified stream as well as the Makiki stream was diverted into the canal to create the Waikiki and Ala Moana districts (Glenn and McMurtry 1995).

The Ala Wai Canal, meaning "path of water" in Hawaiian (Pukui and Elbert 1986), is one of the most fertile estuaries in the world (Fryer 1995; Glenn and McMurtry 1995). In addition to this, the canal is infamous for violating the EPA water quality standards due to its poor water circulation in some areas, and it has "extremely high levels of primary productivity...rivaled by few other water bodies in the world" (Fryer 1995). Because of its small size, differentiated oxygen content in its water column and sediments, freshwater drainage from stream inputs and storm drains, and location in a metropolitan area, the Ala Wai Canal is an ideal estuary for researching the impacts of modern urban life on the environment (Glenn and McMurtry 1995).

Due to its high level of productivity, the Ala Wai Canal supports an abundant array of species (Miller 1975). Because of the availability of fish or crab and the canal's location in a metropolitan area, many people fish at the canal. Fishers use gears such as rods and reels (Fig. 4, 5, 6), handpoles (Fig. 7, 8), gill nets, scoop or mesh nets (Fig. 8, 9), and crab nets (Fig. 10, 11, 12). They fish for the Hawaiian flagtail or *aholehole*, barracuda (Fig. 13), jack, *moi*, *ō`io* (Fig. 14), porcupine pufferfish (Fig. 15), tilapia (Fig. 16), blue pincer crab, Samoan crab, and bait such as shrimp or goby (Table 3).

II. METHODS AND INSTRUMENTATION

The fishers at the Ala Wai Canal generally fish in their spare time and in different areas on Oahu. However, some fishers would be found in different areas along the canal whereas others would be found in the same areas each time they were encountered. Areas surveyed ran the entire length of the canal on both sides including the Manoa-Palolo Drainage Canal up to the Date Street bridge, and each site was sampled completely (Fig. 1).

Areas not surveyed were privately owned or closed walkways such as the Ala Wai Golf Course and the construction site of the Convention Center.

Surveys consisted of gaining information about the number, age, sex, ethnicity, and Catch Per Unit of Effort (CPUE) of the fishers, and the area of residence of the fishers relied on the information given by them. Data also collected includes type of fish and crab as well as their length and weight which were recorded using a tape measure and a spring or electronic scale. A total of 343 hours (Table 1) was spent collecting data.

III. RESULTS AND DISCUSSION

A total of 95 fishers were surveyed during the last two weeks of May 1997 and during the first two weeks of June 1997 along the Ala Wai Canal. Fishers ranged from tourists, English, and non-English speaking individuals that fished for recreation as well as subsistence (Table 2). In addition, these fishers accounted for a total of 8 different ethnic groups which included African, Caucasian, Chinese, Filipino, Japanese, Lao, Polynesian, and people of mixed or unknown ancestry (Table 2).

Many people fished throughout the entire canal, but the most favored fishing areas consisted in locations 28-31, in the back basin on the mauka side at the head of the canal, and 1-3, on the makai end of the block between Ala Moana Boulevard to Kalakaua Avenue (Fig. 1, 17). The most popular fishing location occurred at location 1, where the canal empties into the Ala Wai Boat Harbor, and 29, at the head of the canal (Fig. 1, 18-19).

The fishers at the Ala Wai Canal used a variety of fishing gear, and over half of the fishers surveyed used rods and reels as their preferred gear type (Fig. 20). Crab nets were also commonly used at the canal, and other fishing gear included the handpole, handline, spear, scoop, and gill net (Fig. 21).

Of these fishers, males accounted for the majority with ninety-one percent and females consisted of nine percent of the population of fishers (Fig. 22-23). The prominent age group for female fishers was 61 to 80 years of age, and for males, the main age group was between the ages of 4 to 20 and 31 to 40 (Fig, 24). Women and men fishers tended to be evenly distributed among all ages, except for the dip in men aged 21-30.

Overwhelmingly, Japanese fishers and people of mixed or unknown ancestry (due to information not being revealed to the surveyor) constituted the largest ethnic grouping with a thirty-five percentage (Fig. 25, 26). Non-English speaking fishers such as people of Chinese, Filipino, Japanese, Lao, and European, Polynesian ancestry made up eighteen percent of the fishers at the Ala Wai Canal, while English speaking fishers comprised the largest group with seventy-eight percent (Fig. 18). In addition, Japanese tourists made up only four percent of the fishers at the canal (Fig. 18).

Over the years, the Ala Wai Canal has become heavily laden with various heavy metals, carcinogens, and stream and street runoff due to its poor circulation (Glenn and McMurtry 1995). These chemicals may be ingested by organisms like crabs, which then moves up the food chain when larger organisms like fish ingest the contaminated individuals. Therefore, it has become a public health risk to eat the fish or crab caught in the canal.

However, thirty-eight percent of the total number of fishers surveyed at the Ala Wai Canal were subsistence fishing (Fig. 28), and, of these fishers, eighty-seven percent of both men and women were consuming catch. Although non-English speaking fishers, such as people of Japanese, Chinese, Lao, and Pacific Island ancestry, constituted only a small percentage of the fishers at the Ala Wai Canal, many of them were consuming their catch (Fig. 29, 30). In addition, forty-seven percent of English speaking fishers were also consuming their catch (Fig. 29).

People of Japanese ancestry made up the largest group of fishers by ethnicity, and over half of them were recreational fishing (Fig. 30). On the other hand, over half the people of Chinese ancestry seemed to be fishing with the intention of consuming and they accounted for thirty-seven percent of the non-English speaking fishers that consumed their catch(Fig. 30, 31). In addition to the Chinese fishers, Lao and Polynesian fishers also appeared to be subsistence fishing and made up 25% of the non-English speaking fishers (Fig. 31).

Fishers came from many areas on the island of Oahu to fish at the Ala Wai Canal. These areas included Aiea, Aina Haina, Honolulu, Kalihi, Kaneohe, Liliha, Makiki, Mililani, Pearl City, and Waikiki. However, the majority of the fishers resided in Honolulu, Waikiki, and Kalihi respectively (Fig. 32-33).

Fishers at the canal were catching *Sphyraena barracuda* (Fig. 13)(Table 2, 3), *Albula glossodonta* (Fig. 14)(Table 2, 3), *Tilapia mozambique* (Fig. 16)(Table 2, 3), *Diodox hystrix* (Fig. 15)(Table 2), *Scomberoides lysan* (Table 2), *Thalamita crenata* (Table 2, 4), *Podophthalmus vigil* (Table 2, 6) and bait such as shrimp, guppy, or goby, and the most abundantly caught of these was *Tilapia mozambique* (Fig. 34). It had an average standard and total length of 14.6 cm and 18.5 cm and weighed an average of 131.9 g (Table 5).

Of the species caught in the canal, *Thalamita crenata*, *Podophthalmus vigil*, *Tilapia Mozambique*, *Albula glossodonta*, and *Sphyraena barracuda* are consumed (Fig. 35). *Thalamita crenata* was the second most popular species fished and the most abundantly consumed. It had an average carapace length of 5.7 cm and width of 4.1 cm weighing 57.5g on average (Table 4). *Podophthalmus vigil* and *Tilapia mozambique* were also commonly eaten.

Surveys were taken during three intervals of the day: morning, 7:00 am - 11:00 am, afternoon, 11:01 am - 3:00 p.m., and evening, 3:01 p.m. - 7:00 p.m., and, the most frequent amount of fishers appeared in the evenings and on the weekends. The greatest number of catches occurred on Saturday, Sunday, and Mondays, of which one of the Mondays was a state holiday (Fig. 36).

Catch Per Unit of Effort (CPUE) is a numerical value used to determine the total number of catches over the maximum amount of hours spent fishing or the number of fishes caught per hour. CPUE at the Ala Wai Canal ranged from 0 to 60.6 catches per hour per fisher, but the overall average was 3.73 fishes per hour per fisher (Table 7). The largest number of fishers surveyed as well as the greatest amount of catch occurred in the evenings from 3:01 p.m. to 7:00 p.m. (Fig. 37, 38). However, the greatest CPUE or number of catches per hour per fisher occurred in the morning shift from 7:00 a.m. to 11:00 a.m. (Fig. 39).

Several factors that did not appear to affect the amount of fishers at the Ala Wai Canal included such observations as turbidity (Fig. 40), odor (Fig. 41), amount of debris (Fig. 42), and degree of swelling of the canal (Fig. 43). The waters at the canal were usually murky, odorless, somewhat free of debris, and not swollen with runoff during the time surveyed. Therefore, the current amount of fishers did not appear to be influenced by these factors. In addition, tides did not prove to be a reliable measure as to when fishers were most active because most fished in the evening and Hawai`i's diurnal tides cause two daily high and low tides of different heights which were not all observed during the times surveyed (Fig. 44).

In conclusion, because of the presence of various carcinogens in the Ala Wai Canal, the organisms that inhabit there pose a health hazard to the people ingesting them. It is therefore recommended to post signs along the Ala Wai Canal that prevents fishing and to regularly enforce this decree. In addition, pamphlets could be printed out in different languages that would communicate the hazards of ingesting organisms in the canal to non-English speaking fishers.

IV. SUMMARY

(1) The Ala Wai Canal is a highly prolific man-made estuary located behind Waikiki on the south shore of Oahu in Hawai`i, and a total of 95 fishers were surveyed between May and June of 1997 at the Ala Wai Canal.

(2) Fishers used rods and reels, handpoles, handlines, gill nets, scoop or mesh nets, and crab nets as their fishing gear.

(3) Fishers fish for Hawaiian flagtail (*Kuhlia sandivicensis*), barracuda (*Sphyraena barracuda*), various species of jack (genus Carrangidae), mullet (*Mugil cephalus*), bonefish (*Abula glossodonta*), porcupine pufferfish (*Diodox hystrix*), tilapia (*Tilapia mozambique*), blue pincer crab (*Thalamita crenata*), Samoan crab (*Scylla serrator*), and bait such as shrimp or goby.

(4) The most favored fishing areas were located in the back basin at the head of the canal and on the makai end of the block between Ala Moana Boulevard to Kalakaua Avenue.

(5) Women constituted nine percent of the fishers at the Ala Wai Canal while men made up ninety-one percent.

(6) Most of the male and female fishers were evenly distributed in age except for a dip in men aged 21-30.

(7) Thirty-eight percent of the total number of fishers surveyed at the Ala Wai Canal were subsistence fishing and eighty-seven percent of both men and women were consuming catch.

(8) People of Japanese, Chinese, Lao, and Pacific Island ancestry, constituted only a small percentage of the fishers at the Ala Wai Canal, but many of them were consuming their catch.

(9) Forty-seven percent of English speaking fishers were consuming their catch.

(10) People of Japanese ancestry made up the largest group of fishers by ethnicity, and over half of them were recreational fishing.

(11) Over half the people of Chinese ancestry seemed to be fishing with the intention of consuming and accounted for thirty-seven percent of the non-English speaking fishers that consumed their catch.

(12) Lao and Polynesian fishers also appeared to be subsistence fishing and made up 25% of the non-English speaking fishers

(13) English speaking individuals of Japanese, Filipino, and Chinese ancestry, constituted the largest ethnic group of fishers at the Ala Wai Canal.

(14) Majority of the fishers resided in Honolulu, Waikiki, and Kalihi.

(15) *Thalamita crenata*, *Podophthalmus vigil*, *Tilapia mozambique*, *Albula glossodonta*, *Sphyraena barracuda* are consumed.

(16) *Tilapia mozambique* was commonly consumed and was the most abundantly caught species with an average standard and total length of 14.6 cm and 18.5 cm respectively and an average weight of 131.9 g.

(17) *Podophthalmus vigil* was the most often consumed and the second most popular fished species from the Ala Wai Canal, and its average proportions were 5.6 cm for carapace length, 4.1 cm for width, and weighed 57.5 g.

(18) Most fishers fished in their spare time in the evenings and especially on Saturday, Sunday, and holidays.

(19) The overall average Catch Per Unit of Effort (CPUE) or number of catch per hour per fisher at the Ala Wai Canal was 3.73 catches per hour per fisher.

(20) The average CPUE for three intervals during the day was 11.1 in the morning (7:00 a.m.-11:00 a.m.), 4.9 in the afternoon (11:01 a.m.-3:00 p.m.), and 1.7 in the evening (3:01 p.m.-7:00 p.m.).

(21) The greatest amount of fishers and the most catches occurred in the evening (3:01 p.m.-7:00 p.m.).

(22) Water and weather conditions did not appear to affect fishing at the Ala Wai Canal.

(21) Due to insufficient data, no conclusion can be made about the effect of tide on the amount of fishers.

(22) It is recommended that signs be posted along the Ala Wai Canal that prevents fishing and to regularly enforce this decree. In addition, pamphlets could be printed out in different languages that would communicate the hazards of ingesting organisms in the canal to non-English speaking fishers.

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APPENDIX A

FIGURES 1-44

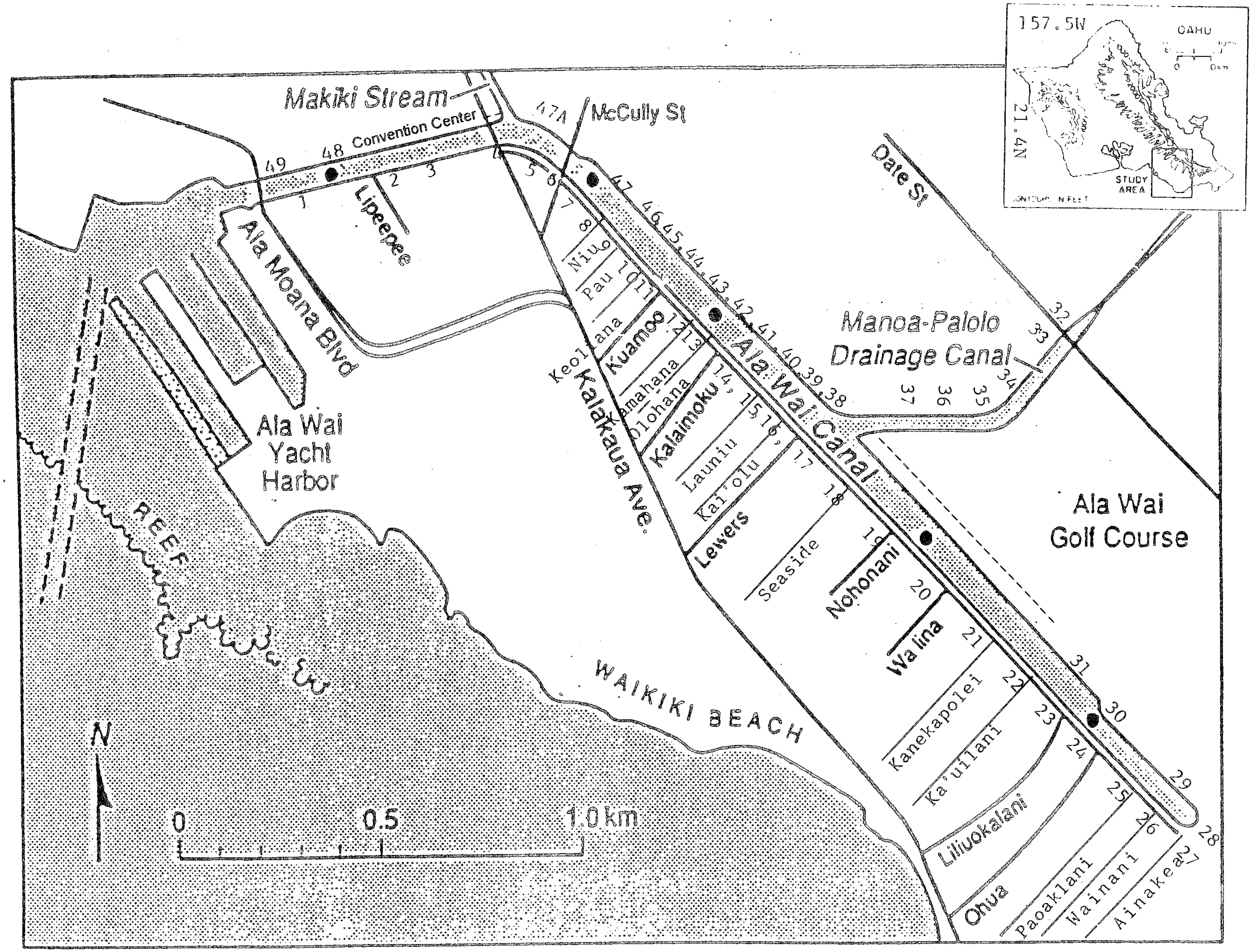


Figure 1. Map of the Ala Wai Canal modified after Resig et. al. 1995 & Laws et. al. 1995
(Numbers correspond to locations sampled)

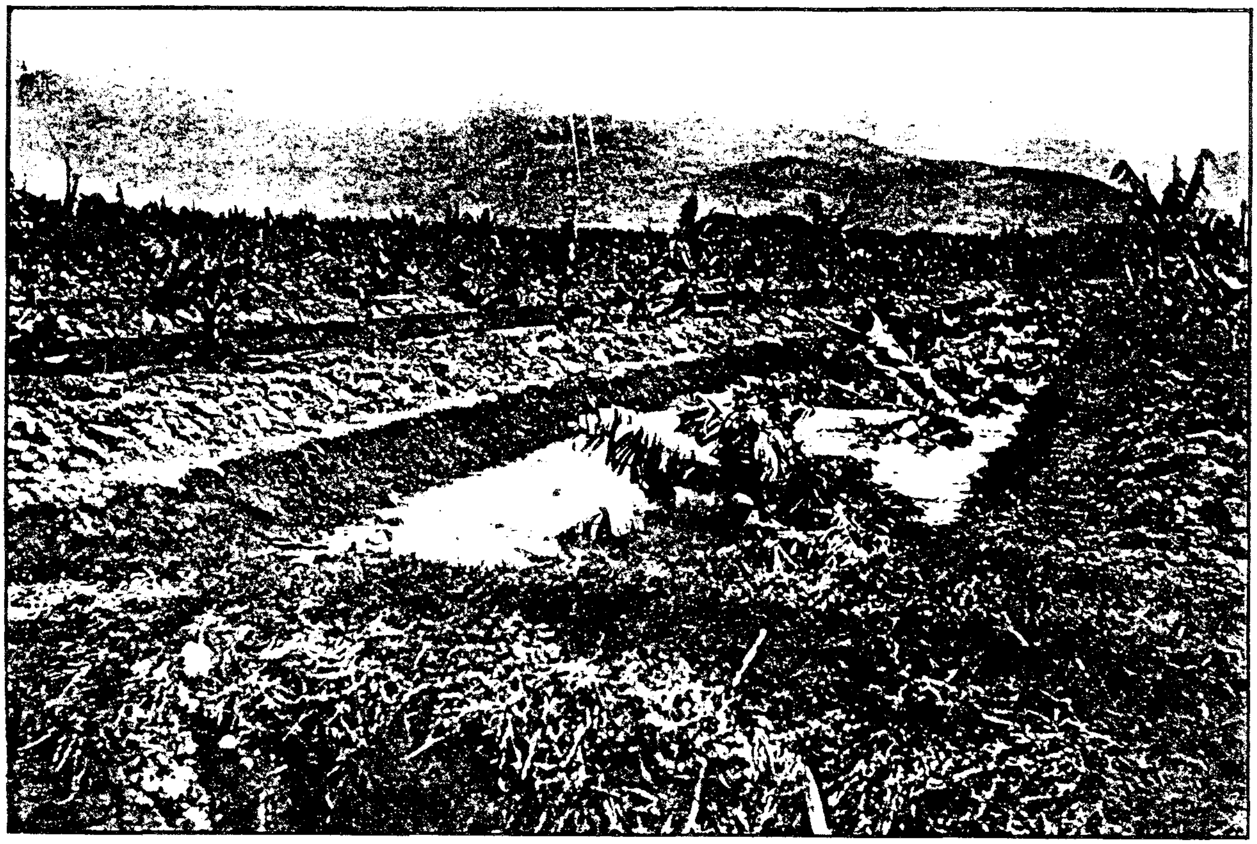


Figure 2. Pictures of banana fields in Waikiki before the Reclamation
from Pinkham 1906

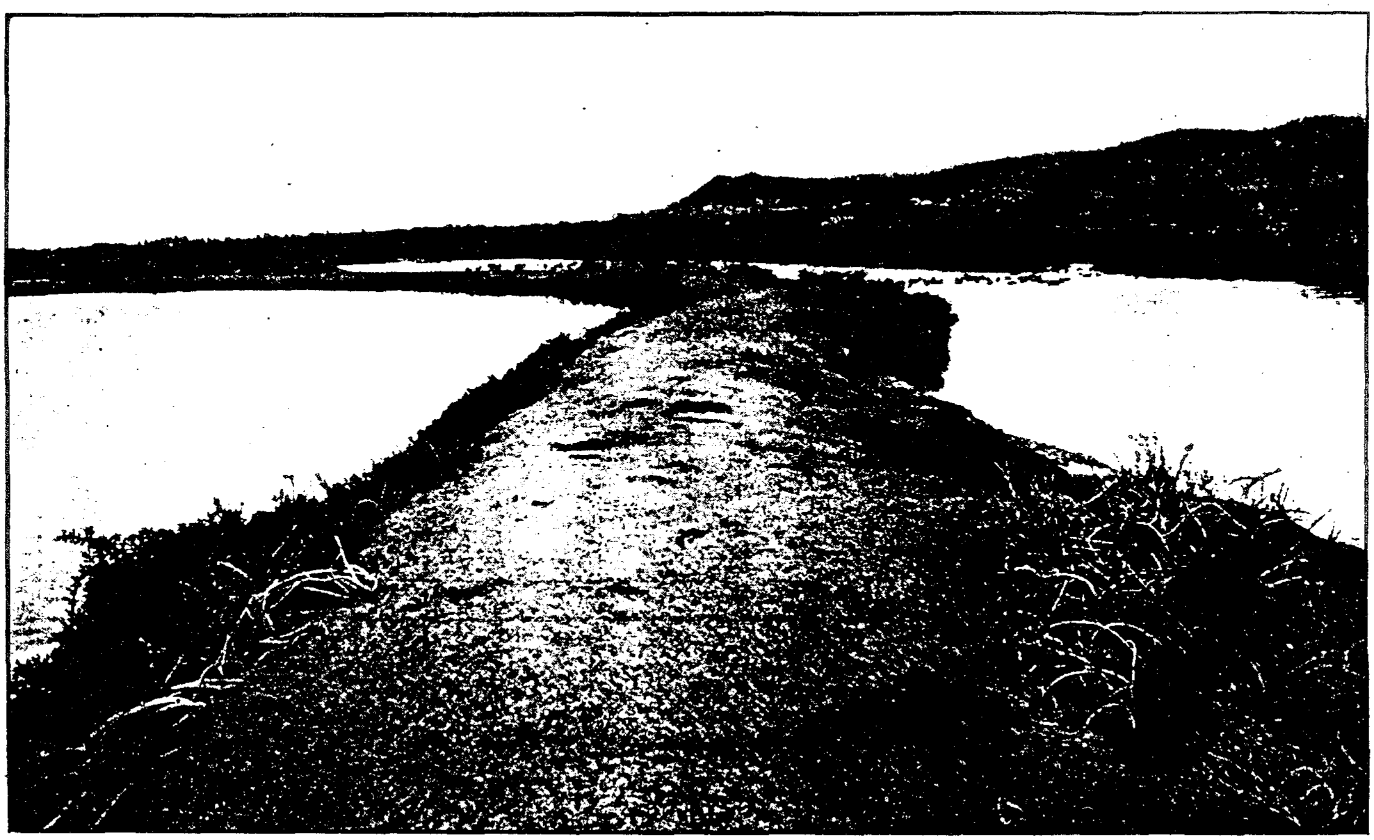


Figure 3. Picture of duck and fish ponds in Waikiki before the Reclamation
from Pinkham 1906

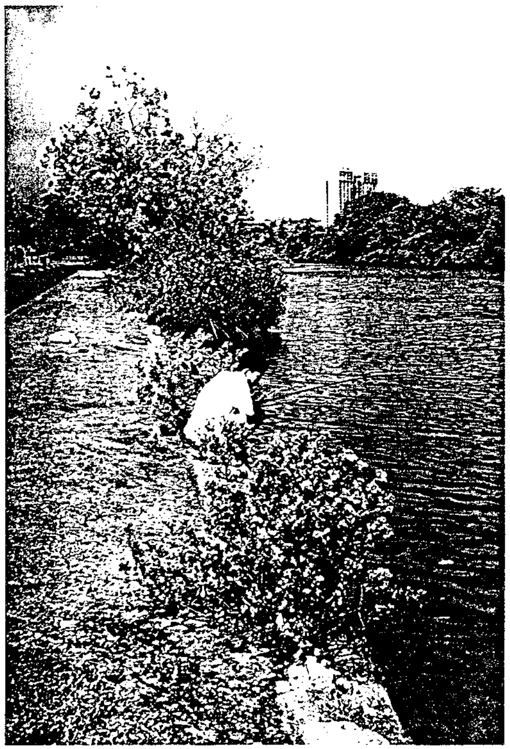


Figure 4. Picture of boy fishing at location 37 using a reel type of fishing pole at the Ala Wai Canal

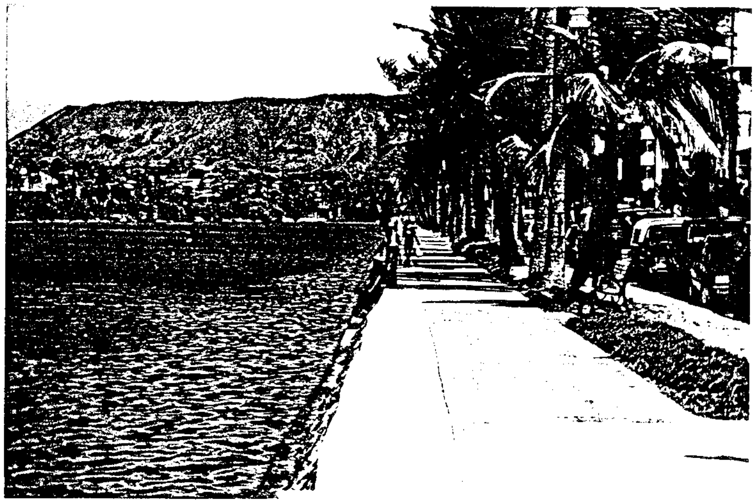


Figure 5. Picture of people fishing using a reel type of fishing pole at the Ala Wai Canal

Figure 6. Picture of Japanese tourists using a reel type of fishing pole at the Ala Wai Canal

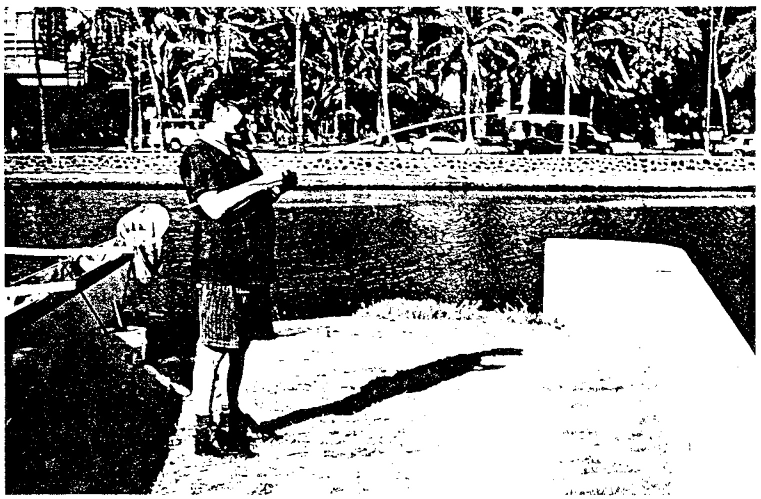


Figure 7. Picture of fisher using a handpole at the Ala Wai Canal

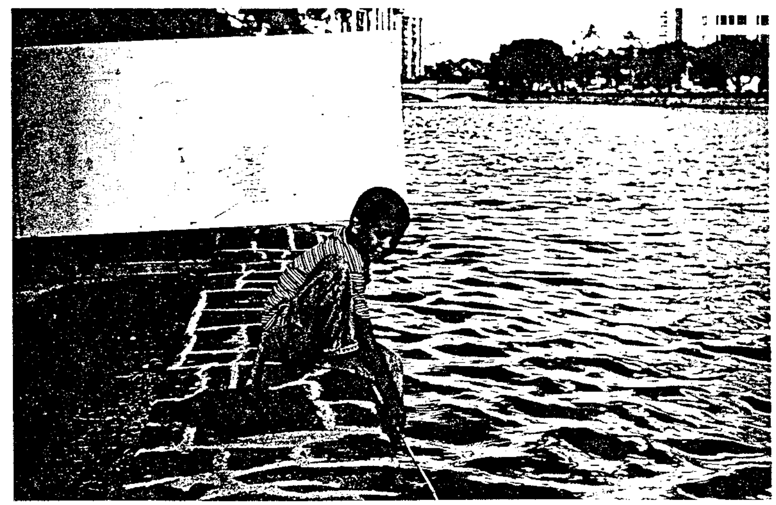


Figure 8. Picture of fisher using a handpole and scoop net at the Ala Wai Canal

Figure 9. Picture of Lao fisher using a scoop net at the Ala Wai Canal

Figure 10. Picture of fisher with three crab net lines at location 32 at the Ala Wai Canal

Figure 11. Picture of fisher holding crab net at location 32 at the Ala Wai Canal

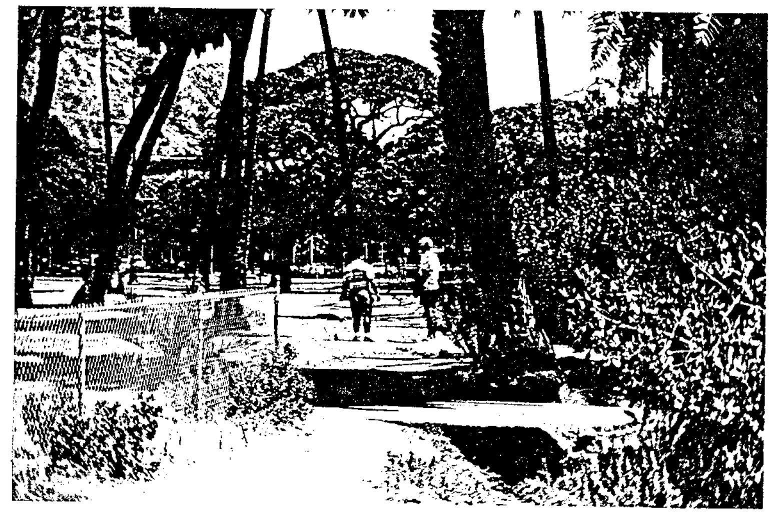


Figure 12. Picture of fisher on the left holding crab net at location 28 at the Ala Wai Canal

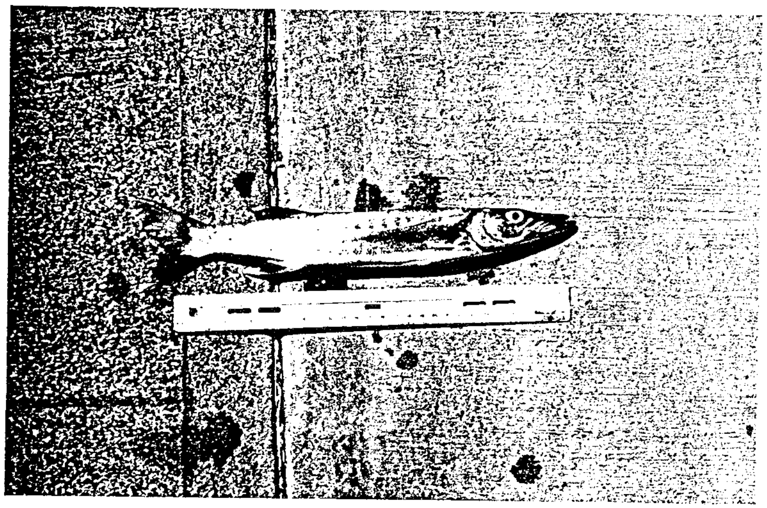


Figure 13. Barracuda (*Sphyraena barracuda*) caught from the Ala Wai Canal
(Ruler = 12 inches)

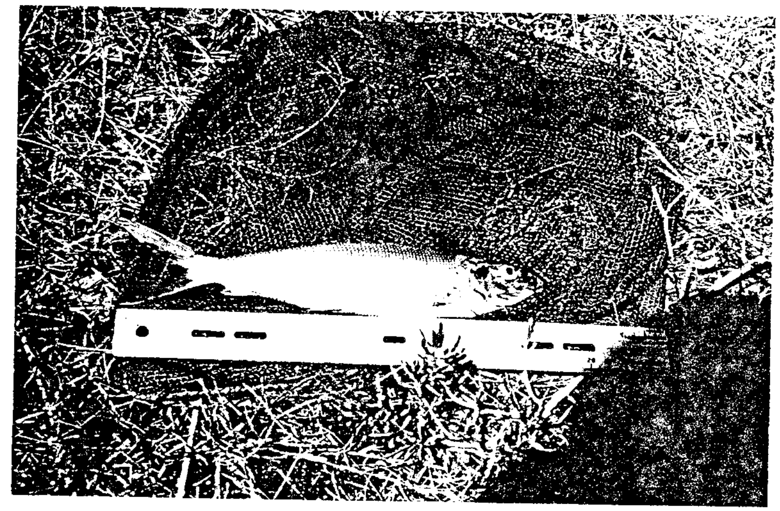


Figure 14. Bonefish (*Abula glossodonta*) caught from the Ala Wai Canal
(Ruler = 12 inches)

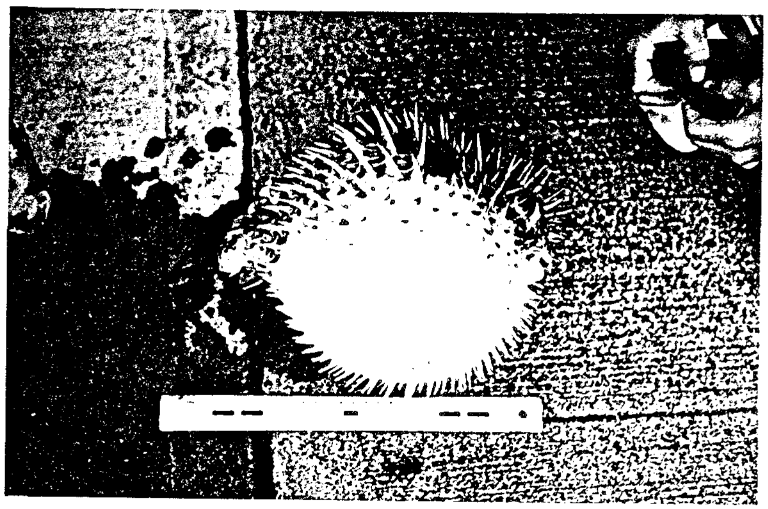


Figure 15. Pufferfish (*Diodox hystrix*) caught from the Ala Wai Canal
(Ruler = 12 inches)

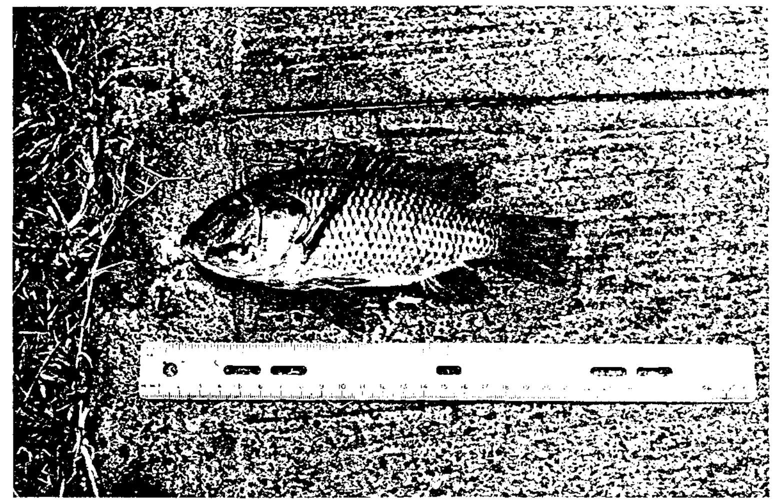
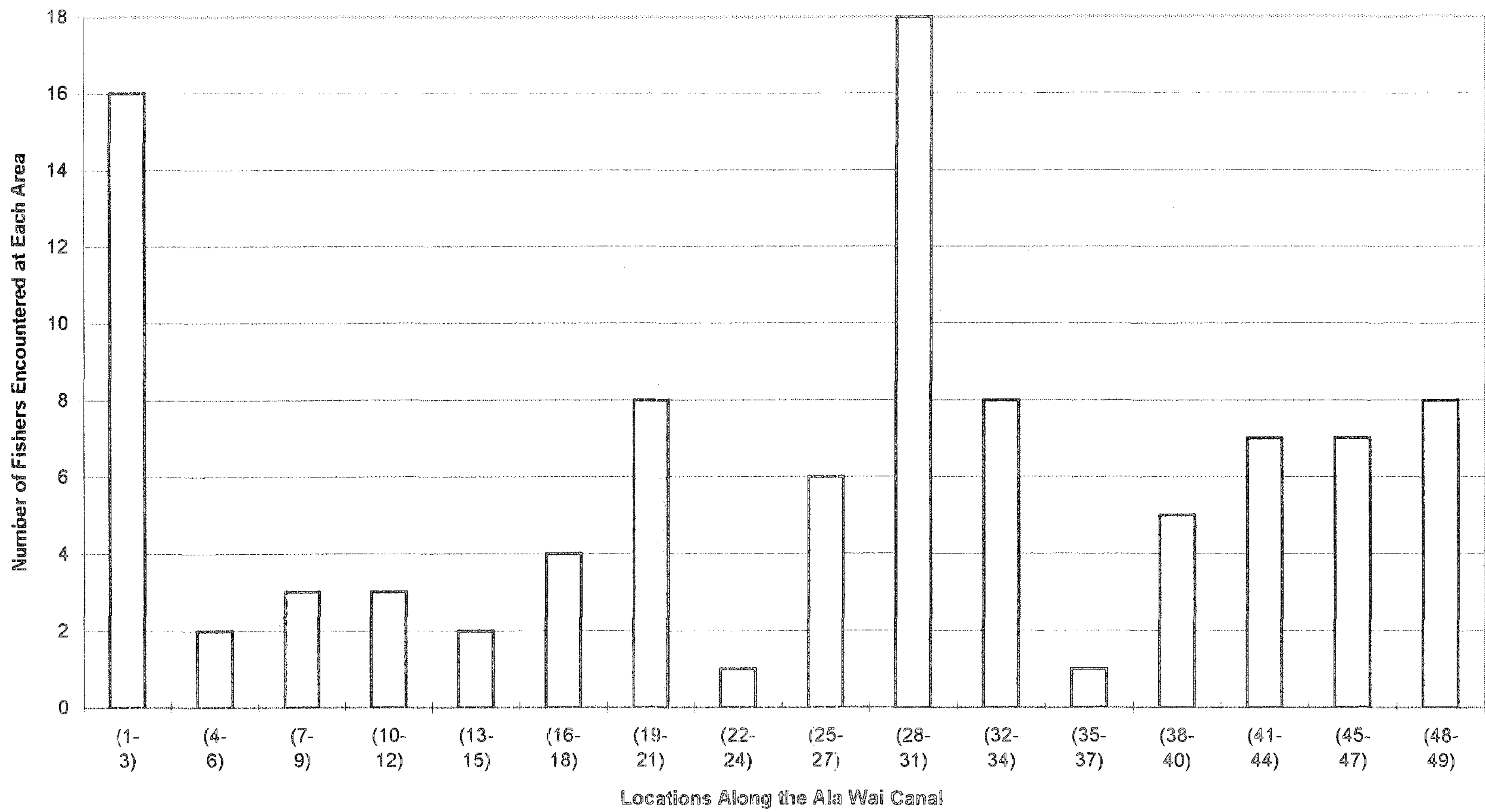


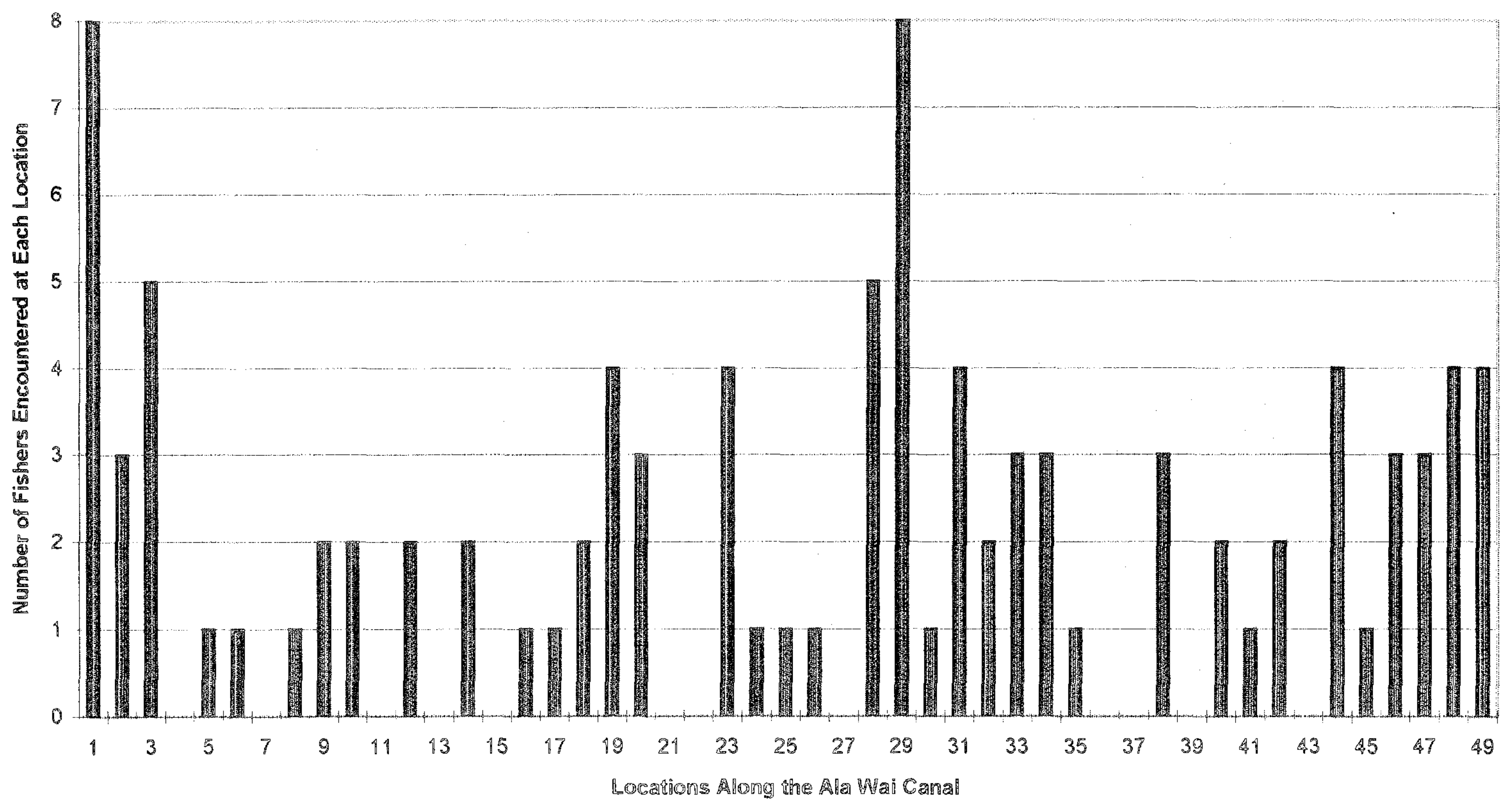
Figure 16. Tilapia (*Tilapia mozambique*) caught from the Ala Wai Canal
(Ruler = 12 inches)

Figure 17. Number of Fishers at Different Areas Along the Ala Wai Canal



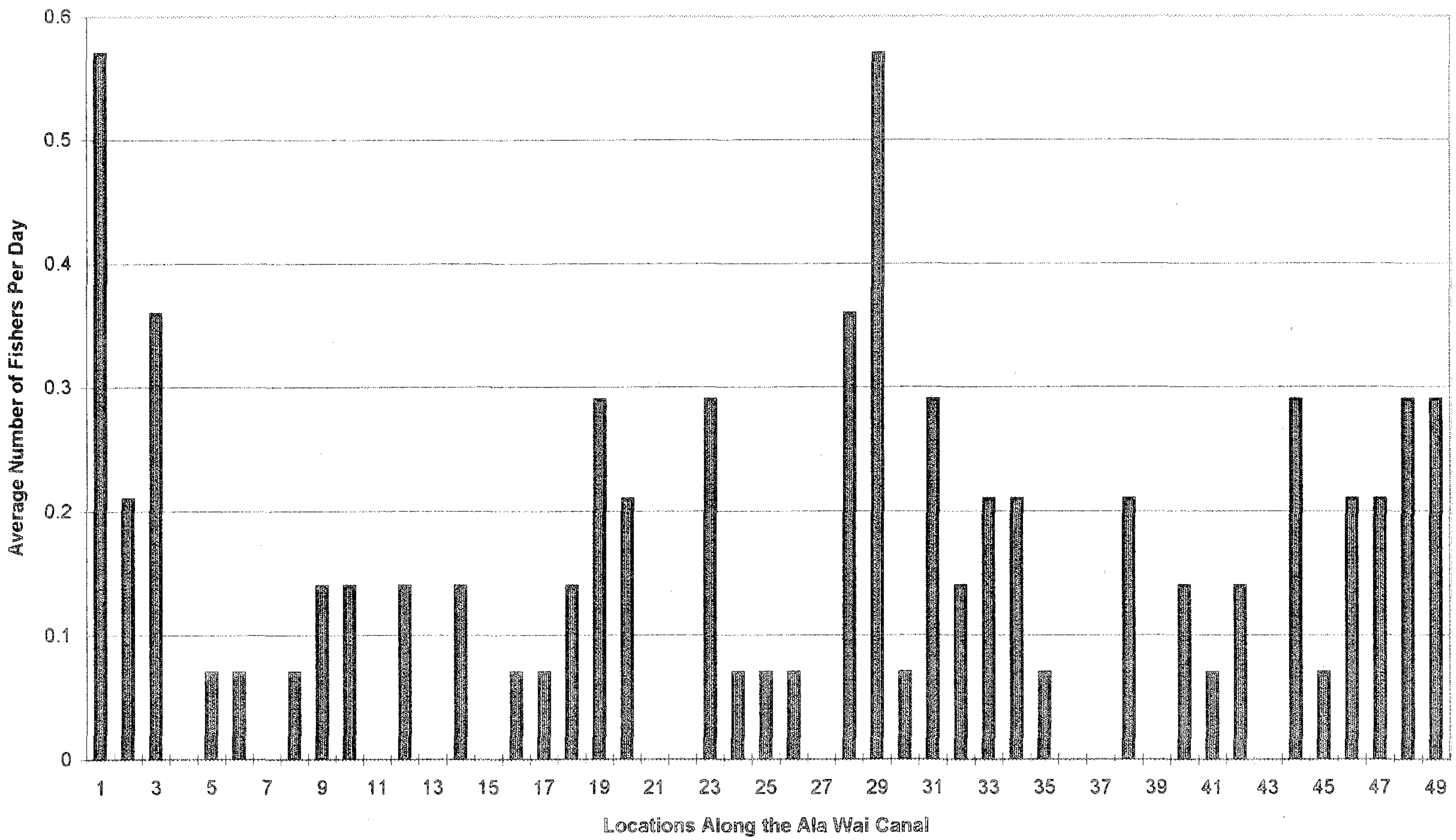
(Total of 99 fishers for this figure due to encountering the same fishers at different locations on the same day.)

Figure 18. Number of Fishers Along the Ala Wai Canal



(Total of 99 fishers for this figure due to encountering the same fishers at different locations on the same day.)

Figure 19. Average Number of Fishers Per Day by Locations at the Ala Wai Canal



(Total of 99 fishers for this figure due to encountering the same fishers at different locations on the same day.)

Figure 20. Percentage of Different Fishing Gear Used by Fishers at the Ala Wai Canal

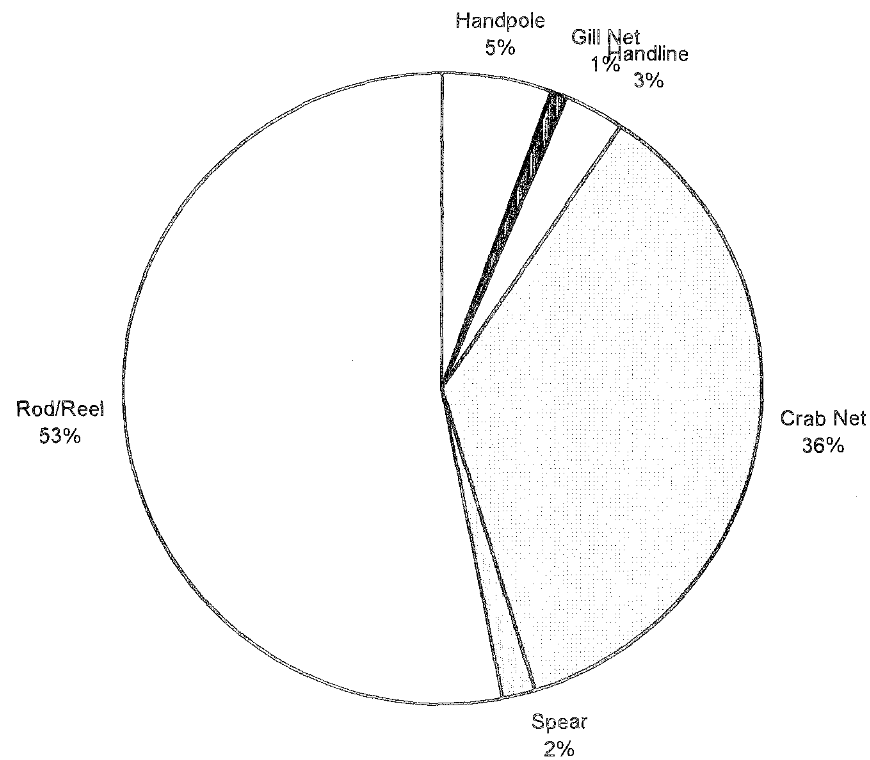


Figure 21. Number of Gear Type Used by Fishers at the Ala Wai Canal

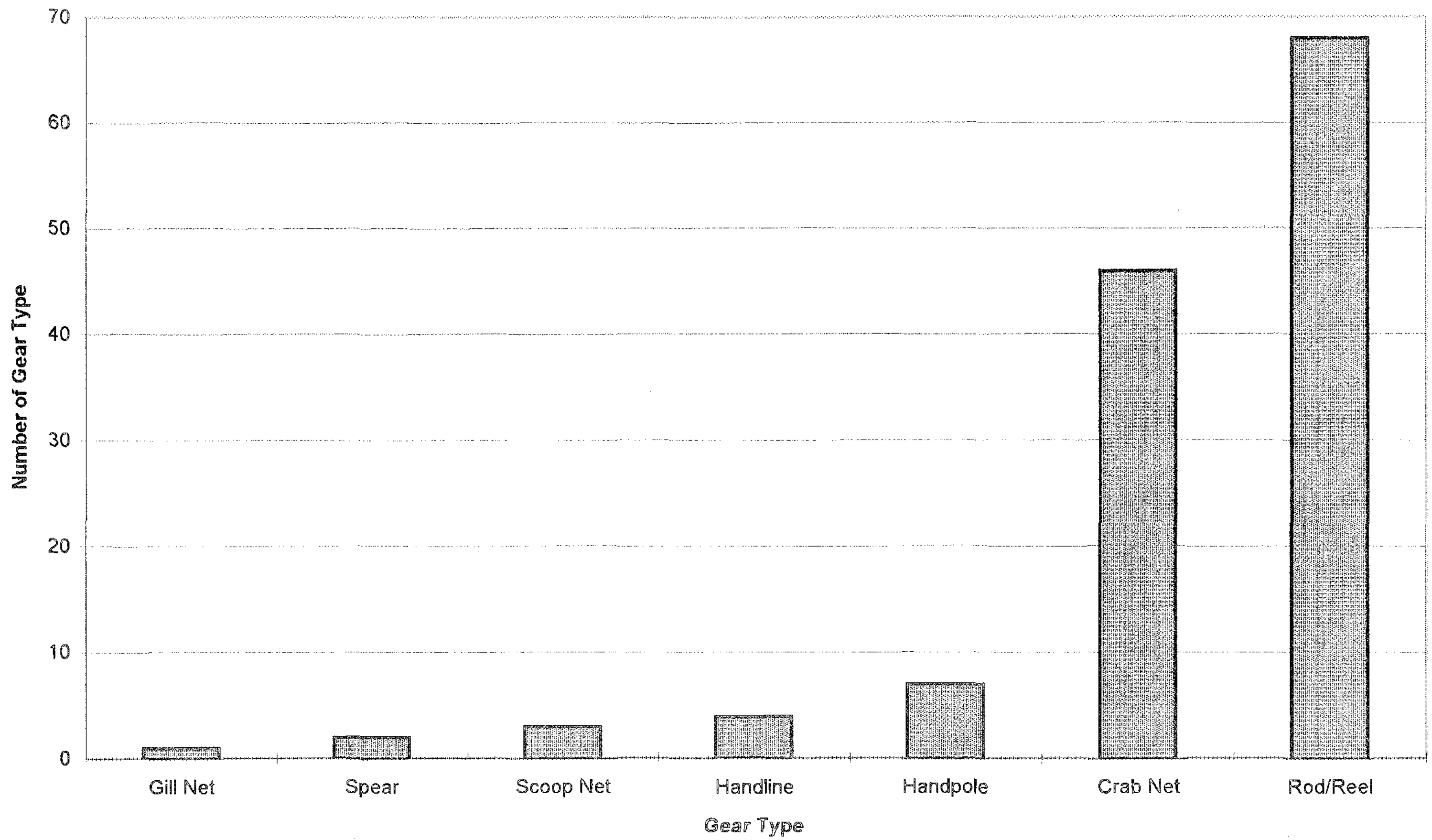
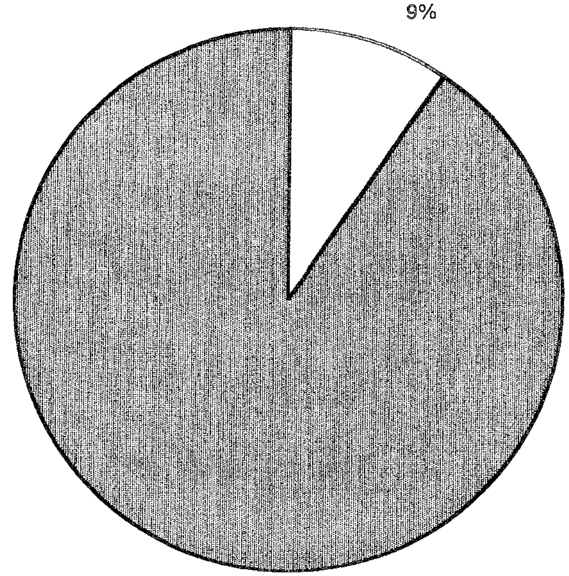
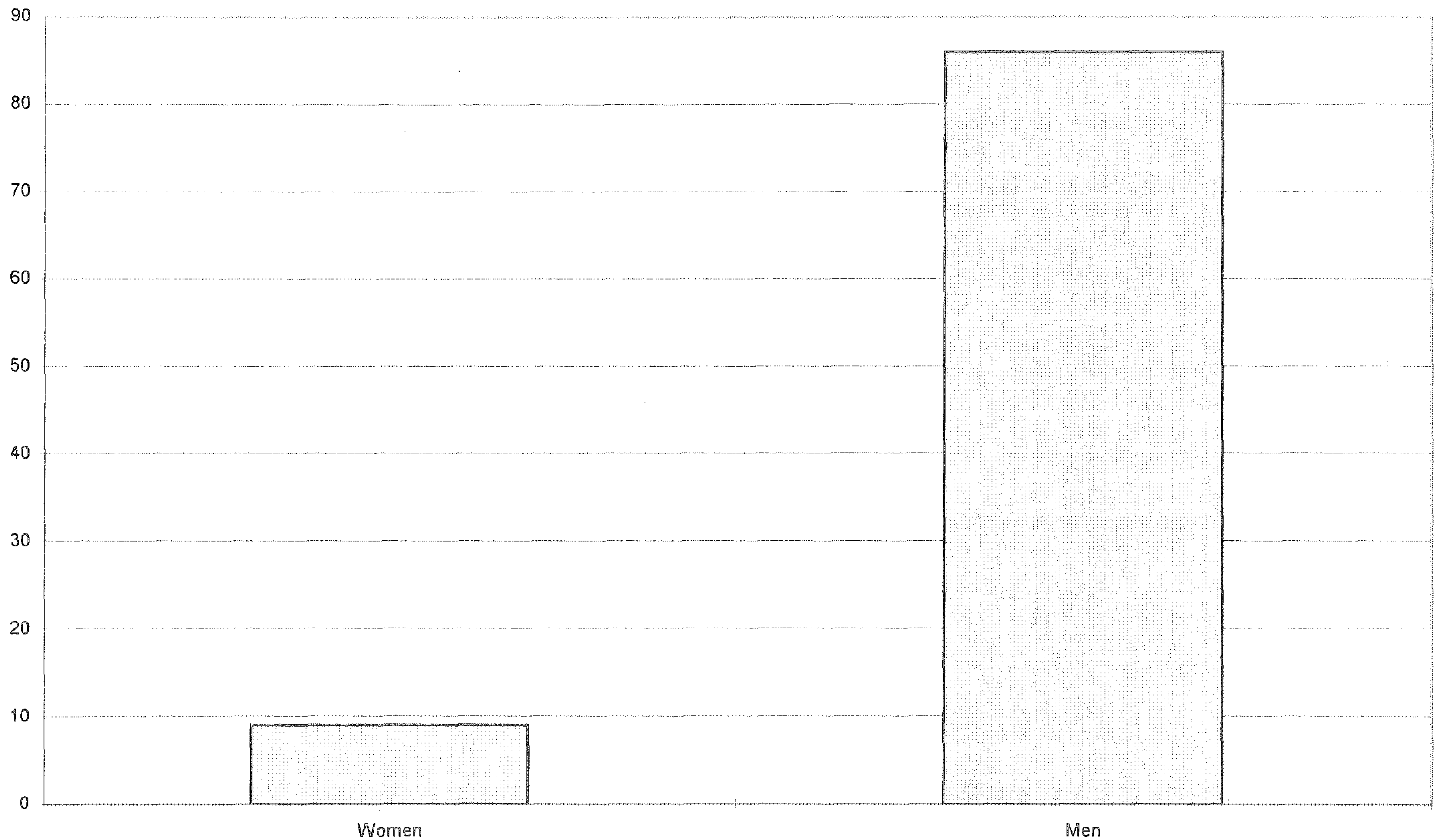


Figure 22. Percentage of Fishers by Sex at the Ala Wai Canal



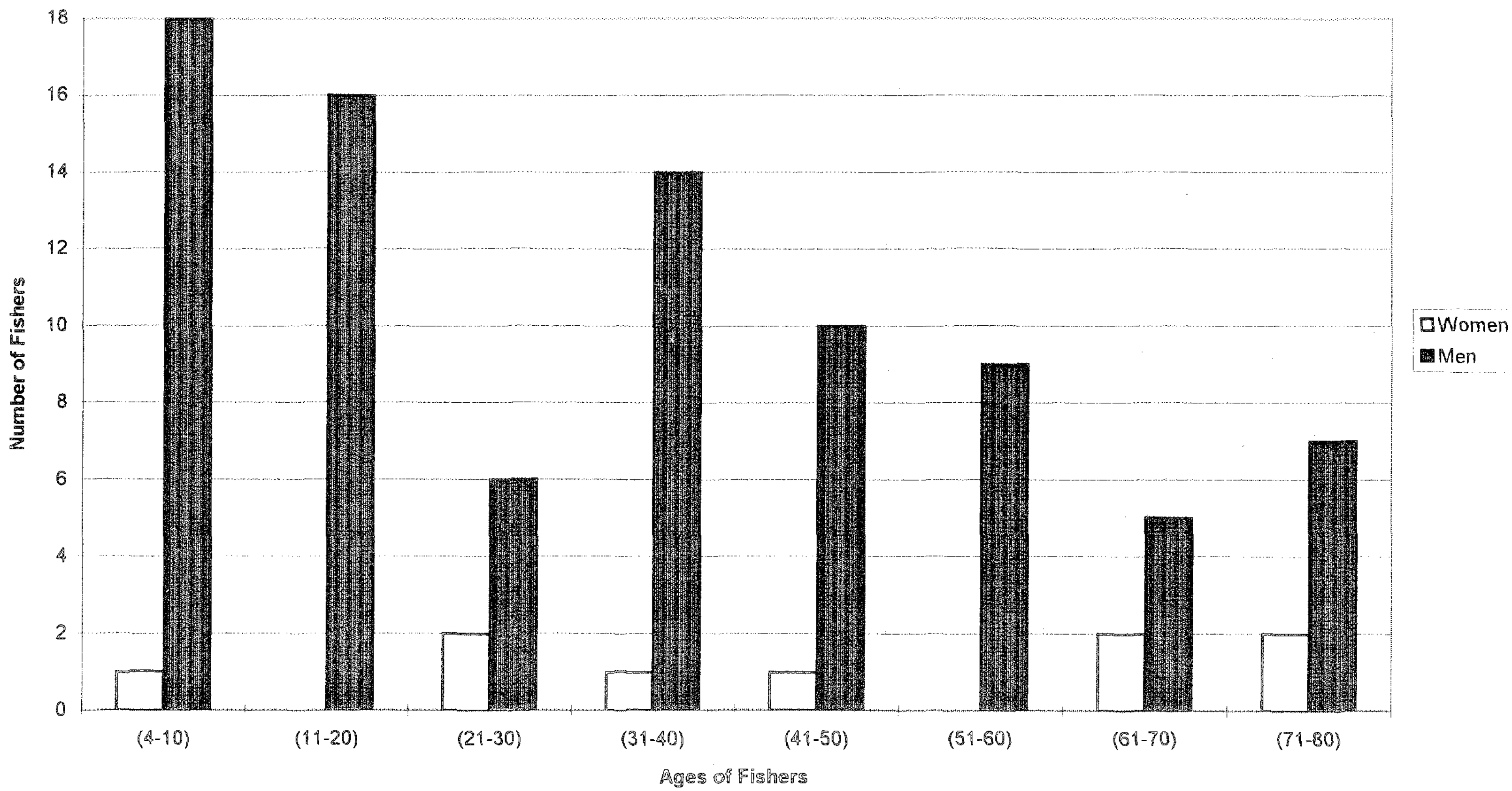
(Total of 95 fishers)

Figure 23. Number of Fishers by Sex at the Ala Wai Canal



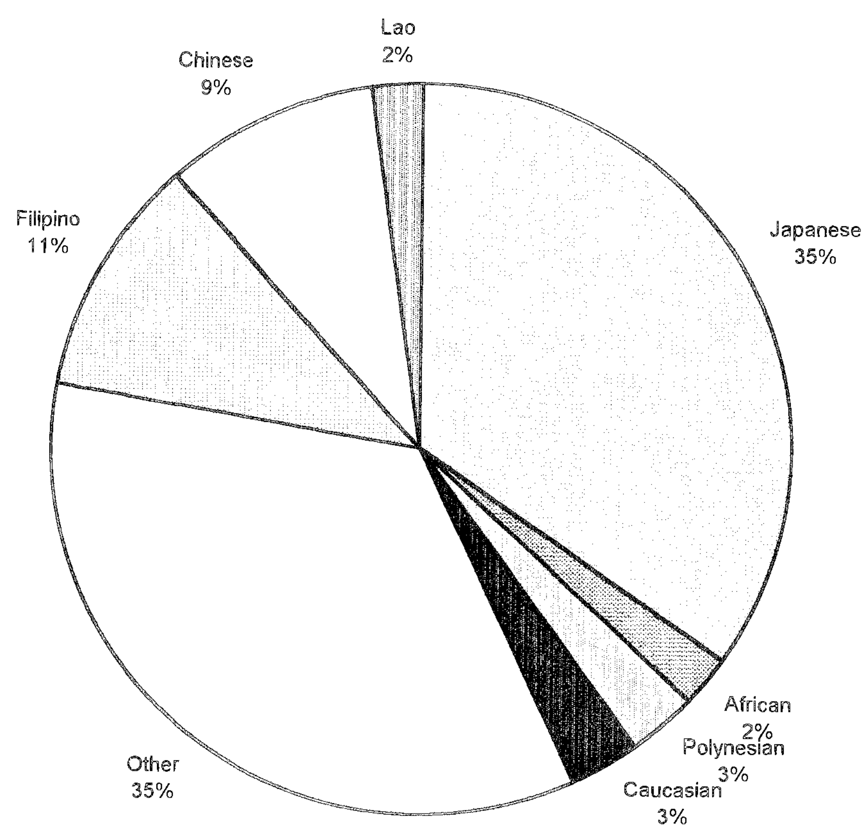
(Total of 95 fishers)

Figure 24. Number of Fishers by Age and Sex at the Ala Wai Canal



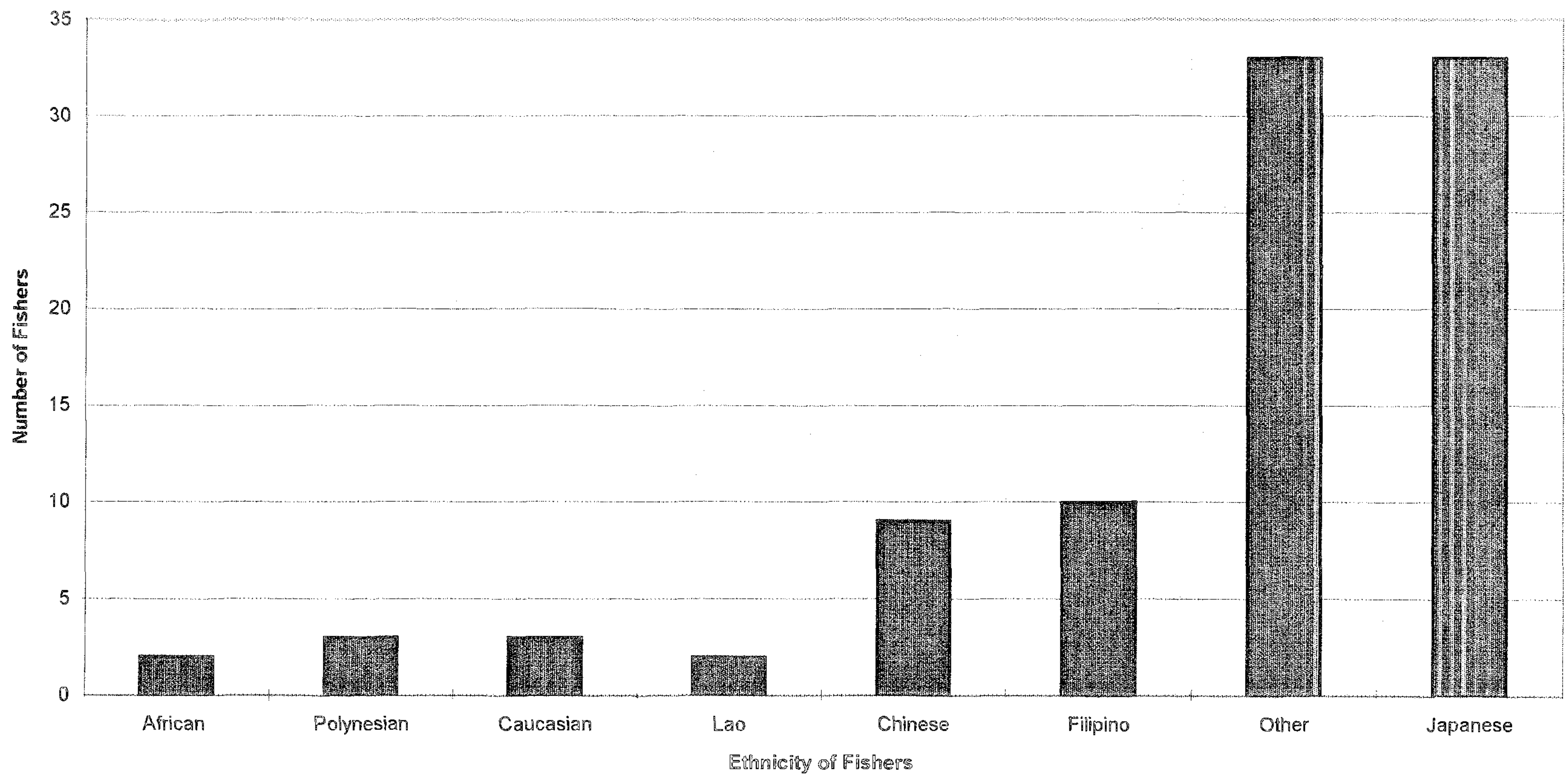
(Total of 95 fishers)

Figure 25. Ethnicity of Fishers at the Ala Wai Canal



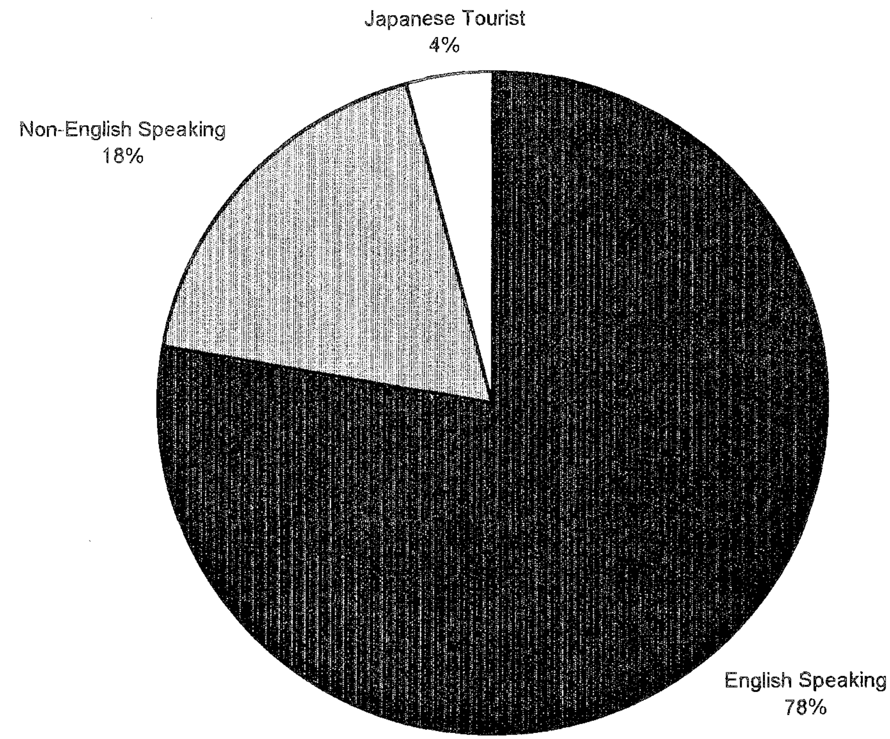
(Total of 95 fishers)

Figure 26. Number of Fishers by Ethnicity at the Ala Wai Canal



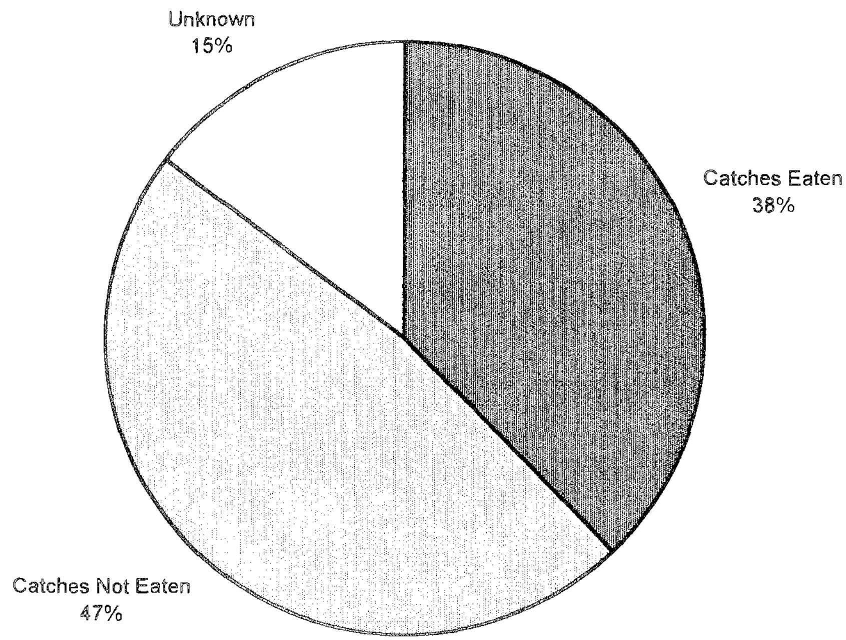
(Total of 95 fishers)

Figure 27. Type of Fishers at the Ala Wai Canal



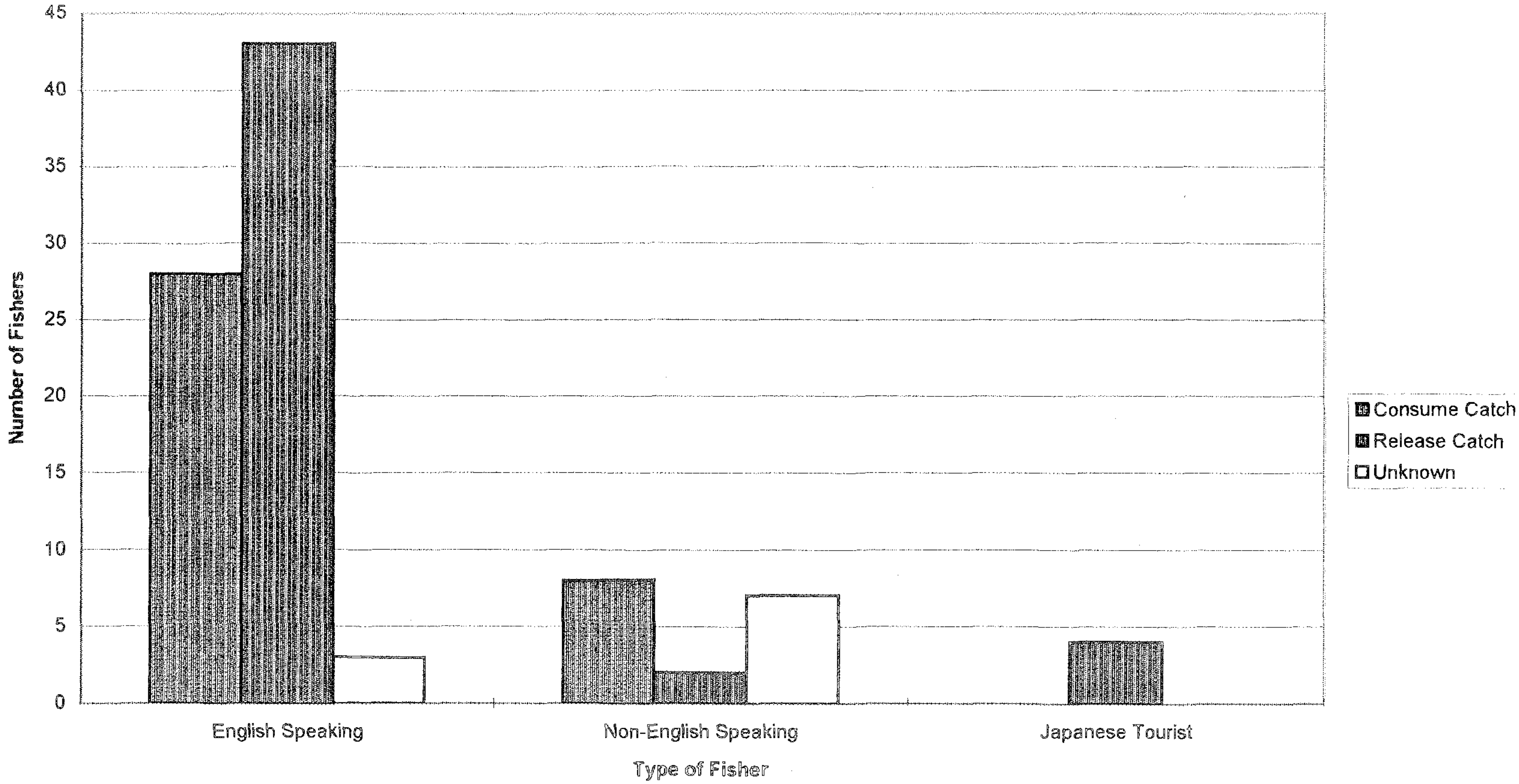
(Total of 95 Fishers)

Figure 28. Disposition of Fishers



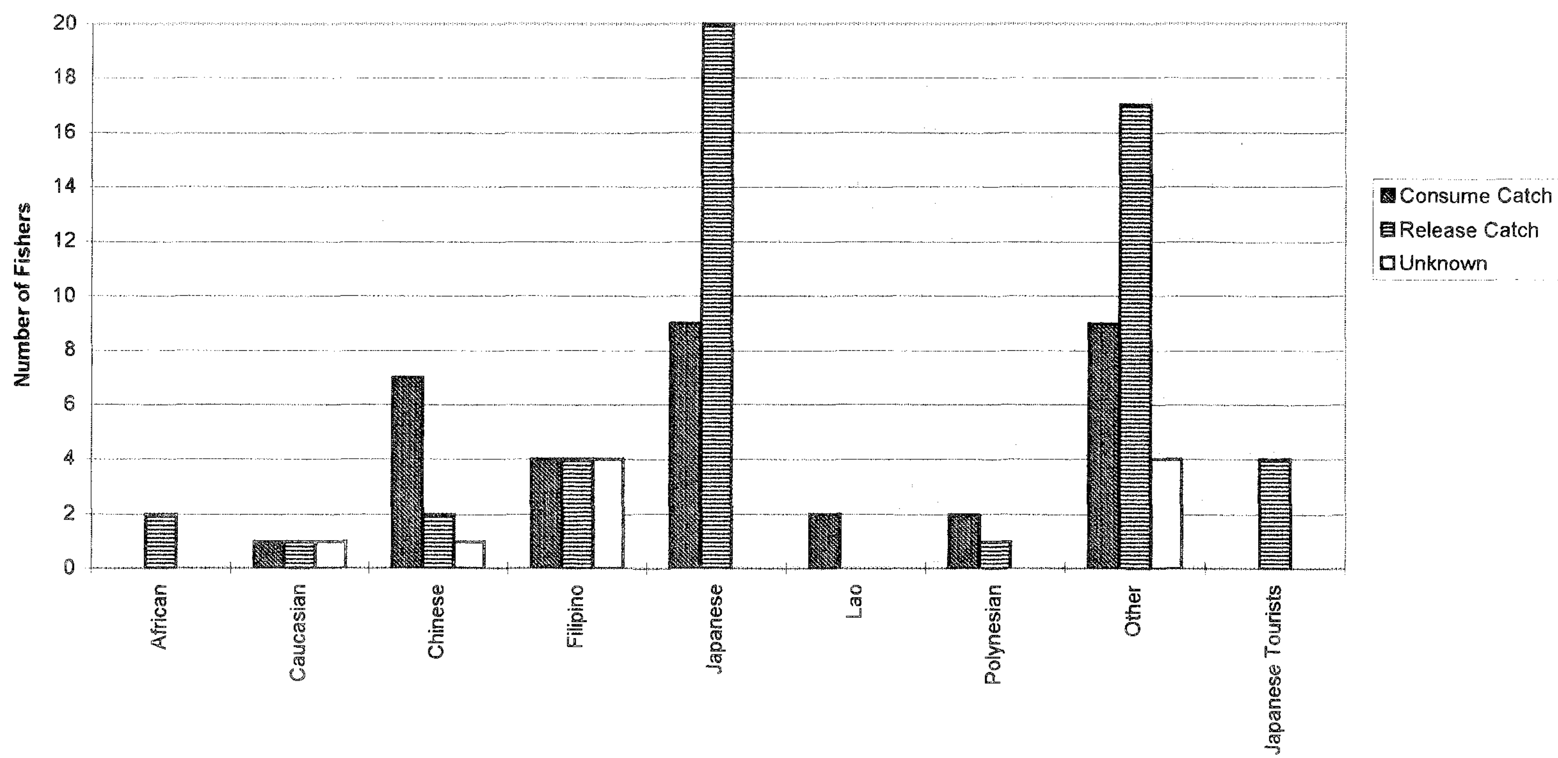
(Total of 95 fishers)

Figure 29. Disposition of Fishers



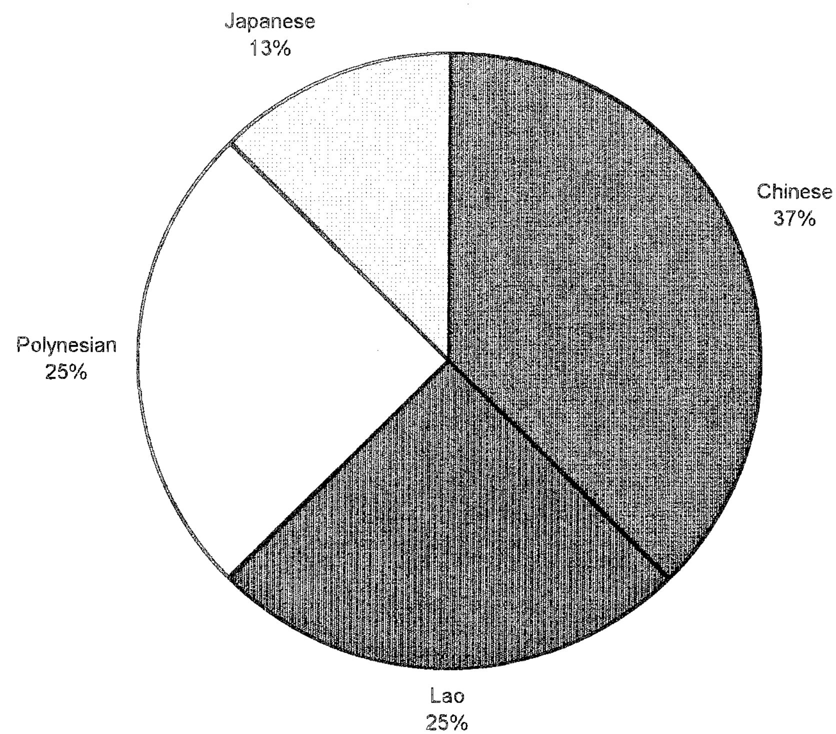
(Total of 95 fishers)

Figure 30. Disposition of Catch by Ethnic Groups at the Ala Wai Canal



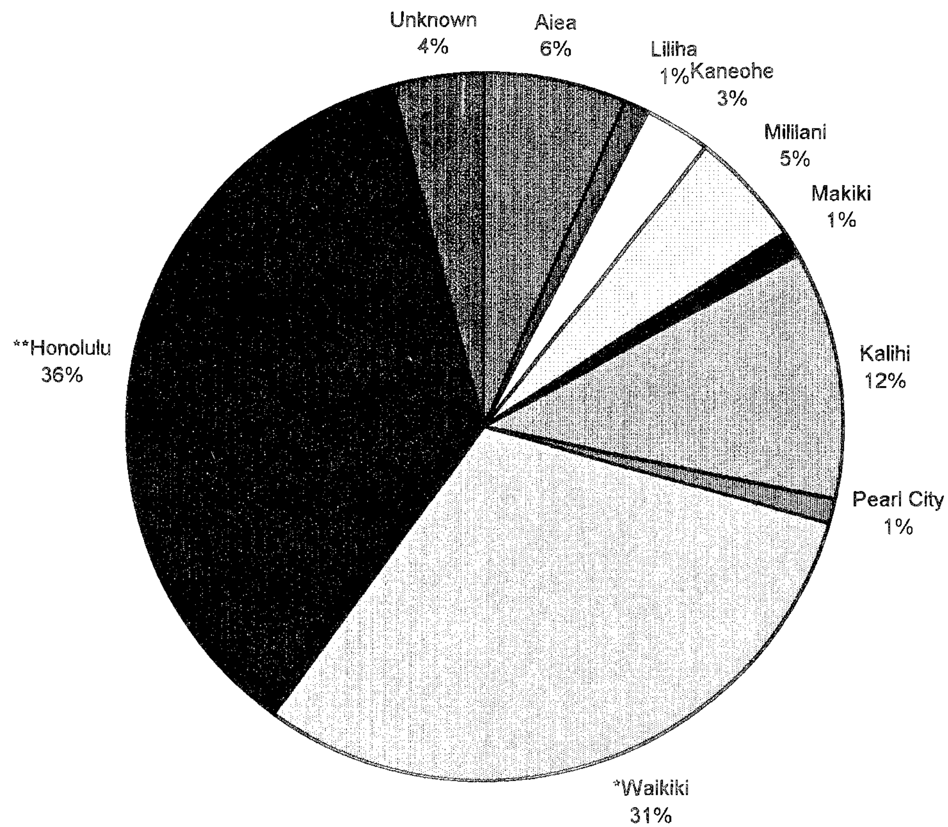
(Total of 95 fishers)

Figure 31. Ethnicity of Non-English Speaking Fishers Consuming Their Catch at the Ala Wai Canal



(Total of 8 Non-English Speaking Fishers)

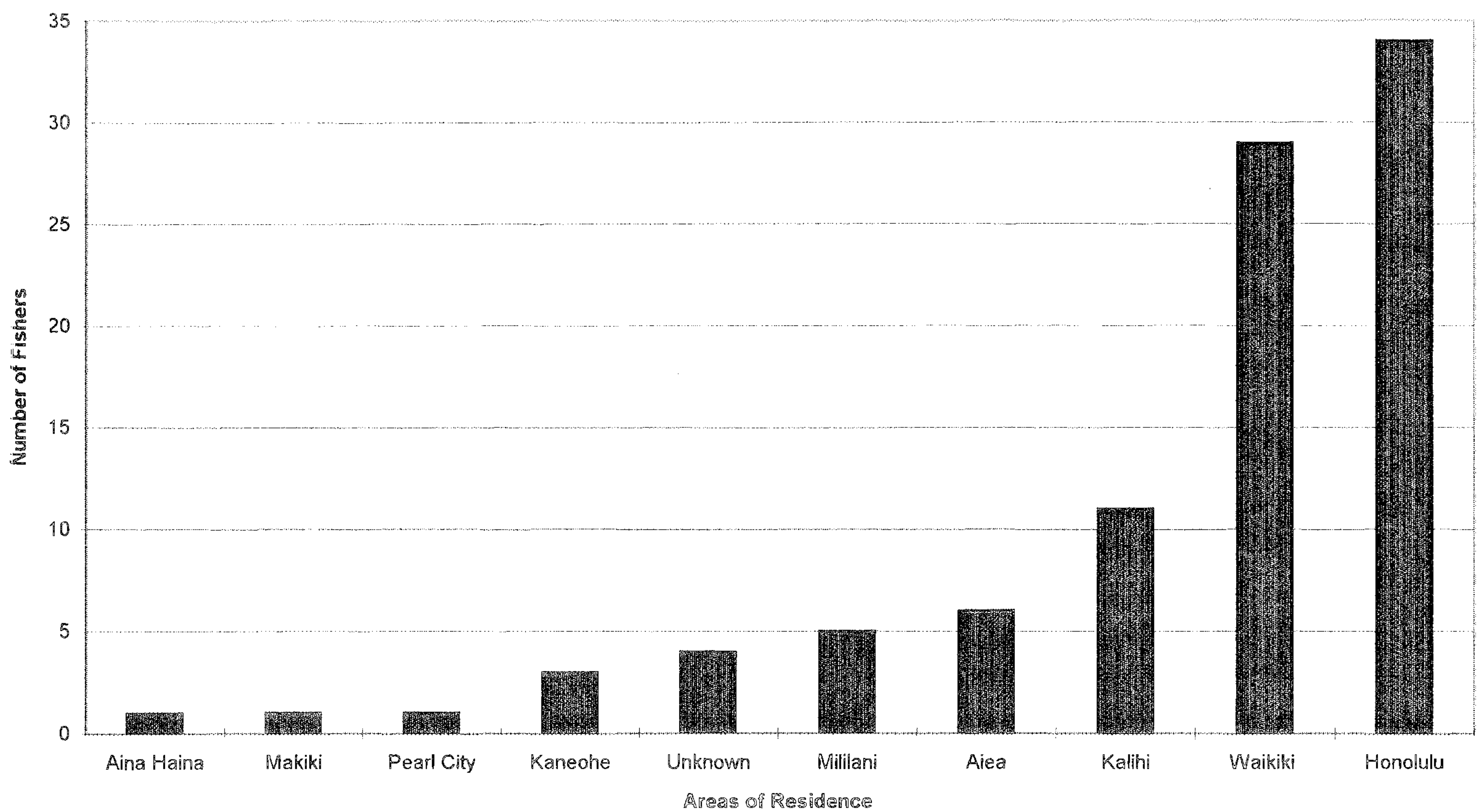
Figure 32. Areas of Residence of the Fishers at the Ala Wai Canal



(Total of 95 fishers)

*Waikiki accounts for the area from Daimond Head to Ala Moana Center.
**Honolulu accounts for the metropolitan area surrounding Waikiki.

Figure 33. Number of Ala Wai Fishers from Various Areas of Residence



(Total of 95 fishers)

Figure 34. Total Amount of Catch at the Ala Wai Canal

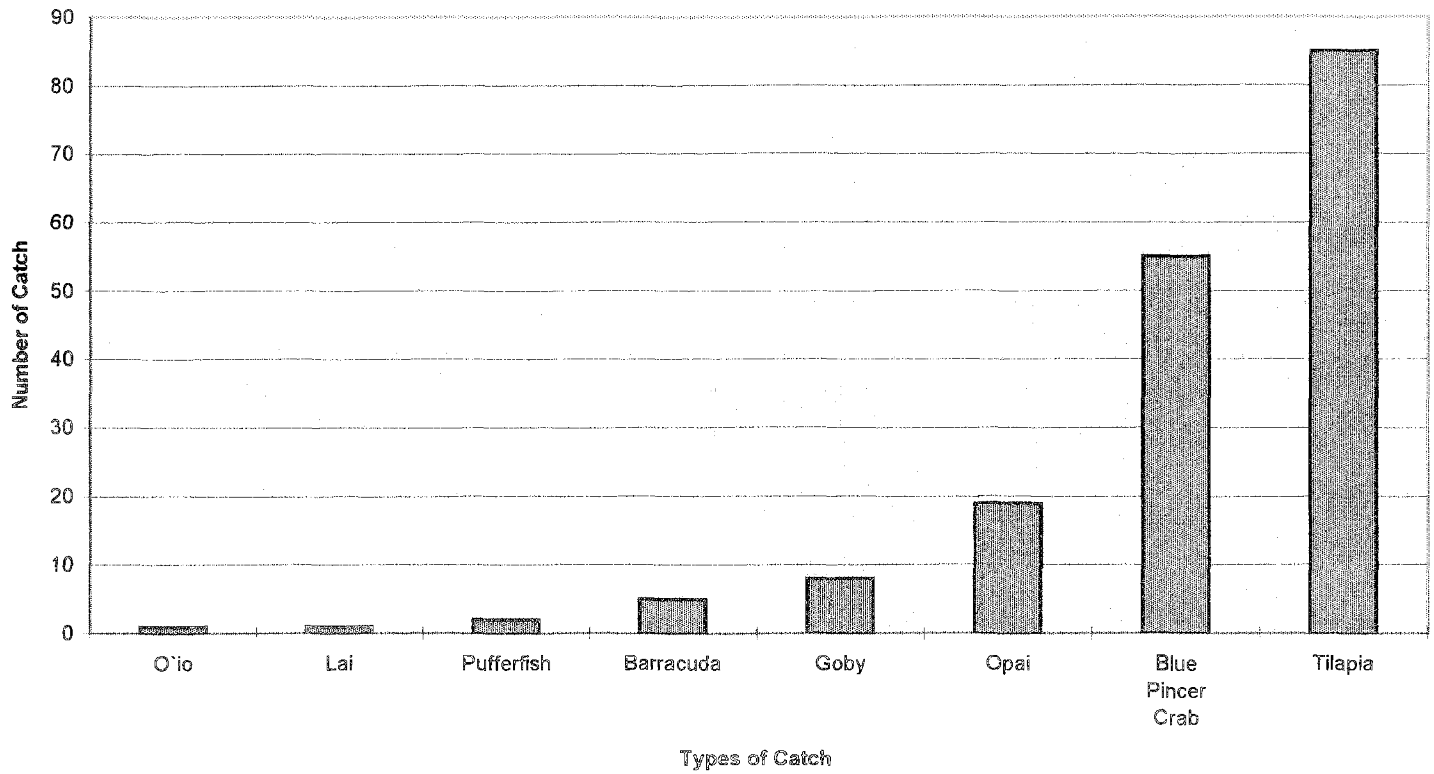


Figure 35. Disposition of the Number of Catches at the Ala Wai Canal

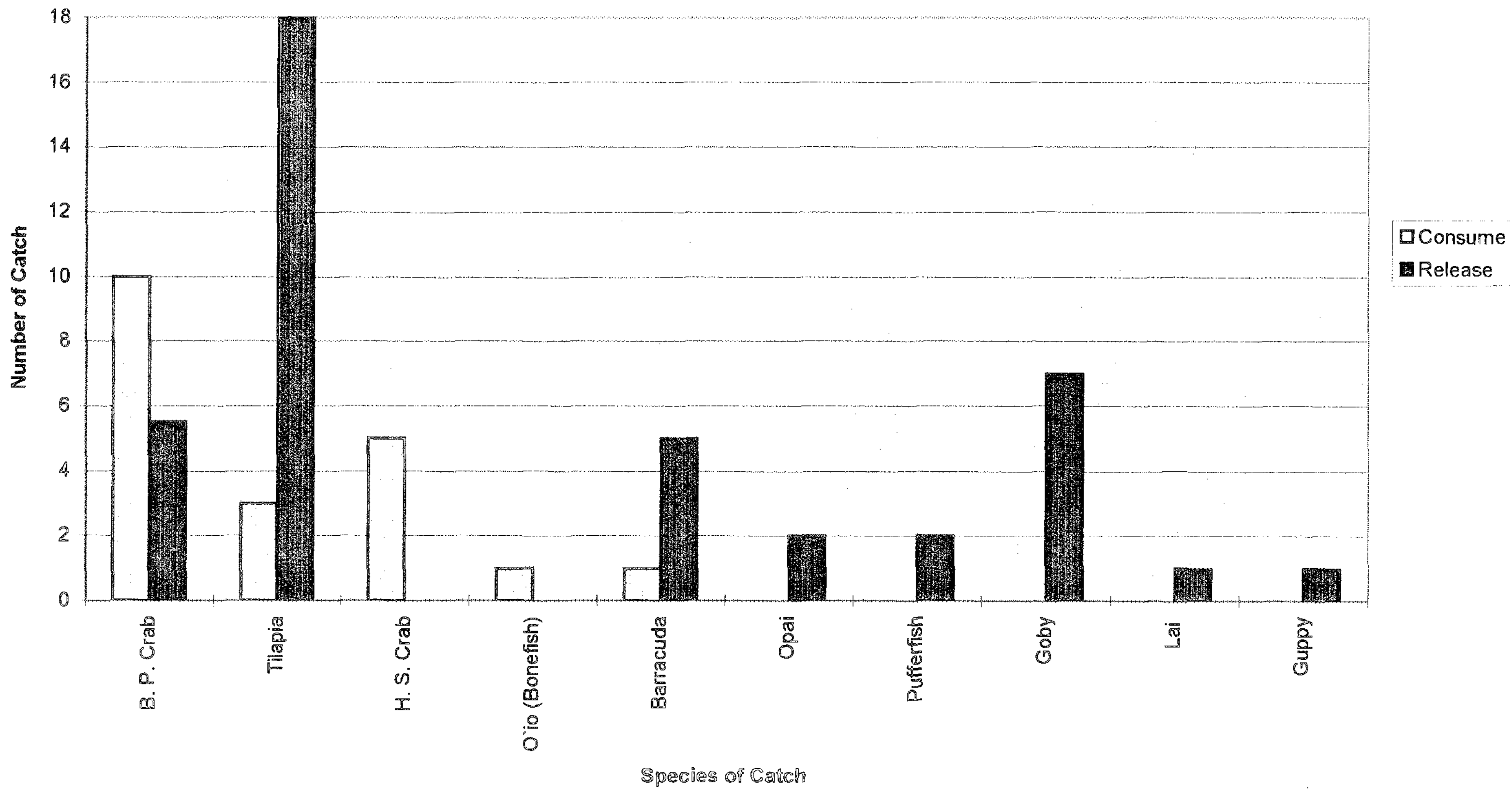


Figure 36. Average Amount of Fishers at Three Intervals a Day Over a Week

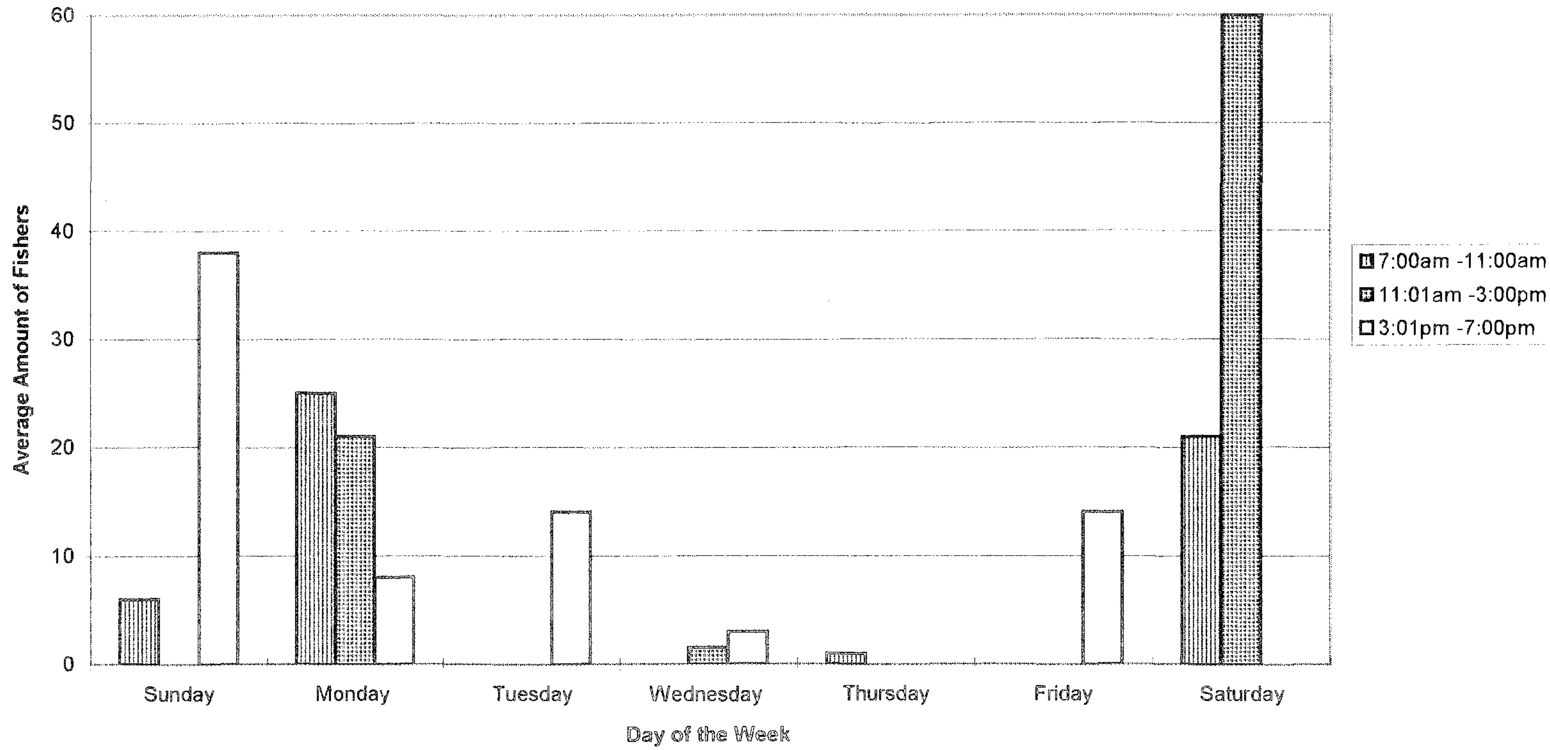


Figure 37. Total Number of Catch at Three Intervals During the Day

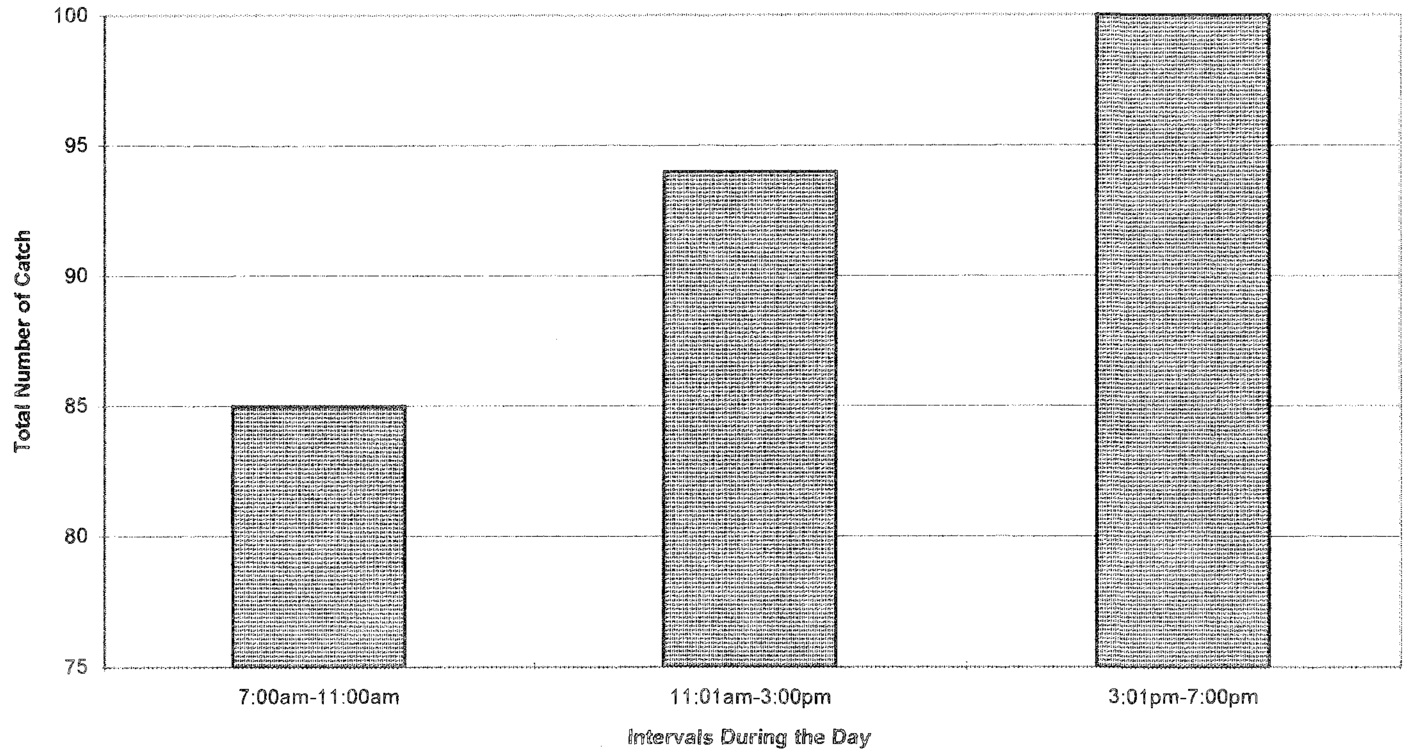
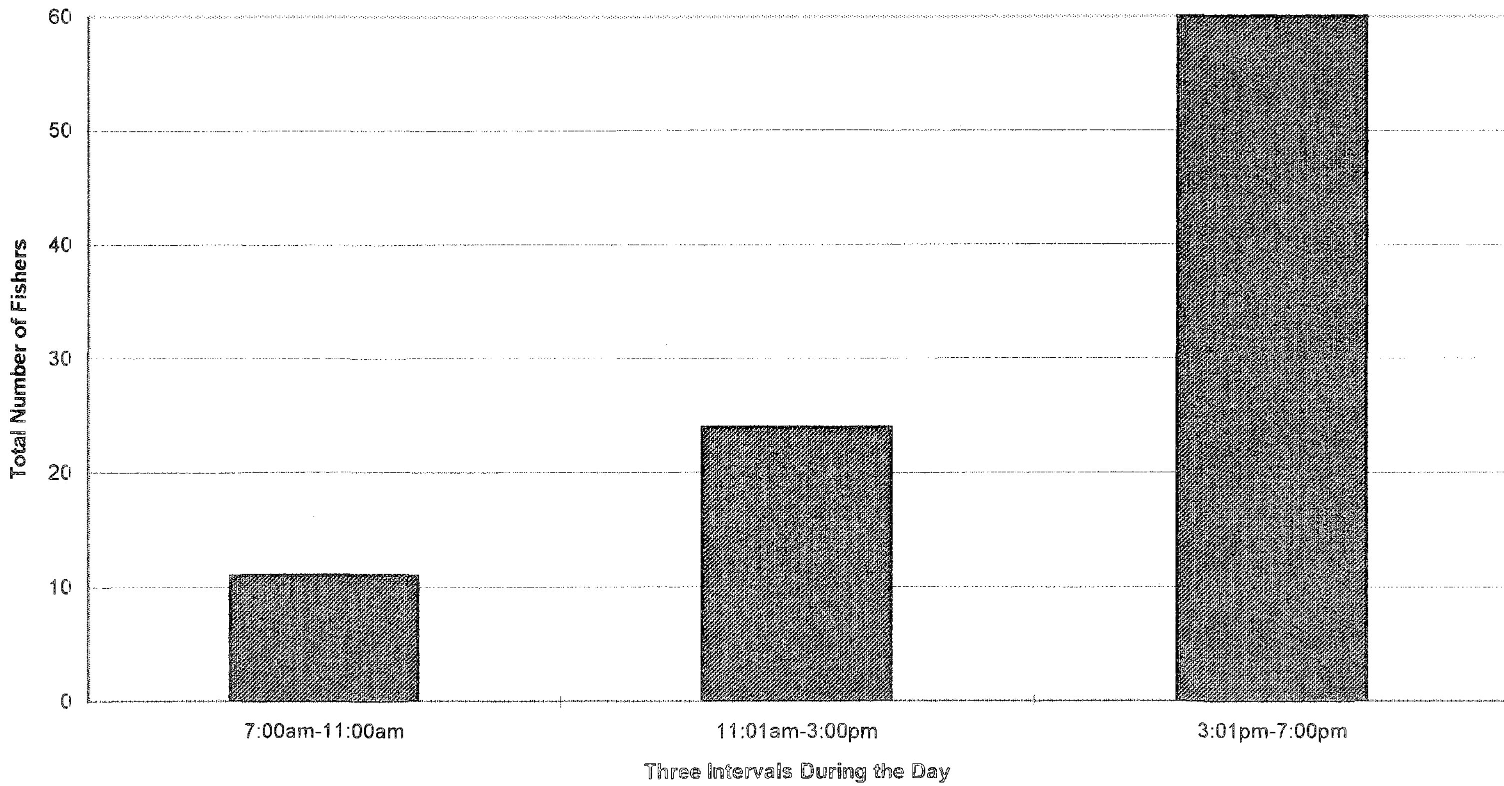


Figure 38. Total Number of Fishers at Three Intervals During the Day



(Total of 95 fishers)

Figure 39. Mean Average Catch Per Unit of Effort (CPUE) at Three Intervals During the Day

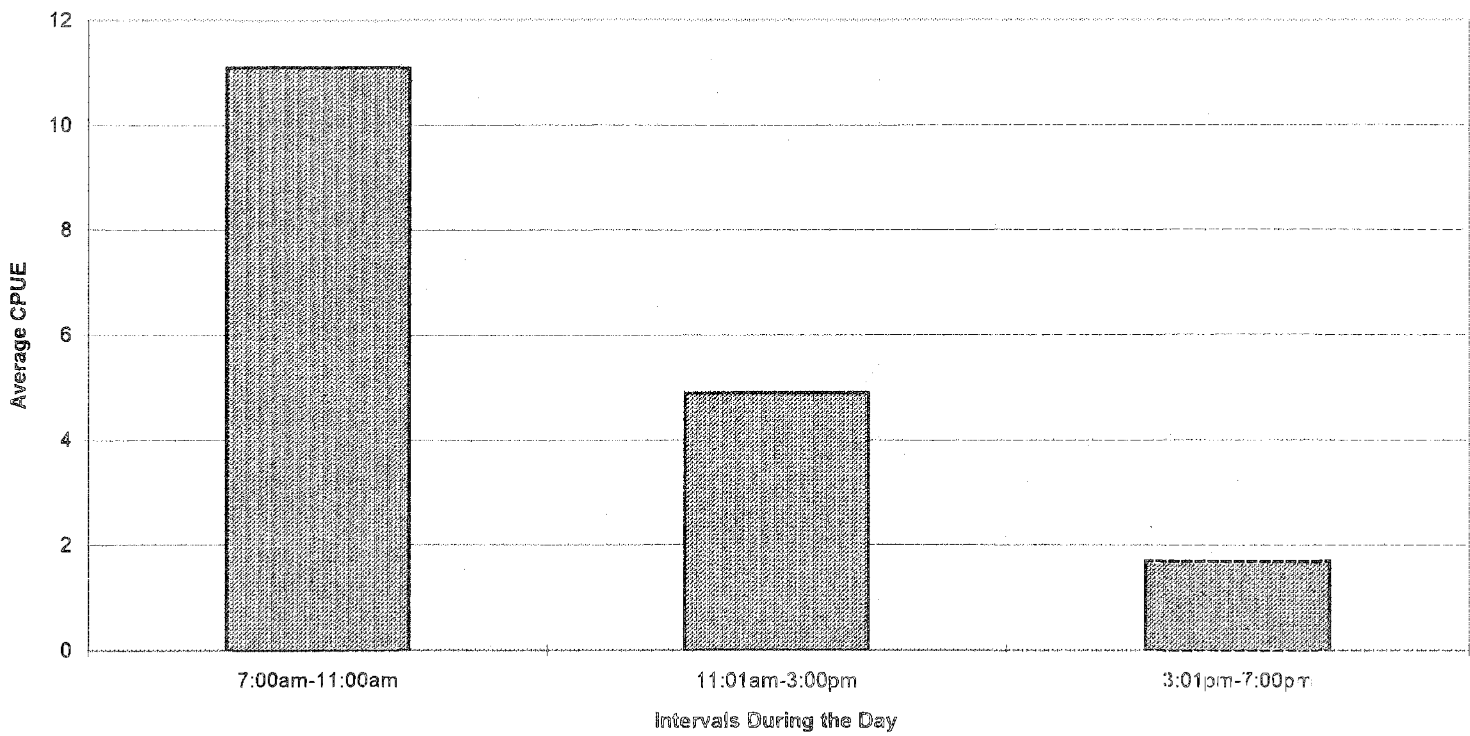
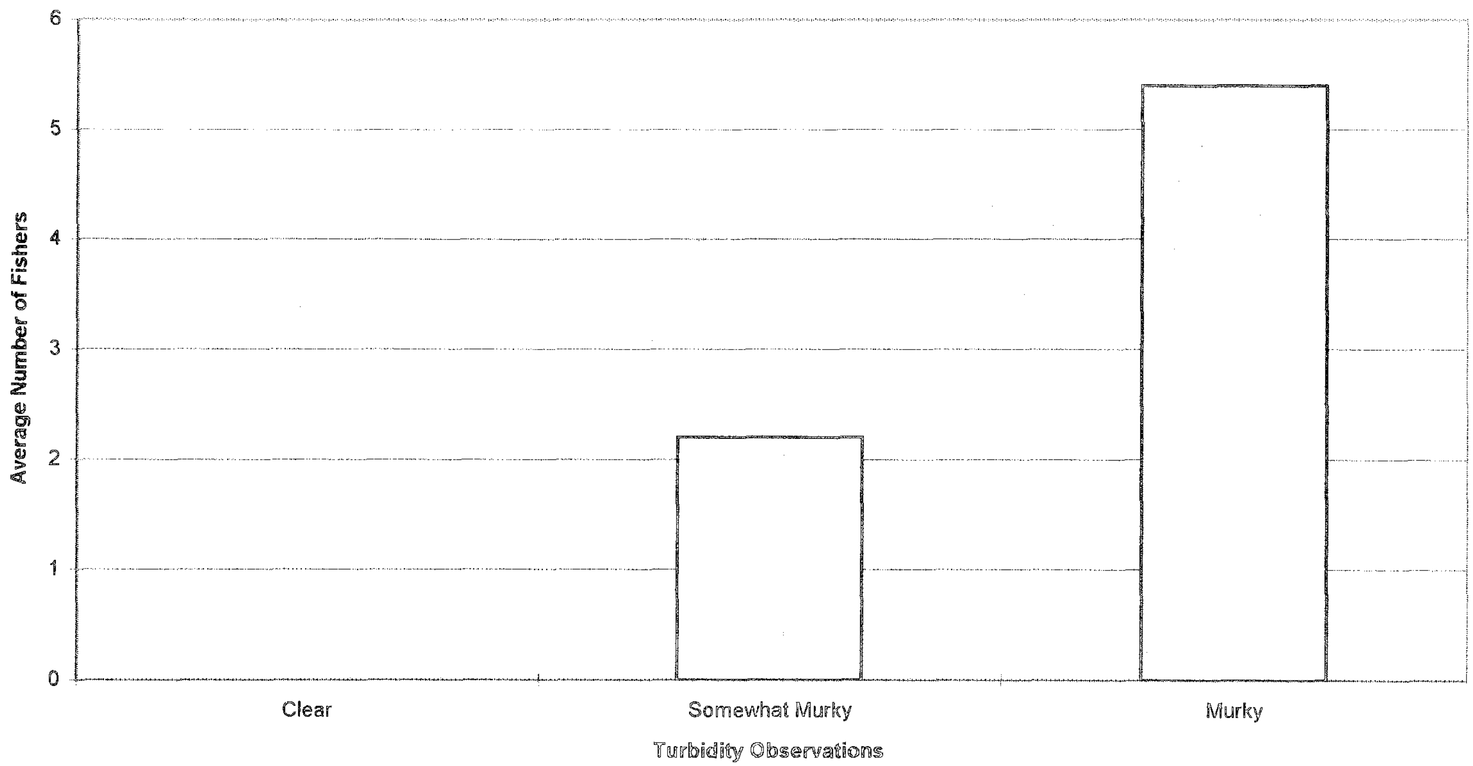


Figure 40. Average Number of Fishers at Various Turbidities



(Clear Observations were never made during the times surveyed.)

Figure 41. Average Number of Fishers Observed During Different Odor Observations at the Ala Wai Canal

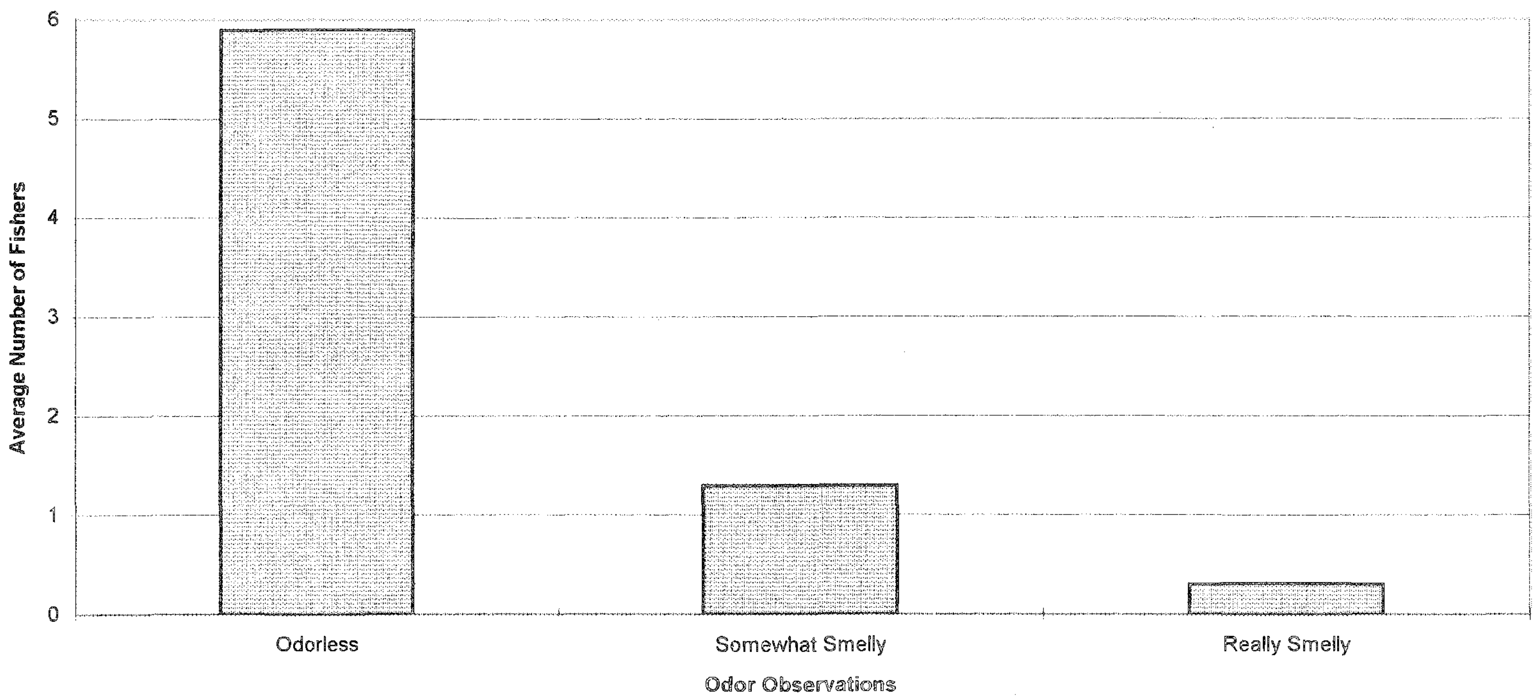


Figure 42. Average Number of Fishers Observed During Various Debris Observations at the Ala Wai Canal

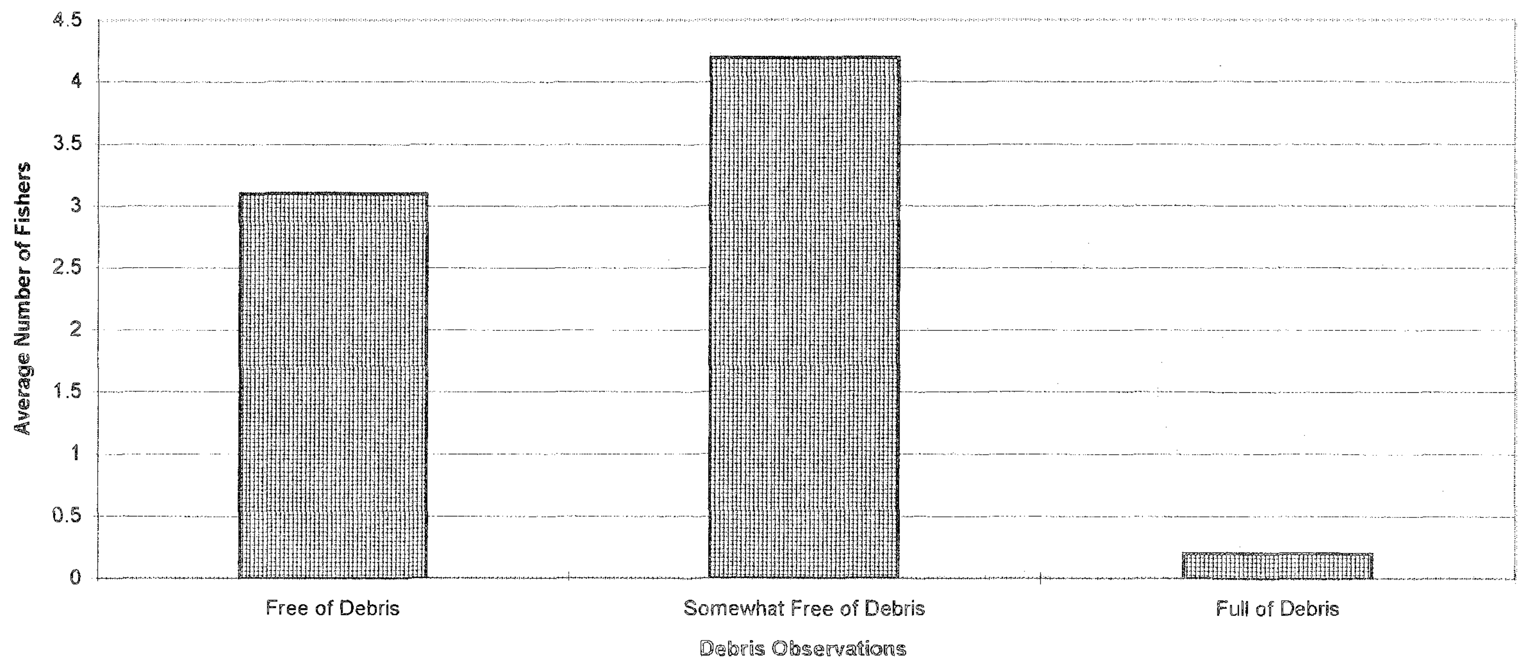


Figure 43. Average Number of Fishers at Various Flooding Observations

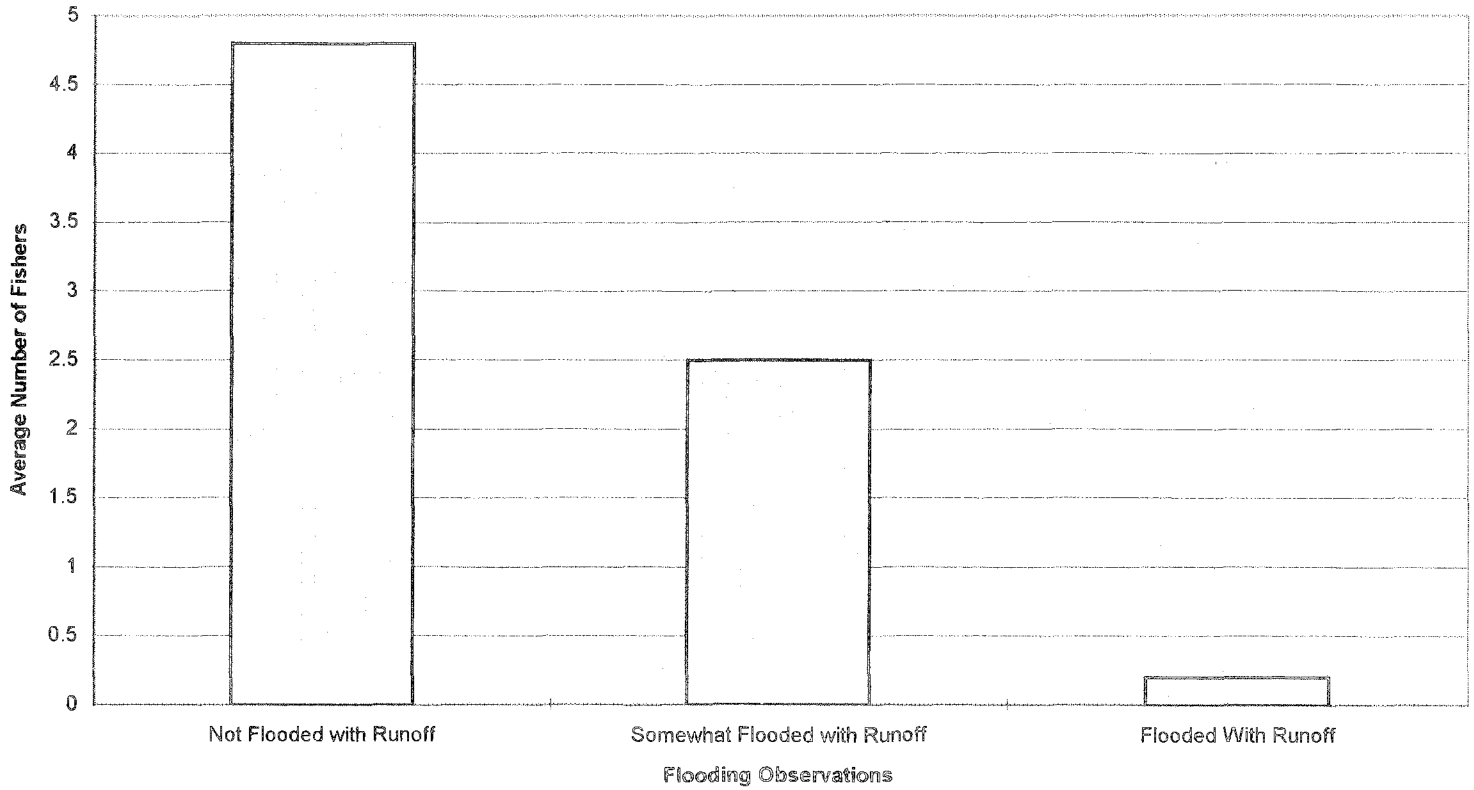
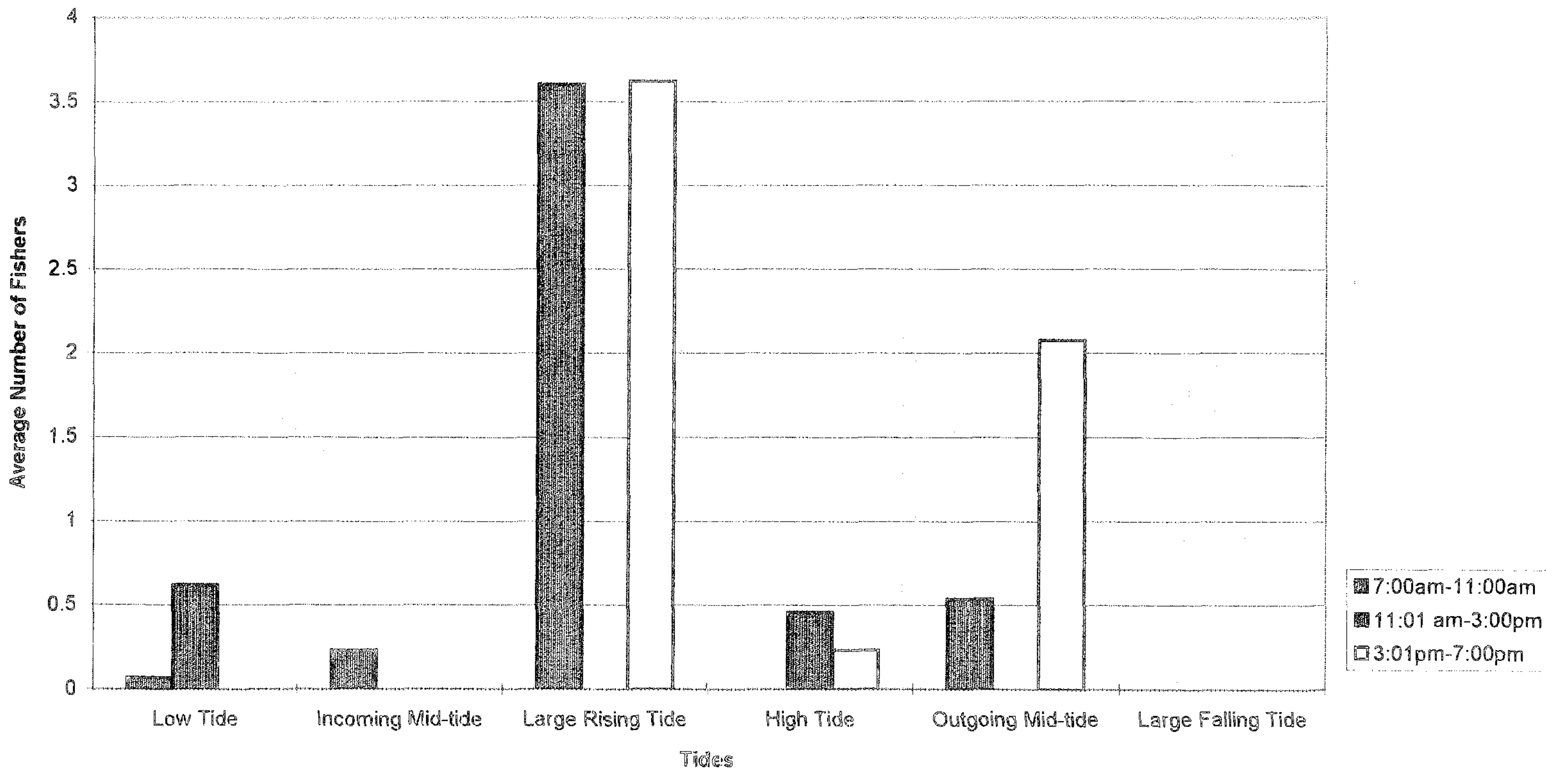


Figure 44. Average Number of Fishers Observed During Various Tides at the Ala Wai Canal



(Not all of the tide observations was observed during data collection.)

APPENDIX B

TABLES 1-8

Table 1. Summary of the Number of Hours Sampled

Day	Date	7:00 a.m. -11:00 a.m.	11:01 a.m. -3:00p.m.	3:01p.m. -7:00 p.m.	Total
Week I					
Thursday	5\22\97	2.5	*	*	2.5
Friday	5\23\97	2.5	*	2.5	5
Week II					
Sunday	5\25\97	1.5	*	2	305
**Monday	5\26\97	2	2	3	7
Tuesday	5\27\97	*	*	2	2
Wednesday	5\28\97	*	*	2	2
Thursday	5\29\97	1.5	*	*	1.5
Saturday	5\31\97	1.5	2	2	5.5
Week III					
Monday	6\2\97	1.5	1.5	1.5	4.5
Tuesday	6\3\97	*	*	1.5	1.5
Wednesday	6\4\97	1	1.5	*	2.5
Thursday	6\5\97	1.5	1	*	2.5
Week IV					
Friday	6\13\97	*	*	1.5	1.5
					343
*Times Not Surveyed					
**Holiday					

Table 2. Summary of Fishers by Ethnicity

Ethnicity		Avg. Fishers/ Day	Mean Avg. Age	Areas of Residence	% Consuming	Type of Catches
African	ES	0.17	30.5	Waikiki, Pearl City	0	0
Caucasian	NES	0.08	75	Waikiki	?	0
	ES	0.17	31	Honolulu	50%	0
Chinese	NES	0.25	18	Honolulu, Waikiki	67%	Tilapia
	ES	0.58	52	Honolulu, Waikiki, Aiea	71%	Tilapia, ō'io, bait: guppies
Filipino	NES	0.25	52	Honolulu	?	0
	ES	0.67	41	Aiea, Kalihi	50%	Tilapia
Japanese	NES	0.08	7	Waikiki	100%	bait: shrimp, goby
	ES	2.42	35	Honolulu, Waikiki, Kalihi, Kaneohe, Mililani	28%	Tilapia, Pufferfish, Blue Pincer Crab, Lai, Barracuda, bait: shrimp, goby
	Tourist	0.33	20	Waikiki	0	0
Lao	NES	0.17	75	Waikiki	100%	Blue Pincer Crab
Polynesian	NES	0.25	32	Waikiki	67%	Blue Pincer Crab
Other	NES	0.08	35	Waikiki	?	0
	ES	2.33	27	Kalihi, Honolulu, Waikiki, Liliha, Aina Haina, Aiea	36%	Blue Pincer Crab, Hawaiian Crab, Tilapia, Pufferfish, Barracuda

NES= Non-English Speaking
ES= English Speaking

?= Unknown due to information not being revealed.

Table 3. Common, Hawaiian, and Scientific Names of Species Fished in the Ala Wai Canal

	Common Name	Hawaiian Name	Scientific Name
Fish:	Barracuda	*kaku*	*Sphyraena barracuda*
	Bonefish	*ō`io*	*Abula glossodonta*
	Hawaiian Flagtail	*āholehole*	*Kuhlia sandvicensis*
	Various Species of Jack	*papio*	genus: Carrangidae
	Leatherback	*lai*	*Scomberoides lysan*
	Porcupine Pufferfish	*kokala*	*Diodox hystrix*
	Threadfin	*moi*	*Polydactylus sexfilis*
	Tilapia	/	*Tilapia mozambique*
Crab:	Blue Pincer Crab	*pāpa`i*	*Thalamita crenata*
	Hawaiian Swimming Crab	*pāpa`i*	*Podophthalmus vigil*
	Samoan Crab	*pāpa`i*	*Scylla serrata*

Table 4. Length and Weight of Barracuda, Bonefish, and Blue Pincer Crab (May-June 1997)

	Standard Length (cm)	**Total Length (cm)**	**Weight (g)**
Sphyraena barracuda	35.5	40	250
Albula glossodonta	20	25	4.75
Thalamita crenata	**Carapace Length (cm)**	**Carapace Width (cm)**	**Weight (g)**
1	3.1	2.7	
2	3.5	2.4	
3	5.1	3.3	
4	5.2	3.4	total (1-4): 225
5	4.4	3.2	
6	4.4	3.5	
7	4.5	3.2	
8	4.5	2.5	
9	4.7	3.9	
10	4.8	3.8	
11	5	4.1	
12	5.1	3.2	
13	5.1	4.1	
14	5.2	4.1	
15	5.2	4.4	
16	5.2	4.8	
17	6	3.8	
18	6.2	3.8	
19	6.2	4.1	total (5-19): 500
20	4.9	3.1	27
21	5	3.4	32
22	5.2	3.3	32
23	5.4	3.4	35
24	5.5	3.7	48
25	5.7	4.4	50
26	5.8	3.8	48
27	6	4	58
28	6	3.9	48
29	6	4.1	50
30	6	5	100
31	6	5	50
32	6.2	4.5	50
33	6.2	5	100
34	6.3	4.3	100
35	6.6	4.8	100
36	6.7	4.5	83
37	7	5	100
38	7	4.5	50
39	7	5	100
40	7	5	50
41	7	4.8	50
42	7.5	5.8	150
43	8	5.1	142
44	8	5.7	150
Sum			**1803**
Average	**5.7**	**4.1**	**57.5**

Table 5. Length and Weight of Tilapia
(May-June 1997)

Tilapia mozambique	**Standard Length (cm)**	**Total Length (cm)**	**Weight (g)**
1	11	14.2	60
2	12	15.2	100
3	12	15.4	150
4	13	16.5	100
5	13.1	16	100
6	13.2	16.6	100
7	13.2	17.4	101
8	13.3	17.2	100
9	13.4	17.2	122
10	13.5	17	150
11	13.5	17	101
12	13.5	17.8	104
13	13.5	18	120
14	13.6	17.5	107
15	13.8	17.9	117
16	13.8	18.3	127
17	14	16.5	100
18	14	17.9	117
19	14	18.5	50
20	14.1	18.2	122
21	14.2	18.2	50
22	14.2	18.3	121
23	14.2	18.6	124
24	14.2	19	121
25	14.3	18.1	120
26	14.3	18.4	121
27	14.4	18.4	129
28	14.5	18.3	132
29	14.6	17.2	100
30	14.6	17.9	150
31	14.6	18.1	128
32	14.6	18.2	150
33	14.6	19.1	127
34	14.7	17.5	111
35	14.7	18.2	100
36	14.7	19.1	107
37	14.9	17.2	150
38	14.9	17.9	150
39	14.9	18.1	150
40	14.9	18.4	150
41	14.9	18.9	145
42	14.9	19.1	157
43	15	18.4	150
44	15	19.2	150
45	15	19.5	150
46	15	19.7	156
47	15.1	18.1	150
48	15.2	17.9	150

Table 5. Length and Weight of Tilapia
(May-June 1997)

Tilapia mozambique	**Standard Length (cm)**	**Total Length (cm)**	**Weight (g)**
49	15.2	17.9	150
50	15.2	18.2	150
51	15.2	18.4	150
52	15.2	19.1	150
53	15.2	20.3	150
54	15.3	28	160
55	15.4	19	150
56	15.4	20	100
57	15.5	19.4	172
58	15.5	19.6	200
59	15.5	20	155
60	15.5	20.1	172
61	15.8	20	152
62	15.9	19.1	150
63	15.9	19.1	150
64	15.9	20	162
65	16	19.1	200
66	16	19.7	100
67	16.3	20.1	130
68	18.2	20	150
69	19.5	24	200
Sum			**9100**
Average	**14.6**	**18.5**	**131.9**

Table 6. Length and Weight of the Hawaiian Swimming Crab
(May-June 1997)

Podophthalmus vigil	Carapace Length (cm)	Carapace Width (cm)	Weight (g)
1	7.1	2.8	0
2	7.4	2.9	50
3	7.6	3.9	50
4	8	3.8	50
5	8	3.2	50
6	8.5	4.4	50
7	9	4	50
8	9	4	50
9	9.3	4.2	100
10	9.4	3.8	50
11	9.5	4.4	50
12	10.4	4.4	150
13	11.4	4.6	150
14	11.4	4.7	150
15	12	5.1	150
16	12.1	5.2	150
17	12.2	5	200
18	12.4	5.2	200
Sum			**1700**
Average	**9.7**	**4.2**	**94.4**

Table 7. Catch Per Unit of Effort at the Ala Wai Canal
(May-June 1997)

	Total Hours Fished	Total Number of Fishers	Total Line Hours	Total Number of Catch	CPUE (no. caught/max hrs)
	0	3	0	0	0
	0	1	0	0	0
	0	1	0	0	0
	0	1	0	0	0
	0.08	2	0.17	0	0
	0.08	1	0.08	0	0
	0.17	2	0.33	0	0
	0.17	1	0.17	0	0
	0.17	1	0.17	0	0
	0.17	1	0.17	0	0
	0.17	1	0.83	0	0
	0.25	1	0.25	2	8
	0.25	2	0.5	2	4
	0.25	1	0.25	5	20
	0.25	1	0.25	4	16
	0.25	3	0.75	0	0
	0.25	1	0.25	0	0
	0.25	1	0.25	0	0
	0.25	2	0.5	0	0
	0.25	1	0.25	0	0
	0.33	2	0.67	3	4.48
	0.33	1	0.33	20	60.6
	0.5	1	0.5	2	4
	0.5	1	0.5	0	0
	0.5	1	0.5	0	0
	0.5	1	0.5	0	0
	0.5	1	0.5	0	0
	0.5	2	1	0	0
	0.5	1	0.5	0	0
	0.5	2	1	0	0
	0.58	1	0.58	1	1.72
	0.67	3	2	20	10
	0.75	1	0.75	1	1.33

Table 7. Catch Per Unit of Effort at the Ala Wai Canal
(May-June 1997)

	Total Hours Fished	Total Number of Fishers	Total Line Hours	Total Number of Catch	CPUE (no. caught/max hrs)
	0.75	1	0.75	10	13.33
	0.75	1	0.75	9	12
	0.75	2	6.17	0	0
	1	1	1	21	21
	1	1	1	0	0
	1	1	1	0	0
	1	1	1	0	0
	1	1	1	0	0
	1	1	1	0	0
	1	1	1	0	0
	1.17	1	1.17	39	33.3
	1.17	1	2.33	0	0
	1.25	3	2.25	31	13.78
	1.25	3	2.5	10	4
	1.33	1	1.33	1	0.75
	1.5	1	7.5	6	0.8
	1.5	2	3	20	6.67
	1.5	3	4.5	12	3.67
	1.75	3	5.25	8	1.52
	1.75	1	1.75	1	0.57
	2	1	2	2	1
	2	1	2	0	0
	2	1	2	0	0
	2.17	1	2.17	15	6.91
	2.5	1	5	0	0
	2.75	1	13.75	0	0
	2.75	5	63.25	37	0.58
	5.58	1	5.58	0	0
	7.67	1	61.36	0	0
	8.5	2	110.5	0	0
	*	1	*	*	*
	*	1	*	*	*
	*	3	*	*	*

Table 7. Catch Per Unit of Effort at the Ala Wai Canal
(May-June 1997)

	Total Hours Fished	Total Number of Fishers	Total Line Hours	Total Number of Catch	CPUE (no. caught/max hrs)
	**	**	**	**	**
Sum	71.26	96	328.36	282	250.01
Average	1.06	1.42	4.9	4.21	3.73
	*Data unknown because of non-English speaking persons.				
	**Data unknown because drift net's owner could not be found.				

Table 8. Number of Fishers by Ethnicity at each Location Along the Ala Wai Canal (May-June 1997)

Location	African	Caucasian	Chinese	Filipino	Japanese	Lao	Polynesian	Other
1	0	0	0	3	4	0	0	0
2	0	1	0	0	0	0	0	2
3	0	0	0	0	0	0	0	5
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	1
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	1	0	0
9	0	0	0	0	2	0	0	0
10	0	0	0	0	0	1	0	1
11	0	0	0	0	0	0	0	0
12	0	0	0	0	2	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	2	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	0	1	0	0	0
17	0	0	0	0	0	0	0	1
18	0	0	0	1	0	0	0	1
19	0	0	0	0	3	0	0	1
20	0	0	3	0	0	0	0	0
21	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0
23	0	0	1	0	3	0	0	0
24	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	1
26	0	0	0	0	1	0	0	0
27	0	0	0	0	0	0	0	0
28	0	0	1	1	2	0	0	1
29	0	0	0	2	1	0	0	2
30	0	0	0	0	0	0	0	1
31	0	0	0	0	3	0	0	1
32	0	0	1	1	0	0	0	0
33	0	0	1	1	0	0	0	3
34	0	0	1	1	1	0	0	0
35	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0
38	0	0	1	0	2	0	0	0
39	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0
41	0	0	1	1	0	0	0	0
42	0	1	0	0	1	0	0	0
43	0	0	0	0	0	0	0	0
44	0	0	0	0	1	1	1	0
45	1	0	0	0	0	0	0	0
46	1	0	0	3	0	0	0	0
47	1	0	0	0	1	0	0	1
48	0	0	0	0	1	0	2	1
49	0	1	0	1	2	0	0	0
Total	3	3	10	15	33	3	3	23

Number:___

Ala Wai Canal Quality Improvement Project

Date _/_/97 Day: S M T W Th F Sa Interview by: LC

Tide:__________ft Location: ________

Weather Observations: clear / somewhat cloudy / overcast / rainy

Water Observations: clear / somewhat murky / murky

odorless/ somewhat smelly/ really smelly

free of debris/ somewhat free of debris/ full of debris

not swollen with runoff/ somewhat/ flooding

Time Started Fishing	Time of Interview

Methods (No. & Gear Type):

rod/reel ____ net(s):

handpole (bamboo) ____ scoop/fine mesh ____

misc. (specify) ____ throw ____

______________ ____ crab net ____

No. & Age of Fishers:

Male	Female

Where do you live?	
Nationality?	
Do you eat your catch?	Yes/No

Species	length (mm)	weight (g)	Species	length (mm)	weight (g)

1	Aholehole	A	A'ama
2	Barracuda	B	Blue Pincers
3	Lai	C	Opai
4	Mullet	D	Samoan Crab
5	Papio	E	
6	Tilapia	F	
7			
8			
9			

Total hrs fished	Total no. fishers	Total line hrs	Total no. fish caught	CPUE (no. caught/max hrs)

Fishers Consuming Catch at the Ala Wai Canal

November 1997- January 1998

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Fishers Consuming Catch at the Ala Wai Canal

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I. Results of Fishers' Survey

The Ala Wai Canal is a 3,100 m long man-made tropical estuary designed to control the flooding of the Manoa, Palolo, and Makiki Streams on the south shore of the island of Oahu. Because of its location in a metropolitan area, it is an ideal area to study the effects of urbanization on a marine environment.

The study conducted from November 1997 to January of 1998 at the Ala Wai Canal (see August 1997 "Fishing Practices of the Ala Wai Canal" for Surveying Methods) displays people of Chinese, Japanese, Lao, Filipino, and other (mixed) or unknown ancestry to have consumed their catches from the Ala Wai Canal (Table 5). As in the August 1997 survey, Chinese, Japanese and Filipino made up the largest group of fishers that consumed their catch. The fishers ranged mostly from thirty to fifty year olds to seventy to eighty year olds, and three ages that deviated from these fishers were people aged seven, eleven, and twenty-eight (Table 4). Again, as in the August 1997 survey, most of the fishers were males, and female fishers made up one twentieth of the total fishers surveyed.

The species consumed from the Ala Wai Canal included Blue Pincer Crab, Samoan Crab, papio, barracuda, awa, and aholehole. According to the information surveyed, it can be estimated that these fishers mostly harvest barracuda of the above species from the canal at an estimated 1,189 pounds per year and 74.3 pounds per person per year (Table 3). Papio can be estimated at 354 pounds per year and 28 pounds per person per year, Samoan Crab at 202 pounds per year and 50.5 pounds per person per year, Blue Pincer Crab at 212 pounds per year and 19.3 pounds per person per year, and aholehole at 24 pounds per year (Table 3). (These figures were calculated based on the information given by the fishers to the surveyor. For example, the surveyor would ask for the amount of catch in pounds per week or month by the year, and then the yearly estimated total amount was calculted per person per year.)

Recent fish testing for carcinogens in tilapia of the Ala Wai Canal have revealed the presence of such toxins. According to the biology of fish, the toxins are more concentrated in the organs than in the flesh of the animal. In this study, it has been found that Blue Pincer and Samoan Crabs were eaten whole, and awa flesh and the head were eaten. Papio and barracuda were both filleted as well as cooked whole. None of the fish organs were found to be ingested (Table 3).

No fishers were found to be eating tilapia during the times surveyed for this study. However, according to the previous survey, Fishing Practices at the Ala Wai Canal (August 1997), people were consuming tilapia. For example, a male Chinese fisher aged 53 had caught two tilapia with the intension of eating it during the summer survey. Another two male fishers aged 12 and 14 would fish up to three times a week at the Ala Wai Canal. They were Hong Kong immigrants that did not speak English. The tilapia they caught would be shared with up to 6 other people. During this survey on 5/23/97 at 6:10 pm , they had caught 20 tilapia. However, considering that they often fished at the canal, they were not found during the months surveyed for this study, and perhaps the reason may be that tilapia consumers were greater in number during the summer. According to a fisher that fishes at the Ala Wai Canal on a daily basis, the only fishers that he has seen catching tilapia to probably eat, were Vietnamese fishers. However, this information may not be reliable, but the fact remains that immigrants or non-English speaking fishers are the ones eating tilapia according to the August 1997 survey. In conclusion, the tilipia consumption data is sparse and were not collected during the November 1997 to January 1998 surveys. Therefore, this information was not included it in the following tables.

Because of the presence of various carcinogens in the organisms of the Ala Wai Canal, ingesting organisms dwelling there may pose a health hazard. It is therefore recommended to post signs along the Ala Wai Canal that warns against consuming fish. In addition, pamphlets could be printed out in different languages and an ambassador of the canal could be appointed to patrol the area to communicate the hazards of ingesting organisms in the canal to non-English as well as English speaking fishers.

The results of this study provide the data of fishing practices for management recommendations to provide the people of Hawaii with an aesthetic value and a safe recreational fishing environment at the Ala Wai Canal.

II. Summary

(1) People of Chinese, Japanese, Filipino, Lao, other (mixed) or unknown ancestry consume their catch from the Ala Wai Canal.

(2) Chinese, Japanese and Filipino make up the largest group of fishers that consume their catch.

(3) The fishers ranged mostly from thirty to fifty year olds and seventy to eighty year olds.

(4) Most of the fishers were males, and female fishers made up one twentieth of the total fishers surveyed.

(5) The species consumed from the Ala Wai Canal included Blue Pincer Crab, Samoan Crab, papio, barracuda, awa, and aholehole.

(6) Barracuda was consumed the most at an estimated 1,189 pounds per year and 74.3 pounds per person per year.

(7) Papio can be estimated at 354 pounds per year and 28 pounds per person per year.

(8) Samoan Crab was consumed whole at an estimated 202 pounds per year and 50.5 pounds per person per year.

(9) Blue Pincer Crab was consumed whole and at an estimated 212 pounds per year and 19.3 pounds per person per year.

(10) Aholehole was consumed at an estimated 24 pounds per year and 24 pounds per person per year.

(11) The flesh and head of awa were eaten while papio and barracuda were both filleted as well as cooked whole. None of the fish organs were found to be ingested.

(12) Although tilapia consumers were found during the August 1997 surveys, no tilapia consumers were found during the couse of this study.

(13) It is recommended that signs be posted along the Ala Wai Canal that warns against consuming fish. In addition, pamphlets could be printed out in different languages and an ambassador of the canal could be appointed to patrol the area to communicate the hazards of ingesting organisms in the canal to non-English as well as English speaking fishers.

APPENDIX A

FIGURE 1

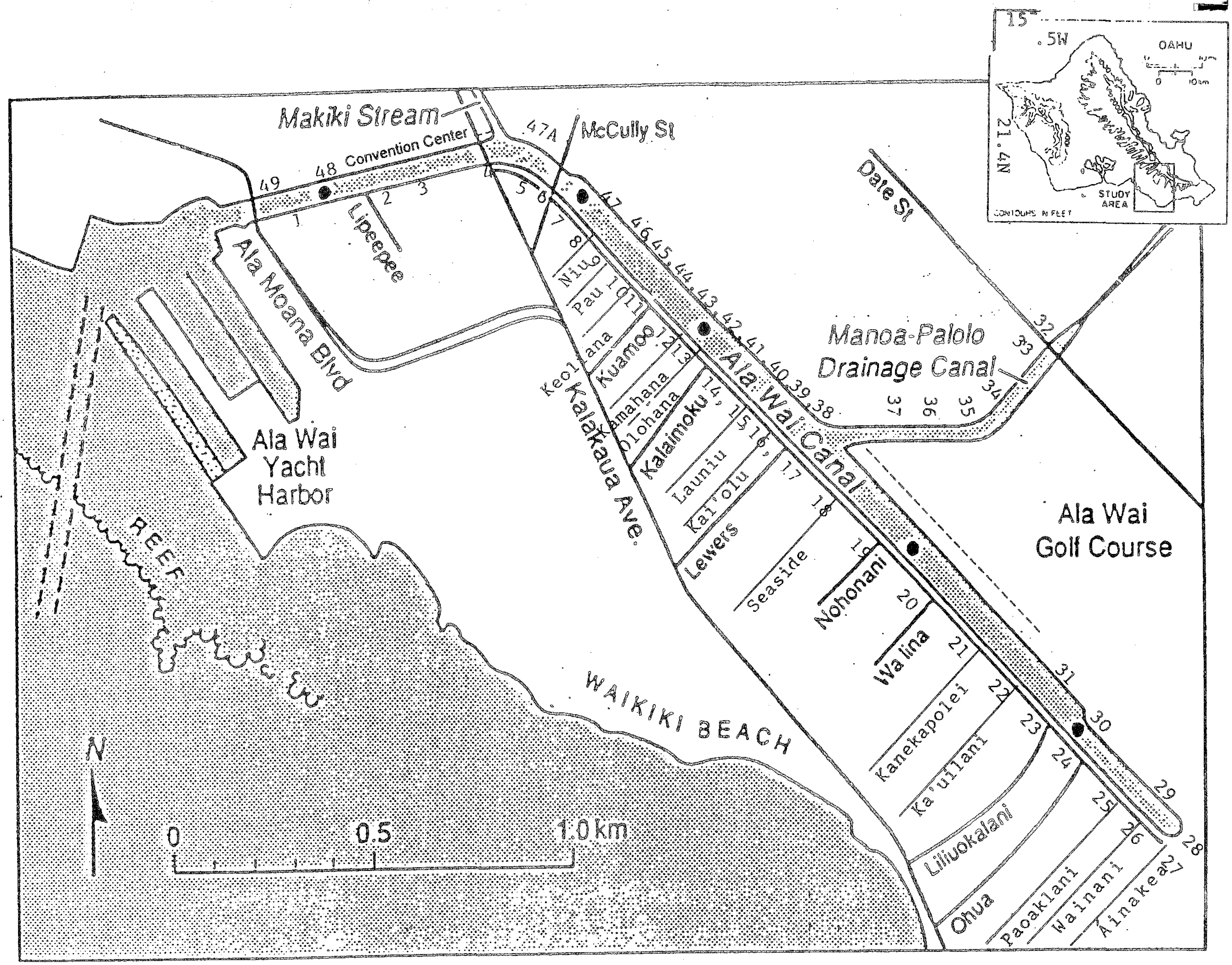

Figure 1. Map of the Ala Wai Canal modified after Resig et. al. 1995 & Laws et. al. 1995
(Numbers correspond to locations sampled)

APPENDIX B

TABLES 1-6

Table 1. Times Surveyed at the Ala Wai Canal

Month	Date	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Total Hours
November	7						3-5pm		2
	11			3-5pm					2
	15							2-4pm	2
	16	12-2pm							2
	21						3-5pm		2
	22							9-11:30am, 2:30-5pm	5
	29							1-3pm	2
	30	2-4pm							2
December	26						12-2pm		2
January	3							1-3pm	2
	5		8-10am						2
	6			9-11am					2
	7				7:30-11:30am, 1-5pm				8
	8					7:30-10am, 1-3:30pm			5
	9							7:30-9:30am	2
	31							3-6 pm	3
February	1	10am -12pm							2
									total: 47

Table 2. Summary of Surveys to Assess the Amount of Catch Consumed by Fishers

Survey #	Date	Day	Time	Location	Age	Sex	Ethnicity	SPP	Frequency Consumed	Parts Consumed	Comments
1	11/7/97	Friday	3:50 PM	23	~7	M	Unknown	Blue Pincer Crab	2 lb	?	Non-English Speaking. Fishers left before survey was completed.
					~35	M	Unknown				
2	11/11/97	Tuesday	2:45 PM	30	46	M	Chinese	Barracuda, Awa	20 lb / week	flesh, head	Dennis fished here for 30 years. He sashimi/steams catch.
					80	F	Chinese				
					five aged 70-80's		Chinese				
3	11/15/97	Saturday	2:30 PM	35	40	M	Other	Samoan Crab	1-3 lb / week	whole	Sometimes catch sold to Bob's Peanut.
					55	M	Japanese	Samoan Crab	1-3 lb / week	whole	"
4	11/15/97	Saturday	2:35 PM	38	55	M	Japanese	Papio	1 lb / week	flesh, head	
					41	F	Japanese	Papio, Barracuda	1 lb / week	flesh, head	
5	11/15/97	Saturday	2:50 PM	1	36	M	Japanese	Papio, Barracuda	1 lb / week	flesh, head	
6	11/16/97	Sunday	12:30 PM	2	45	M	Chinese	Aholehole or Papio?	2 lb / month	fillet	Non-English Speaking
7	11/22/97	Saturday	9:50 AM	13	49	M	Filipino	Blue Pincer Crab	1 lb / week	whole	
					28	M	Filipino				
8	11/22/97	Saturday	9:40 AM	22	35	M	Other	Samoan Crab	2 lb / week	whole	
9	11/22/97	Saturday	10:05 AM	1	53	M	Filipino	Blue Pincer Crab	2-3 lb / week	whole	
					53	F	Filipino	Blue Pincer Crab	1 lb / week	whole	
10	11/22/97	Saturday	4:07 PM	12	35	M	Chinese	Papio	0.25 lb / year	flesh, head	
11	11/30/97	Sunday	2:20 PM	6	52	M	Other	Samoan Crab, Blue Pincer Crab	10 lb / year	whole	
12	11/30/97	Sunday	2:36 PM	37	11	M	Other	Barracuda, Blue Pincer Crab	2 lb / year	whole (crab)	
13	11/30/97	Sunday	2:40 PM	33	44	M	Other	Blue Pincer Crab	0.25 lb	whole	First time fishing at Ala Wai Canal
14	11/30/97	Sunday	2:45 PM	38	55	M	Japanese	Papio	1 lb / month	fillet	
15	12/26/97	Friday	12:10 PM	30	37	M	Japanese	Papio, Barracuda	5 lb / month	fillet	
16	1/3/98	Saturday	2:35 PM	31	54	M	Chinese	Papio	1.5 lb / month	flesh, head	
17	1/5/98	Monday	8:15 AM	30	37	M	Japanese	Papio, Barracuda	5 lb / month	fillet	
18	1/6/98	Tuesday	9:45 AM	30	37	M	Japanese	Papio, Barracuda	5 lb / month	fillet	
19	1/7/98	Wednesday	1:25 PM	30	54	M	Chinese	Barracuda	0.5 lb / month	flesh, head	
					51	F	Chinese				
20	1/7/98	Wednesday	1:50 PM	44	70	M	Filipino	Barracuda	5-10 lb / year	flesh, head	
					52	M	Filipino				
21	1/7/98	Wednesday	3:45 PM	10	~75	F	Lao	Blue Pincer Crab	3 lb	whole	Non-English Speaking: usually seen at same time everyday.
22	1/7/98	Wednesday	4:00 PM	44	43	M	Filipino	Papio	3 lb / month	fillet	
					several aged 40-50's		Filipino				
23	1/8/98	Thursday	4:30 PM	9	~75	F	Lao	Blue Pincer Crab	3 lb	whole	Non-English Speaking: usually seen at same time everyday.

Table 3. Amount of Catch Consumed by Fishers at the Ala Wai Canal During November- January '97-'98

SPP	Blue Pincer Crab	Samoan Crab	Papio	Barracuda	Awa	Aholehole
Total No. of People Consuming Catch	11	4	13	16	5	~1
Parts Consumed (% of people consuming)	whole (100%)	whole (100%)	flesh & head (38%)	flesh & head (81%)	flesh & head (100%)	
			fillet (62%)	fillet (19%)		
Amount Consumed	0.25 lb	1-3 lb / week	1 lb / week	20 lb / week	(infrequent catch)	2 lb / month
	2 lb	1-3 lb / week	1 lb / week	1 lb / week		
	2 lb	2 lb / week	1 lb / week	1 lb / week		
	3 lb	10 lb / year	2 lb / month	0.5 lb / month		
	3 lb		1 lb / month	5 lb / month		
	1 lb / week		1.5 lb / month	5 lb / month		
	1 lb / week		3 lb / month	2 lb / year		
	2-3 lb / week		5 lb / month	5-10 lb / year		
	2 lb / year		5 lb / month			
	10 lb / year		0.25 lb / year			
Estimated Total Catch/ Year	at least 212 lb/ yr	at least 202 lb/yr	at least 354 lb/yr	at least 1189 lb/yr		at least 24 lb/yr
Estimated Catch Consumed per Person/ Year	19.3 lb/ yr	50.5 lb/ yr	28 lb/ yr	74.3 lb/ yr		24 lb/ yr

(~ means estimated guess)

Table 4. Ages of Fishers That Consumed Catch at the Ala Wai Canal (Nov-Jan '97-'98)

Age	Sex	Ethnicity
~7	M	Unknown
11	M	Other
28	M	Filipino
~35	M	Unknown
35	M	Other
35	M	Chinese
36	M	Japanese
37	M	Japanese
37	M	Japanese
37	M	Japanese
several aged 40-50's		Filipino
40	M	Other
41	F	Japanese
43	M	Filipino
44	M	Other
45	M	Chinese
46	M	Chinese
49	M	Filipino
51	F	Chinese
52	M	Other
52	M	Filipino
53	M	Filipino
53	F	Filipino
54	M	Chinese
54	M	Chinese
55	M	Japanese
55	M	Japanese
55	M	Japanese
five aged 70-80's		Chinese
70	M	Filipino
~75	F	Lao
~75	F	Lao
80	F	Chinese

(~ "Estimated Guess)

Table 5. Ethnicity of Fishers at the Ala Wai Canal (Nov-Jan '97-'98)

Ethnicity	Age	Sex	Total by Ethnicity
Chinese	five aged 70-80's		
Chinese	80	F	
Chinese	35	M	
Chinese	45	M	
Chinese	46	M	
Chinese	51	F	
Chinese	54	M	
Chinese	54	M	Chinese: 12
Filipino	28	M	
Filipino	several aged 40-50's		
Filipino	43	M	
Filipino	49	M	
Filipino	52	M	
Filipino	53	M	
Filipino	53	F	
Filipino	70	M	Filipino: 9
Japanese	36	M	
Japanese	37	M	
Japanese	37	M	
Japanese	37	M	
Japanese	41	F	
Japanese	55	M	
Japanese	55	M	
Japanese	55	M	Japanese: 8
Lao	~75	F	
Lao	~75	F	Lao: 2
Other	11	M	
Other	35	M	
Other	40	M	
Other	44	M	
Other	52	M	Other: 5
Unknown	~35	M	
Unknown	~7	M	Unknown: 2

(~Estimated Guess)

Table 6. Sex of Fishers that Consume Catch at the Ala Wai Canal (Nov-Jan '97-'98)

Sex	Age	total by sex
F	41	
F	51	
F	53	
F	~75	
F	~75	
F	80	Females: 6
M	~7	
M	11	
M	28	
M	~35	
M	35	
M	35	
M	36	
M	37	
M	37	
M	37	
M	40	
M	43	
M	44	
M	45	
M	46	
M	49	
M	52	
M	52	
M	53	
M	54	
M	54	
M	55	
M	55	
M	55	
M	70	Males: 24
	several aged 40-50's	2
	five aged 70-80's	5

(~ "Estimated Guess")

APPENDIX E

PADDLERS HEALTH SURVEY

WELFARE OF PADDLERS AT THE ALA WAI CANAL

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Advisor: Eugene Dashiell, Ala Wai Watershed Coordinator
at Environmental Planning Services
February 1998

I. INTRODUCTION

The Ala Wai Canal, even in its present state is a valued resource in Hawaii. Many people use the Ala Wai as a recreational location. Sports partaken at the Ala Wai vary from Soccer and Softball in the park, to Football on the field, Basketball on the courts and Canoe Paddlers in the Canal. Although we know that there are a large number of people using the land surrounding the Ala Wai Canal, do we really know how many people are Paddling, Kayaking, and Rowing in the Ala Wai? The Ala Wai Canal is well known for its polluted waters, but a vast number still use its waterways, why? First, the Ala Wai is in a central location with easy access to the ocean; and second, with the great number in paddlers, clubs need practice sites to launch their boats from. Clearly there's no room left along the shoreline of Honolulu for the launching of Canoes and the holding of permanent residency for Canoe Clubs.

The Canoes weigh four-hundred-pounds, and are roughly twenty-two feet in length. Transportation of these boats to and from the Ala Wai is difficult due to the weight and length of these boats. It is also difficult because the Canoes need to be taken apart when they are transported, which means more time is needed each day to carry the boats, transport the boats, and re-assemble the boats. Most people have busy schedules and so this is not an option. The Ala Wai Canal is the perfect location to house these Canoes. It is also easier and quicker for paddlers to carry the already assembled, four-hundred-pound Canoes to and from the water.

The waterways of the Ala Wai Canal are congested especially when Paddling Seasons are in session, which is a constant throughout the year. There are approximately 13 Clubs, and each club has at least three to four boats. Which means that if seven of the 13 clubs are on the water at the same time, there are at least twenty-one to twenty-eight boats practicing together. This is often the case because practice times are usually the same; children train after school, and adults train after work.

The most congested time of the year is the Summer-Short Distance Season—occurring from April to August. When this Season ends, the Long Distance simultaneously with the Interscholastic League of Hawaii's (I.L.H.) Kayaking Season begins. Directly after I.L.H. Season for kayaking ends, the Season for I.L.H. Canoe Paddling begins—Practice for Paddling continues throughout the Winter break. Following the ending of I.L.H. Season is O'ahu Interscholastic Association--O.I.A. (Na 'Opio) Canoe Paddling, which ends in March. Then it returns to the Summer-Short Distance Season, and as you see the cycle continues from there. (Table located on page 15.)

How many people are practicing in the Ala Wai Canal? "There are nearly two hundred paddlers in Hui Lanakila," says Coach Rosie Lum. Rosie is also the Head Coach at Kamehameha Schools, an I.L.H. Canoe Racing participant. There are well over two hundred students paddling under her supervision. Hui Lanakila, located nearest to the McCully Bridge (Map 1, # 4), is surrounded by at least five other clubs. Rosie also says "There are at least one hundred paddlers in each club." Most Clubs house almost one hundred paddlers with the exception of four clubs on the Ala Wai that house nearly two hundred. The first is Hui Lanakila; second is Outrigger Canoe Club (Map 1, #1); the third is Lokahi--located furthest in to the Ala Wai (Map 1, # 1); and the last is Koa Kai—located closest to the Ocean (Map 1, #5). At an average of one hundred paddlers per club with a total of 13 Clubs—the four exceptions included, practicing in the Ala Wai at any given time. It is estimated that there are 1,300 plus paddlers using the Ala Wai Canal. This does not include the over 150 Kayakers, one-man Canoers, and Rowers using the Ala Wai.

With the widespread number of Paddlers practicing in the debris filled water of the Ala Wai, there is a concern for possible health problems. Are paddlers being affected substantially by pollutants in the Ala Wai Water? I conducted an eight-week survey to find out if paddlers practicing at the Ala Wai Canal had a higher rate of illness and rash than paddlers practicing in another location. Before conducting this survey I met with Eugene Dashiell, the Coordinator for the Ala Wai Watershed Project. We put together different questionnaire sheets and decided on the locations that would best suit the survey. After about a month of meeting with Eugene, putting together questionnaires, and surveying for clubs to participate in the survey, I began the process of finding contacts from each club.

There were three clubs from the Ala Wai, and one from Kailua(the Control Group). The three from the Ala Wai were Outrigger Canoe Club (O.C.C.), furthest into the Ala Wai Canal; Waikiki Yacht Club (W.Y.C.), near the mouth of the Ala Wai and closest to the Ocean; and Waikiki Surf Club (W.S.C.), midway between Outrigger and Waikiki Yacht Club. The Control Group was from Kailua Canoe Club (K.C.C.).

The following week, Monday, I drove down to the practice sight of Waikiki Surf Club to ask for their cooperation in the survey and to look for a contact person. After speaking with Derrell, my contact from W.S.C., I rushed down to the Outrigger Canoe Club practice sight, but by the time I reached the practice sight everyone was already out on the water. The following day I went back to the O.C.C. practice sight and looked around for a Coach to talk to, but to my dismay there were no Coaches around. I was a bit frustrated because each time I went back to look for a Coach, they had either gone out to practice or they simply were not there that day. Finally after a few trips--often from my house in Kane'ohe, to the Outrigger practice sight at the Ala Wai, I got in touch with the Head Coach. I then went to Waikiki Yacht Club, the club I practice with, and asked a few people to participate in my survey. After contacting clubs from the Ala Wai, I drove from Waikiki to Kailua, on the other side of the Ko'olau Mountain, to ask for cooperation from Kailua Canoe Club, and to find a contact person. I would pick-up the surveys every week.

II. PROCEEDURES

The purpose of the survey was to ascertain whether or not pollution in the Ala Wai was affecting the paddlers (Pg. 11, Example 1). The survey was modified to fit the time constraints of the paddlers (Pg. 12, Example 2).

This Survey was an individual effort with time and budget constraints. Its purpose was to obtain statements from a small sample of paddlers concerning their health. This technique is known as a self-reporting survey.

Three strategic locations along the Ala Wai Canal:

1) Outrigger Canoe Club (Map 1, # 1), was located furthest into the Ala Wai. The water surrounding the practice site was fairly stagnant, with little or no current. Outrigger's practice site holds no showering facilities.

2) Waikiki Surf Club (Map 1, #2), was located downstream of the Manoa-Palolo Outlet. This area contained a higher flow of fresh water runoff from these two main streams, and paddlers were more closely in contact to bacteria and other such pollutants from those streams.

3) Waikiki Yacht Club (Map 1, #3), closest of the three clubs to the mouth of the Ala Wai, where the waters turbidity increases, and bacteria count decreases. The deeper saline waters have lower levels because of the flow of fresh versus saline water. (Saline water causes significant bacteria die-off.) (Noda, pg. 24.)

Control group:

1) Kailua Canoe Club (Map 2, #4), at Kailua Beach Park was chosen as a control group due to its location furthest away from the Ala Wai. Along with the fact that most of the practicing for the chosen crew was on the open ocean.

Next, a crew from each club, six people in each crew, was given a set of surveys every week, for a duration of eight weeks. Designated leaders passed out and collected all surveys. In one instance a leader, from O.C.C., did not retrieve and return some of the data.

III. RESULTS

The eight-week survey, beginning on June 6th and ending on July 25th, showed that the paddlers practicing in the Ala Wai have a higher rate of, and susceptibility to external infection, when compared to an outside control group. (Appendix B; Figures 4, 4-1, 4-2, & 4-3) On the other hand, when “Illness” --internal infection—rates were compared, the outcomes for all of the clubs were similar, with little variance in number. A total of 24 paddlers participated in this research.

Difficulty arose with retrieving filled surveys on a timely basis. The time frame of practice for the four Clubs participating was 5:30- 7:30, and in most cases paddlers reached the Club sites five minutes before practice began. With the distance between clubs, conflicting workout schedules, and the congestion of traffic, it was difficult to retrieve data on the same day. This problem was resolved with scheduled pick-up and drop-off days.

Now, the results of the four clubs participating in the Survey:

1) Waikiki Surf Club (App. D, Map 1; App. B, #1/ Table 1): The issue of Internal Illnesses(Fig. 1), colds, was addressed, and the result was that within an eight week duration, there were 16 times out of the total 48 representations that paddlers became ill. The average number of persons sick per week was two.

Next was the issue of Showering(Fig.2). How many people showered? With a possible total of 48, 33% did not shower, while over half, 67%, showered. From there the issue of using soap was addressed(Fig. 3 & 3-1). The results showed that 28 times, 58% of the total, soap was not used. The other 42%, almost half the number used soap within the eight-week duration.

Within the eight-week duration the issue of External Infections(Fig. 4) was also addressed. Polls show that of the 48 times paddlers from Waikiki Surf

Club were asked, 18 said that they had some sort of skin irritation, while 30 said that they did not have any irritation.

2) Waikiki Yacht Club (Map 1, # 2/ Table 1-2): From June 6th to July 25th, 1.4 paddlers per week, for a total of 11 paddlers from Waikiki Yacht Club became ill—Internally (Fig. 1-2). Located closest to the mouth of the Ala Wai, where the salinity of the water increased and bacteria count decreased, paddlers for W.Y.C. were less likely than W.S.C.(Waikiki Surf Club) members to contract the same quantity of illnesses (Internal).

The second issue, "Showering," revealed that a larger number of paddlers at W.Y.C. were taking showers(Fig. 2-1). 75% of the 48 times asked, W.Y.C. members said yes to having taken showers directly before or after practicing at the Ala Wai, while only 25% said that they were not showering directly after practice. Were there also a larger number of paddlers using soap? Yes, 30 of the 48 times asked, paddlers from W.Y.C. said yes, while only 18 said no(Fig. 3 & 3-1).

Now, the last question asked was: "Was there any skin irritation or rash?" (Fig. 4-1) The answers showed that 15 said yes, while 33 said no.

3) Outrigger Canoe Club (Map 1, # 3/ Table 1-3): Difficulty arose with retrieval of data, due to miscommunication, and conflict of schedules. Four of the eight weeks were completed and returned, those were the last four weeks of the survey. As for the issue of illness (Internal—Fig. 1-3), twice out of the twenty-four times Outrigger paddlers were asked, they said yes, while the other twenty-two times they said no. (The data received from Outrigger was not

enough to determine whether or not they were substantially affected by the conditions of the Ala Wai.)

Outrigger Canoe Club site is not facilitated with showers(Fig. 2-2). Therefore, when the question of whether or not they showered directly after or before practice, O.C.C. paddlers said they used either neighboring, Lokahi Canoe Club, showers, or went to Outrigger Canoe **Club** to shower(Fig. 2-3). Of the twenty-four time O.C.C. paddlers were asked if they used soap, an astonishing twenty-four said no, 100%(Fig. 3 & 3-1).

Seven out of twenty-four paddlers said that a rash developed, while seventeen said no.

Although the results show that O.C.C. paddlers were less affected by the Ala Wai than the two previous clubs spoken of, the data is not complete and therefore, not conclusive.

4) Kailua Canoe Club (Map 2, #4/ Table 1-4) the control group: The question "Did you feel ill during the week?," was answered with a similar number to that of W.Y.C. and W.S.C., with twelve times saying yes, and thirty-six times saying no(Fig. 1-4). However, there was a greater percentage of paddlers not showering directly before or after practice; 56% didn't shower, and 44% did shower(Fig. 2-4), while W.S.C. paddlers showered 67% and W.Y.C. paddlers showered 75%. Only 9 paddlers from Kailua used soap when rinsing off directly after practice(Fig. 3 & 3-1).

Finally was the question of whether or not Kailua paddlers developed skin irritation. From the data it shows that there were only 4 instances out of the 48 times the question was asked, when the paddlers said yes, the rest of the time they said no (Fig. 4-3).

IV. CONCLUSION

The data indicates that the paddlers practicing in the Ala Wai Canal are affected by the water conditions of the Canal.

Waikiki Surf Club, with a location directly below the Manoa-Palolo Outlet appears to be more significantly affected then clubs at other locations. Of the three clubs from the Ala Wai, W.S.C. had the highest number of paddlers with rash (External Infection—sixteen paddlers), as well as the highest number with Illness (Internal Infection—eighteen paddlers). As compared to the Control Group (Kailua Canoe Club with 4 paddlers contracting rashes-Externally), the Ala Wai Canal Canoe Clubs had a higher rash rate (with roughly 11-12 paddlers from each club contracting an External Infection/ rash). However, as for Internal Infections, all of the participating Clubs resulted in similar findings.

Within only a short eight-week period, of the two hundred and eighty-eight times the question on Illness (Internal and External Infections) was asked, seventy-eight (or 32 % of the paddlers from the Ala Wai) said they had developed an Infection. The 32% was from 18 paddlers. If 1,300 or more paddlers are using the Ala Wai Canal, then that means that 32% or 416 people may be contracting some sort of infection. With the large number of people using the waterways of the Ala Wai it is important to ensure their safety and well being.

REFERENCES

Edward K. Noda. A Management Plan for the Ala Wai Canal Watershed.

Dept. of Land and Natural Resources, Honolulu, HI; 1992

***Designated Leaders:

OUTRIGGER CANOE CLUB:	Mark Sandvold	#373-7701
WAIKIKI SURF CLUB:	Derrell DeMello	#235-2972
	Michael Tongg	#526-1969
WAIKIKI YACHT CLUB:	Kerri Cummins	#247-3435
KAILUA CANOE CLUB:	Kupu Lindsey	(May not be paddling again)

WELFARE OF PADDLERS AT THE ALA WAI

TABLE OF CONTENTS

APPENDIX A

EXAMPLES 1- 2

ALA WAI CANAL PADDLER'S HEALTH SURVEY

First Name/ Club Name: _______

____

1. When did you start paddling this year? ____________

2. When do you practice? (Circle all that apply):
Monday/ Tuesday/ Wednesday/ Thursday/ Friday/ Saturday/ Sunday

3. When do you start and when do you finish practice?

I.e. 5:30-7:30 p.m., etc. ____________

4. Did you practice(circle one for each day) during the week?
A. On or after a rainy day B. Neither, it didn't rain this week.
Monday/ Tuesday/ Wednesday/ Thursday/ Friday/ Saturday/ Sunday

5. Did you feel ill during the week? (Check one)
___No
___Yes, if so did you(Check all that apply)
___Continue to practice
___Skip a day or more
___Go to the Doctors--What type of illness:
____

6. Did you shower before or after practice?(Check one
___ Yes
___No

7. Did you use soap? ___Yes ___No

8. Was there any skin irritation or rash?
___No ___Yes: If so, please describe:_______
____

For more information or questions contact:
***Eugene Dashiell #593-8330
Kerri Cummins #247-3435

EXAMPLE # 1

Ala Wai Canal Paddler's Health Survey

1. Did you practice?(Circle One)___during this week?
   A. On or after a rainy day B. Neither, it didn't rain this week

2. Did you feel ill during this week: (Check one)
   ___No
   ___Yes
   If yes, did you (Check all that apply)
   ___Continure to practice
   ___Skip a day or more
   ___Go to the Doctors: What type of illness-
   ____

3. Did you shower (rinse off) directly before or after practice?
   ___Yes
   ___No

4. Did you use soap? ___Yes ___No

5. Was there any skin irritation or rash? ___No ___Yes: If so, please describe--____________
   ____

Ala Wai Water Quality Survey

1. Did you practice?(Circle One)___during this week?
   A. On or after a rainy day B. Neither, it didn't rain this week

2. Did you feel ill during this week: (Check one)
   ___No
   ___Yes
   If yes, did you (Check all that apply)
   ___Continure to practice
   ___Skip a day or more
   ___Go to the Doctors: What type of illness-
   ____

3. Did you shower (rinse off) directly before or after practice?
   ___Yes
   ___No

4. Did you use soap? ___Yes ___No

5. Was there any skin irritation or rash? ___No ___Yes: If so, please describe--____________
   ____

EXAMPLE # 2

APPENDIX B

TABLES 1-4;
PADDLING & KAYAKING SEASONS;
CLUB LISTING

A Survey on Canoe Paddlers At the ALA WAI CANAL

Table 1.
Waikiki Surf Club Survey:
RESULTS

Numbers in columns represent Number of paddlers (6 per WEEK)

	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	TOTAL	Weekly Ave.
ILL	1	1	2	1	2	4	2	3	16	2
NOT ILL	5	5	4	5	4	2	4	3	32	4
SHOWER	6	5	4	4	2	6	5	0	32	4
NOT SHOWER	0	1	2	2	4	0	1	6	16	2
SOAP	5	3	5	2	3	2	0	0	20	2.5
NO SOAP	1	3	1	4	3	4	6	6	28	3.5
RASH	1	1	0	2	2	4	5	3	18	2.25
NO RASH	5	5	6	4	4	2	1	3	30	3.75

Table 1-2.
Waikiki Yacht Club Survey:
RESULTS

Numbers in columns represent Number of paddlers (6 per WEEK)

	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	TOTAL	Weekly Ave.
ILL	1	2	1	1	0	2	1	3	11	1.38
NOT ILL	5	4	5	5	6	4	5	3	37	4.62
SHOWER	5	5	4	6	4	4	4	4	36	4.5
NOT SHOWER	1	1	2	0	2	2	2	2	12	1.5
SOAP	5	4	1	0	3	1	2	2	18	2.25
NO SOAP	1	2	5	6	3	5	4	4	30	3.75
RASH	3	1	1	4	0	1	2	2	14	1.75
NO RASH	3	5	5	2	6	5	4	4	34	4.25

TABLES 1 & 2

Table 1-3.
Kailua Canoe Club Survey:
RESULTS

Numbers in columns represent Number of paddlers (6 per WEEK)

	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	TOTAL	Weekly Ave.
ILL	2	1	1	2	2	1	3	0	12	1.5
NOT ILL	4	5	5	4	4	5	3	6	36	4.5
SHOWER	4	4	3	0	3	2	1	4	21	2.6
NOT SHOWER	2	2	3	6	3	4	5	2	27	3.4
SOAP	1	2	1	0	2	1	0	2	9	1.2
NO SOAP	5	4	5	6	4	5	6	4	39	4.8
RASH	0	0	0	0	1	1	1	1	4	.25
NO RASH	6	6	6	6	5	5	5	5	44	5.75

Table 1-4.
Outrigger Canoe Club Survey:
RESULTS

Numbers in columns represent Number of paddlers (6 per WEEK)

	WEEK 1	WEEK 2	WEEK 3	WEEK 4	TOTAL	EST. TOTAL	Weekly Ave.
ILL	0	1	1	0	2	4	0.5
NOT ILL	6	5	5	6	22	44	5.5
SHOWER	1	1	0	0	2	4	0.5
NOT SHOWER	5	5	6	6	22	44	5.5
SOAP	0	0	0	0	0	0	0
NO SOAP	6	6	6	6	24	48	6
RASH	2	1	1	3	7	14	1.75
NO RASH	4	5	5	3	17	34	4.25

TABLES 3 & 4

PADDLING AND KAYAKING LEAGUES AND SEASONS

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
SUMMER SHORT-DISTANCE	O	O	X	X	X	X	X	X				O
LONG-DISTANCE PADDLING						O	O	X	X	X	X	
Interscholastic League Of Hawaii (I.L.H.) KAYAKING								X	X	X	X	
I.L.H. PADDLING	X	X	X									X
Oahu Interscholastic Association (O.I.A.) Paddling	X	X	X									
HAWAII CANOE AND KAYAK TEAM (H.C.K.T.)	O	O	O	O	X	X	X	X	O	O	O	O
KANAKA IKAIKA (ONE-MAN CANOE RACING)	X	X	X	X	X MOLOKA'I CROSSING	O	O	O	O	O	O	O

X- SEASONAL TRAINING/ CONDITIONING

O- OFF-SEASON TRAINING/ CONDITIONING

***The ALA WAI CANAL is used throughout the YEAR.

LIST OF CLUBS
Using the Ala Wai Canal

(Not including Rowers & One-man Canoers)

No's 1, 2, & 3 were the locations of the participating Canoe Clubs of the SURVEY

CLUB NAME	LOCATION (Refer to Map # 1, Appendix B)	ESTIMATED MEMBERS	NO. OF CANOES	SEASON
Lokahi Canoe Club	1	200	6-8	Long &Short Distance
Outrigger Canoe Club	1 (Participant)	200	6-8	Long & Short Distance
Waikiki Surf Club	2 (Participant)	150	6-7	Long & Short Distance
Kamehameha Schools/ Bishop Estate	2	200	8-9	I.L.H. Canoeing & *Kayaking*
Iolani Canoe Club	2 Off Manoa-Palolo Stream	100	2-3	I.L.H. Canoeing & *Kayaking*
Hawaii Canoe and Kayak Team	2	50	15-20 Kayaks	Races take place in the Summer
Healani Canoe Club	4	100-150	5-7	Long & Short Distance
Hui Lanakila	4	200	6-8	Long & Short Distance

Waikiki Surf Boys	4	100	4-5	Long & Short Distance
Kamehameha Canoe Club	4	100	3-4	Long & Short Distance
St. Louis/ St. Francis/ Sacred Hearts/ Damien High School	4	150-200	3-4	I.L.H. Canoeing & *Kayaking*
Keala Canoe Club	4	50	2	Long & Short Distance
Misc. Clubs: High School Clubs for O.I.A.	4	100-150	3-4	Long & Short Distance
Waikiki Yacht Club	3 (Participant)	150	8	Long & Short Distance
Mid-Pacific Institute "Mid-Pac"	3	100	4	I.L.H. Canoeing and *Kayaking*
Koa Kai Canoe Club	5	200	6-8	Long & Short Distance
Punahou High School Canoe Club	5	200	6-8	I.L.H. Canoeing & *Kayaking*
Misc. Clubs:	5	100-200	4-5	Long & Short Distance
Anuenue Canoe Club	6 Often practice in Ala Wai Canal	100	4-5	Long & Short Distance

APPENDIX C

FIGURES 1; 1-2; 1-3; 1-4;

2; 2-1; 2-2; 2-3; 2-4; 3; 3-A; 3-1;

4; 4-1; 4-2; 4-3

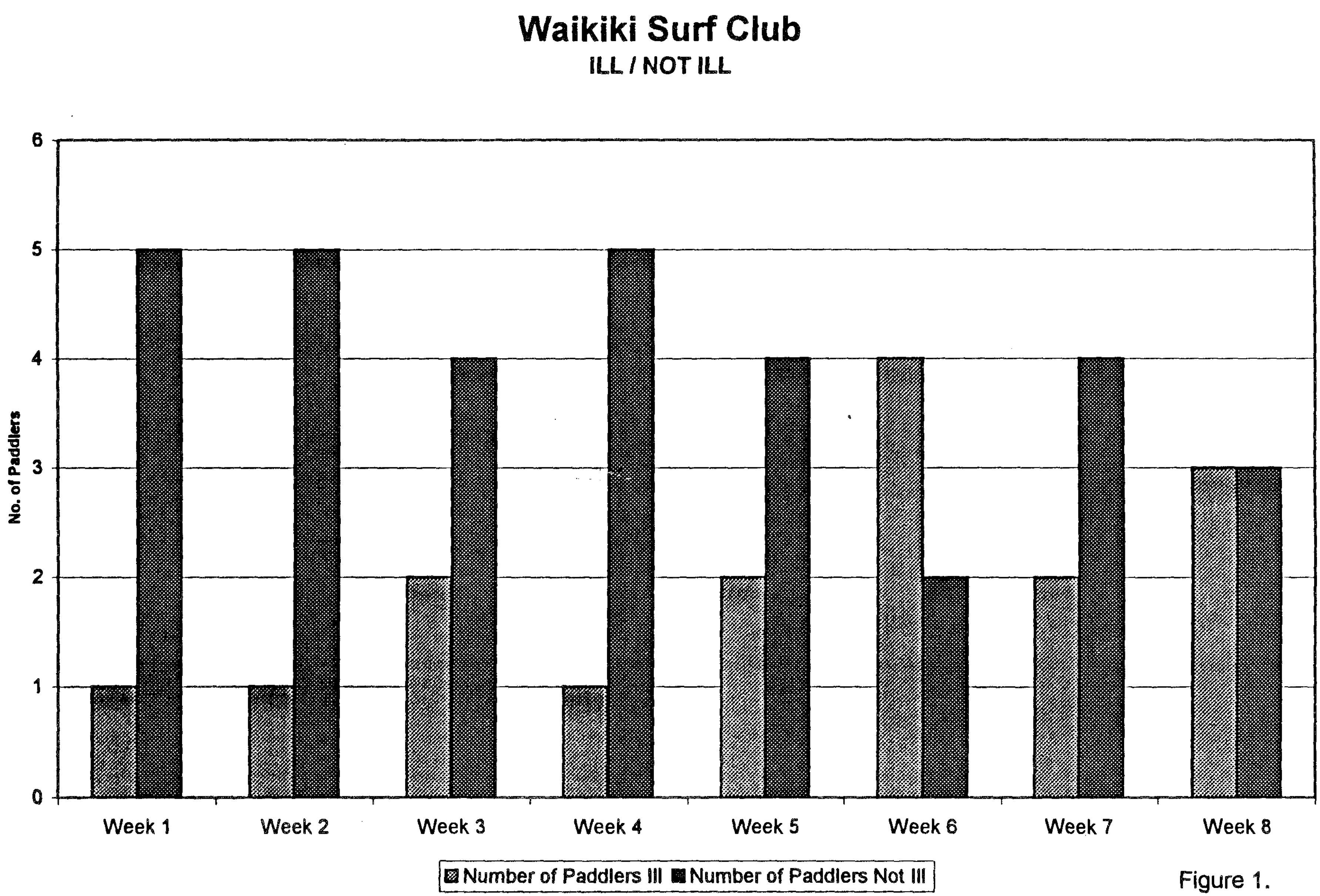

Waikiki Surf Club
ILL / NOT ILL
No. of Paddlers
0
1
2
3
4
5
6
Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Week 7
Week 8
Number of Paddlers Ill
Number of Paddlers Not Ill

Figure 1.

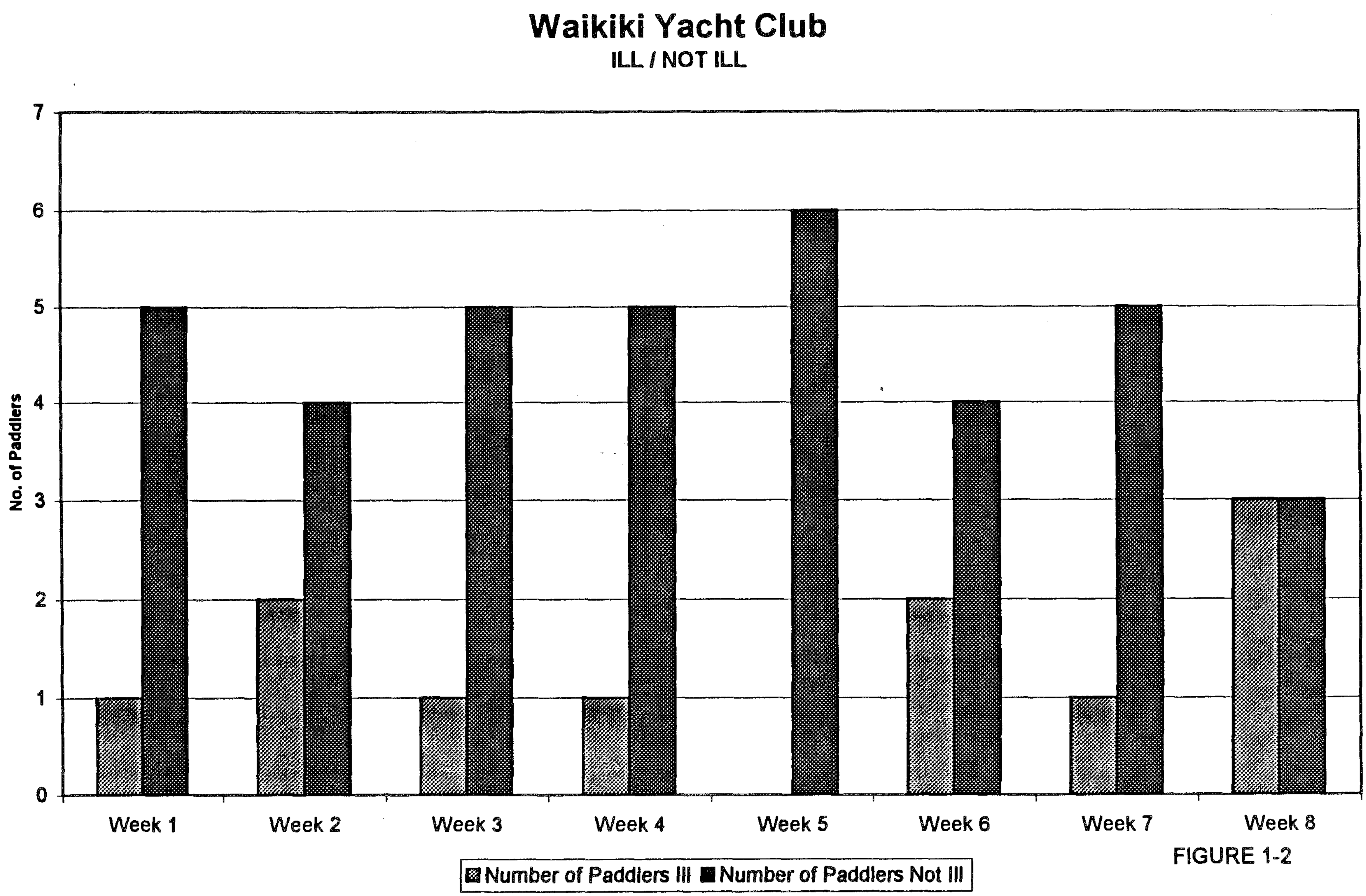

Waikiki Yacht Club
ILL / NOT ILL
No. of Paddlers
0
1
2
3
4
5
6
7
Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Week 7
Week 8
Number of Paddlers Ill
Number of Paddlers Not Ill

FIGURE 1-2

Outrigger Canoe Club Survey

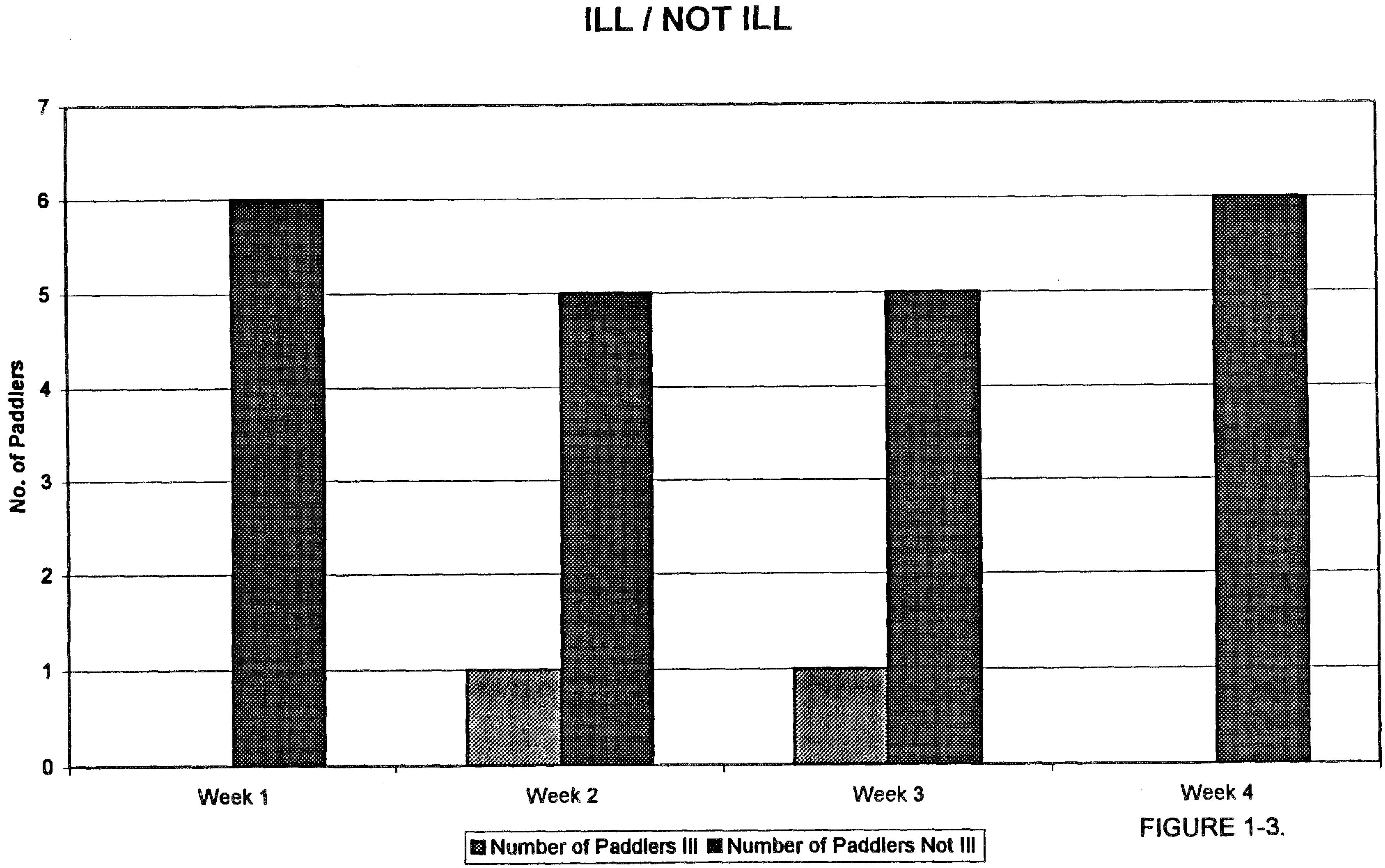


FIGURE 1-3.

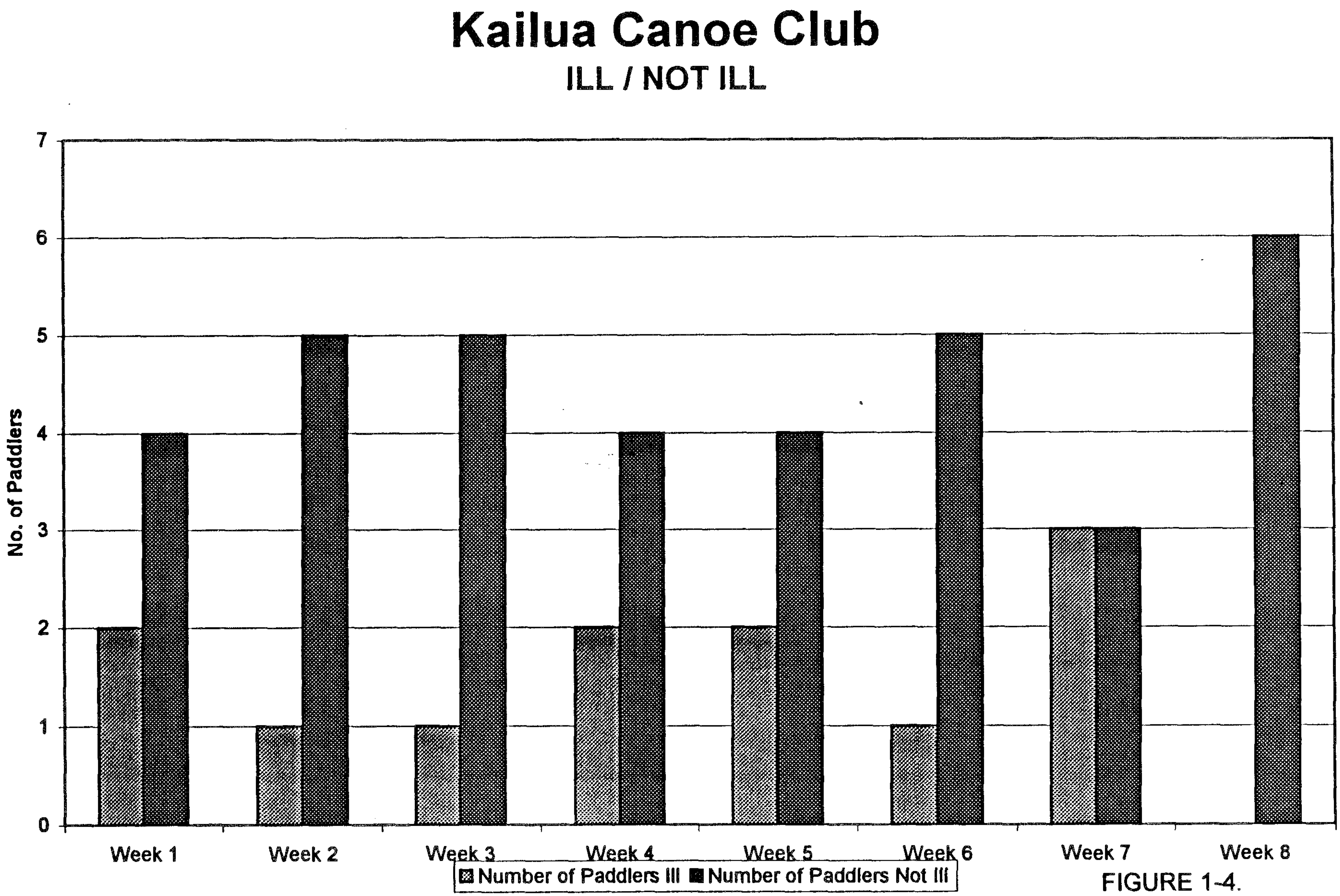

Kailua Canoe Club
ILL / NOT ILL
No. of Paddlers
0
1
2
3
4
5
6
7
Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Week 7
Week 8
Number of Paddlers Ill
Number of Paddlers Not Ill

FIGURE 1-4.

8 Week Combined Total of Showering at Waikiki Surf Club

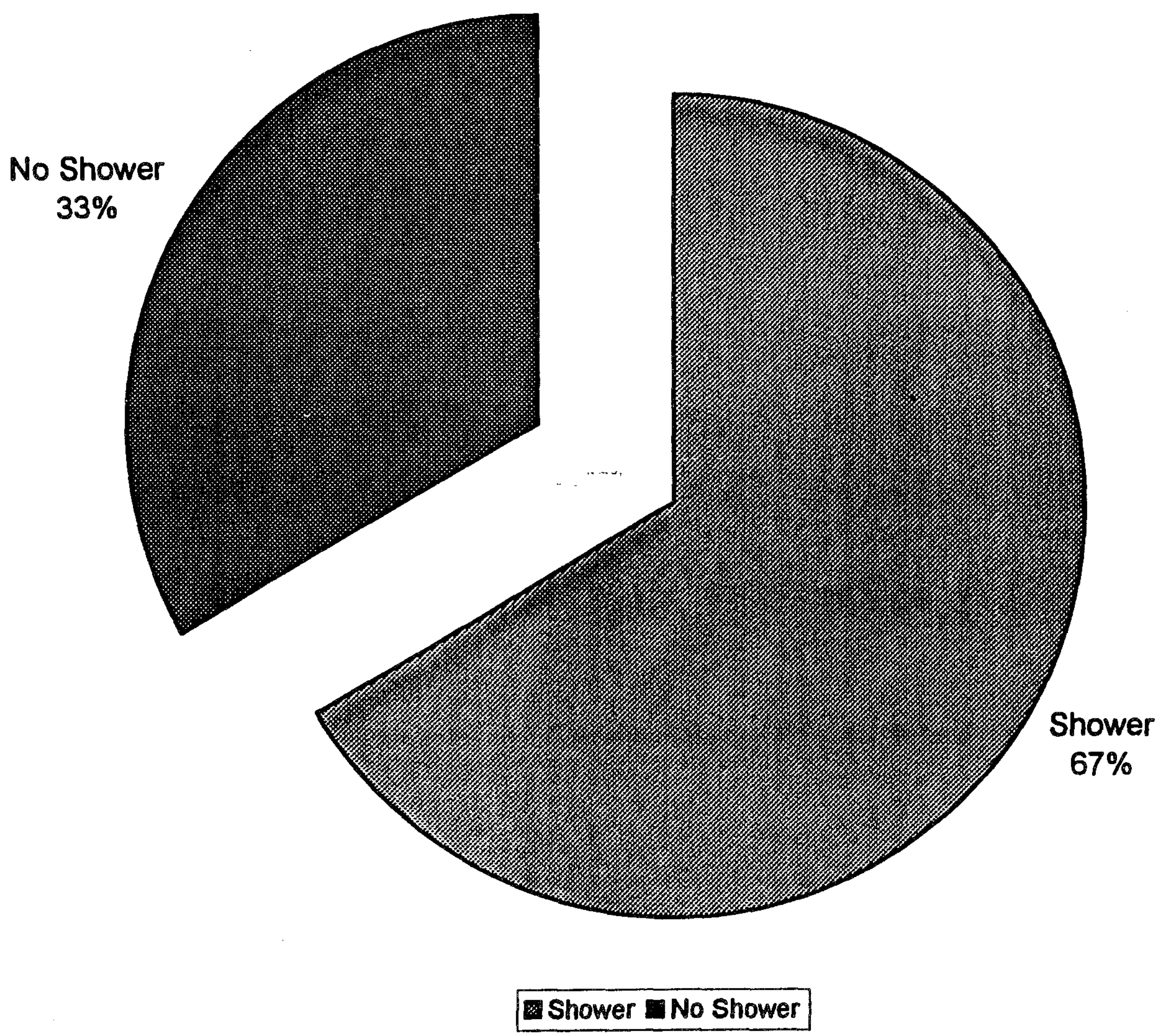


FIGURE 2.

USAGE OF SOAP PER CLUB vs. RASH

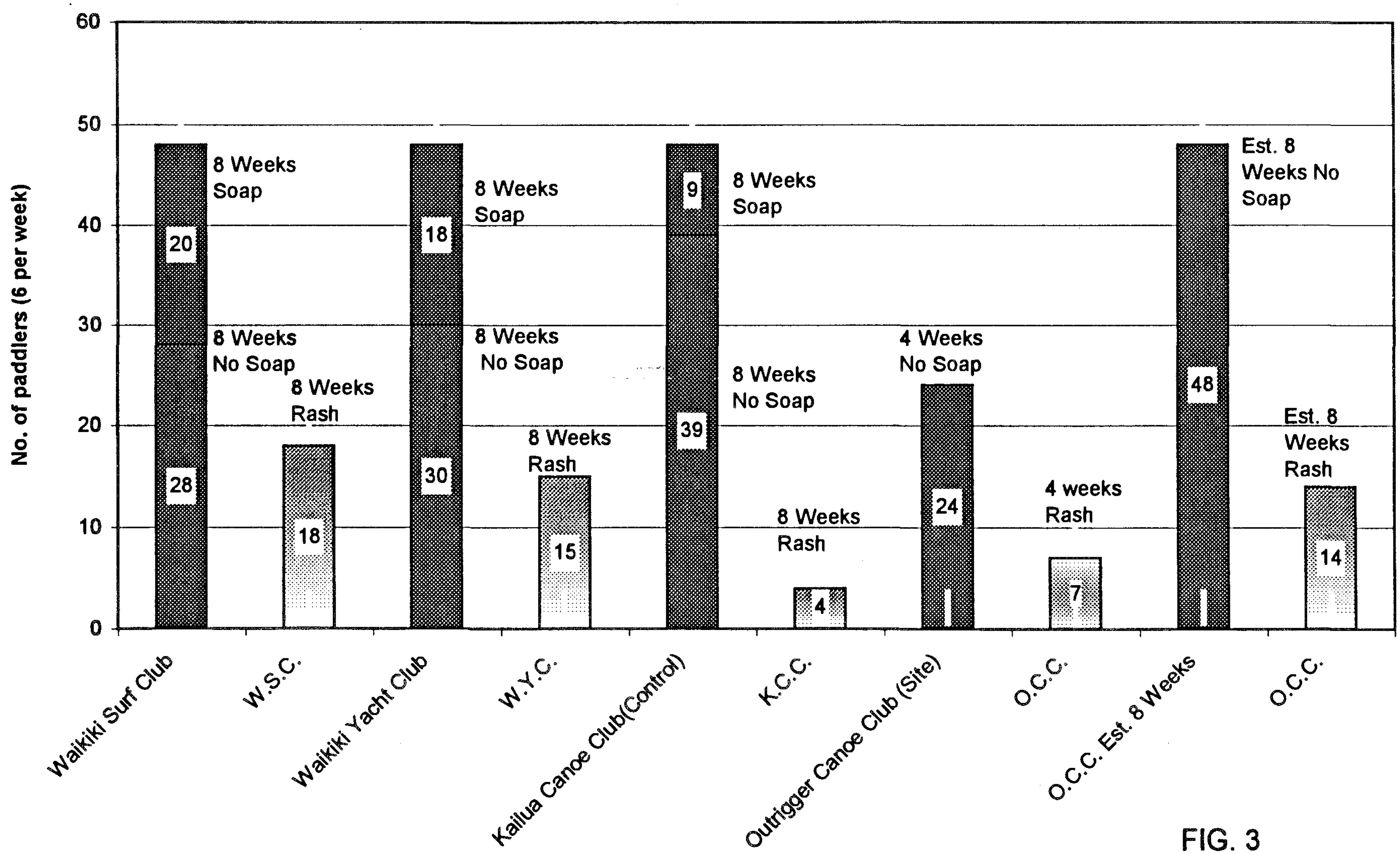


FIG. 3

USAGE OF SOAP PER CLUB vs. ILLNESS

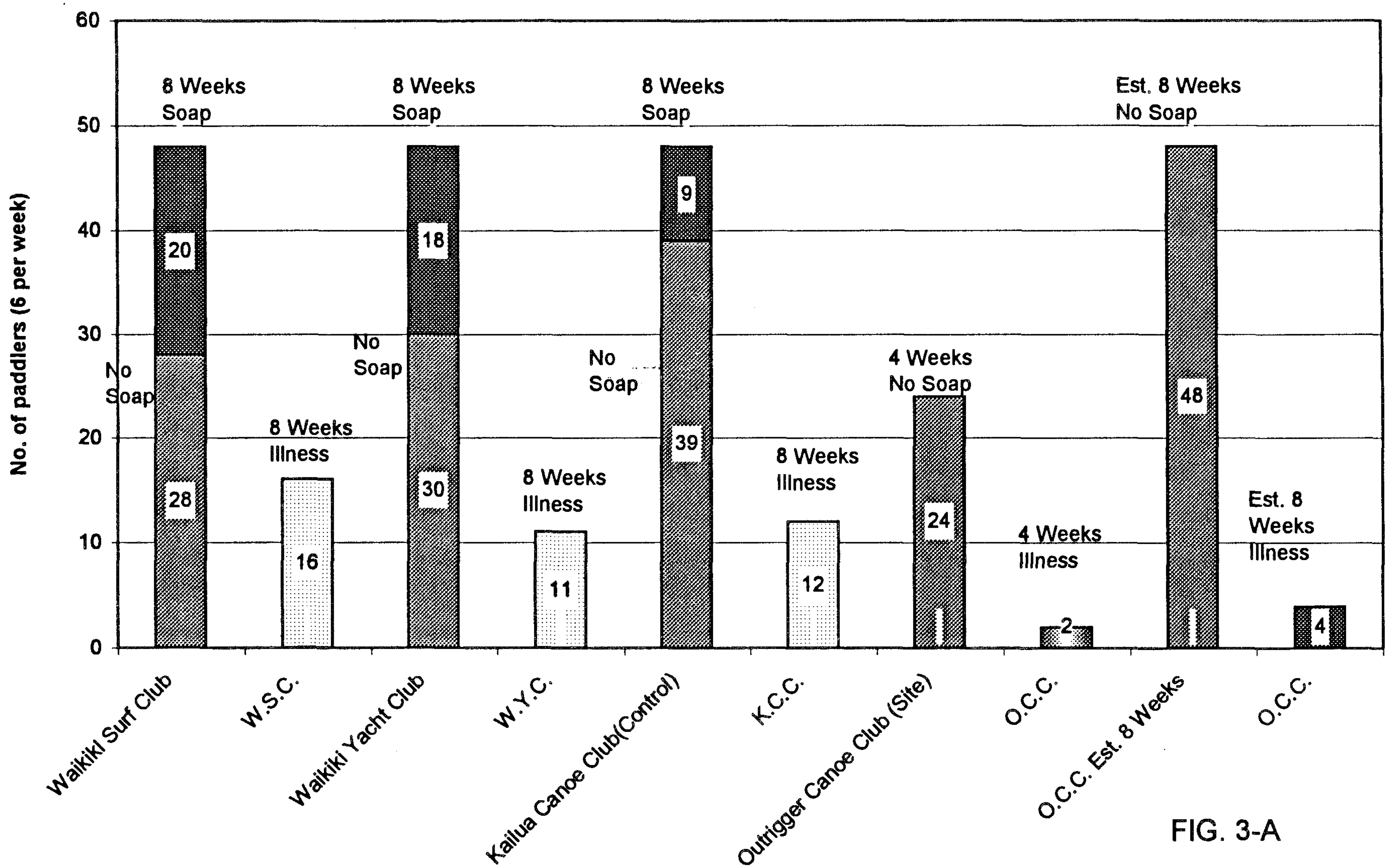


FIG. 3-A

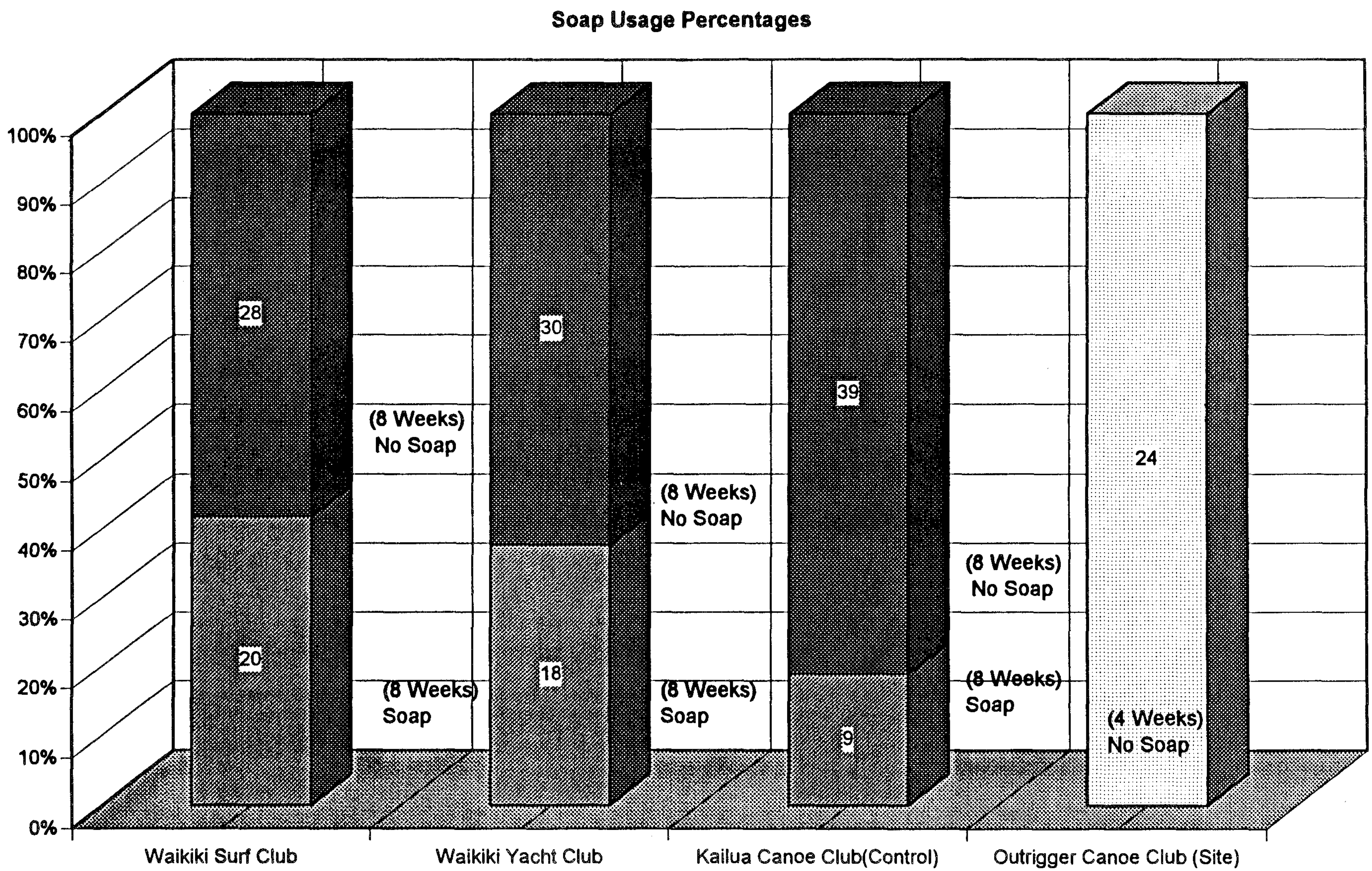
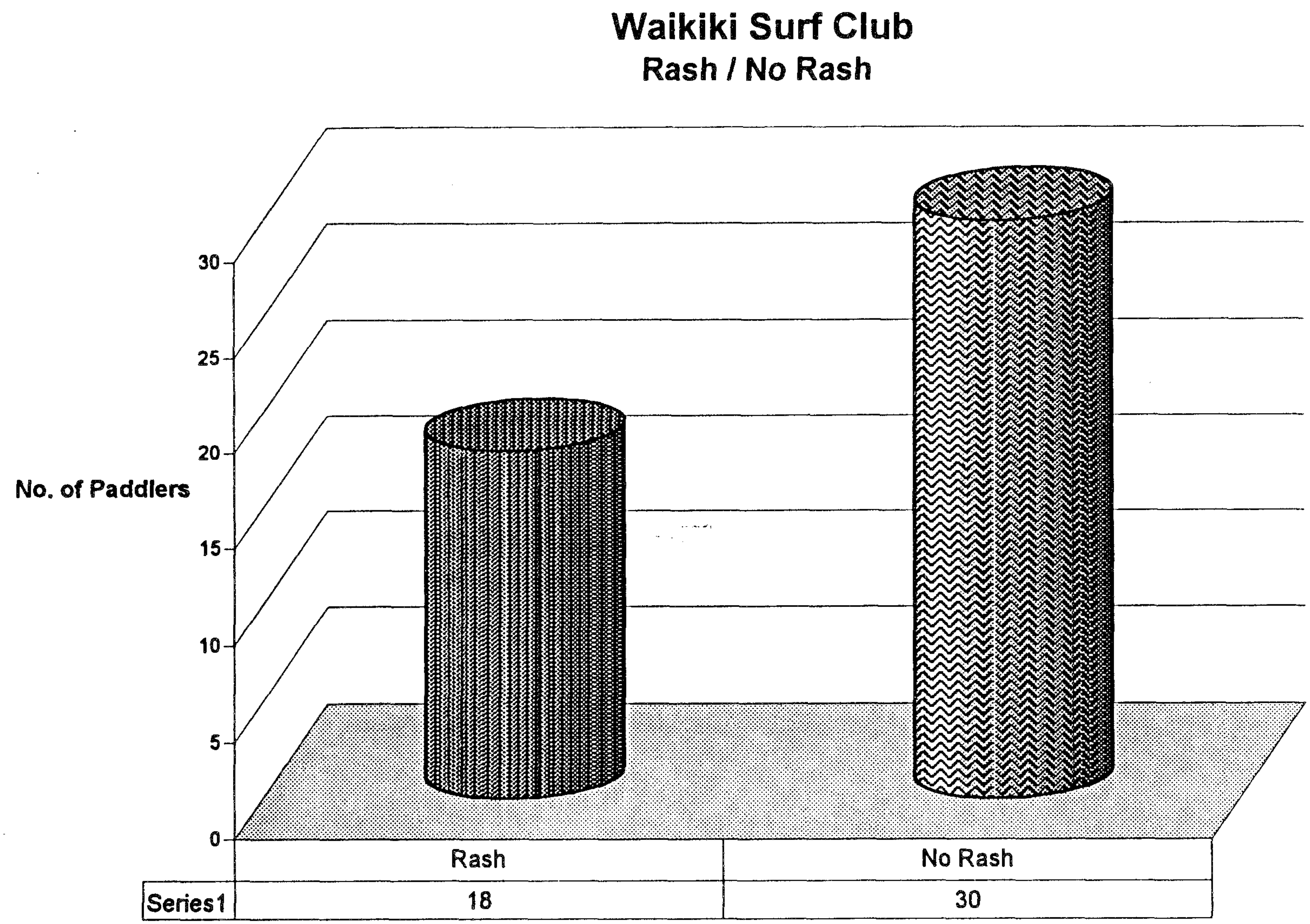

Soap Usage Percentages
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
28
20
(8 Weeks)
No Soap
(8 Weeks)
Soap
30
18
(8 Weeks)
No Soap
(8 Weeks)
Soap
39
9
(8 Weeks)
No Soap
(8 Weeks)
Soap
24
(4 Weeks)
No Soap
Waikiki Surf Club
Waikiki Yacht Club
Kailua Canoe Club(Control)
Outrigger Canoe Club (Site)

FIGURE 3-1.



Waikiki Surf Club
Rash / No Rash
No. of Paddlers
30
25
20
15
10
5
0
Rash
No Rash
Series1
18
30

FIGURE 4.

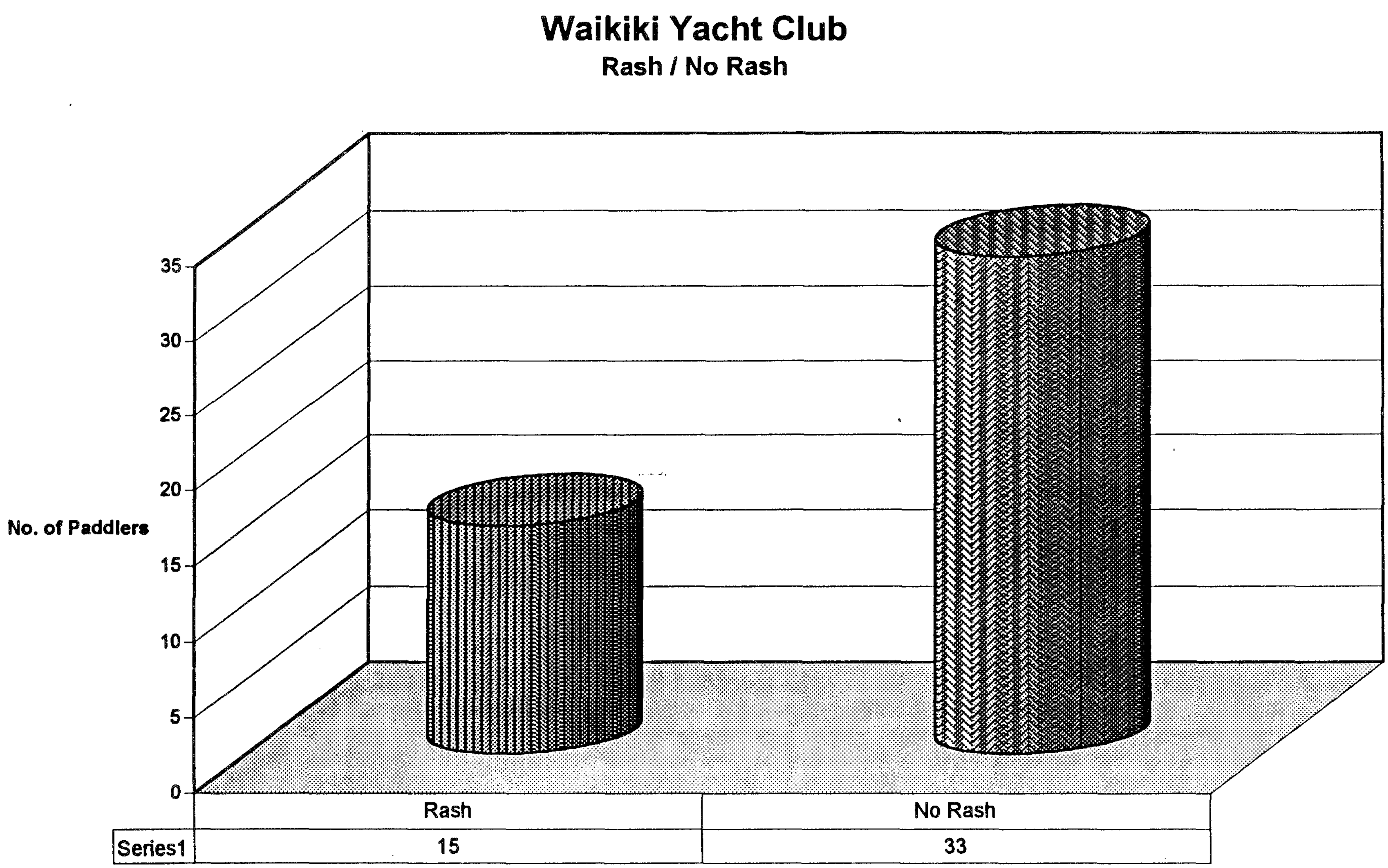
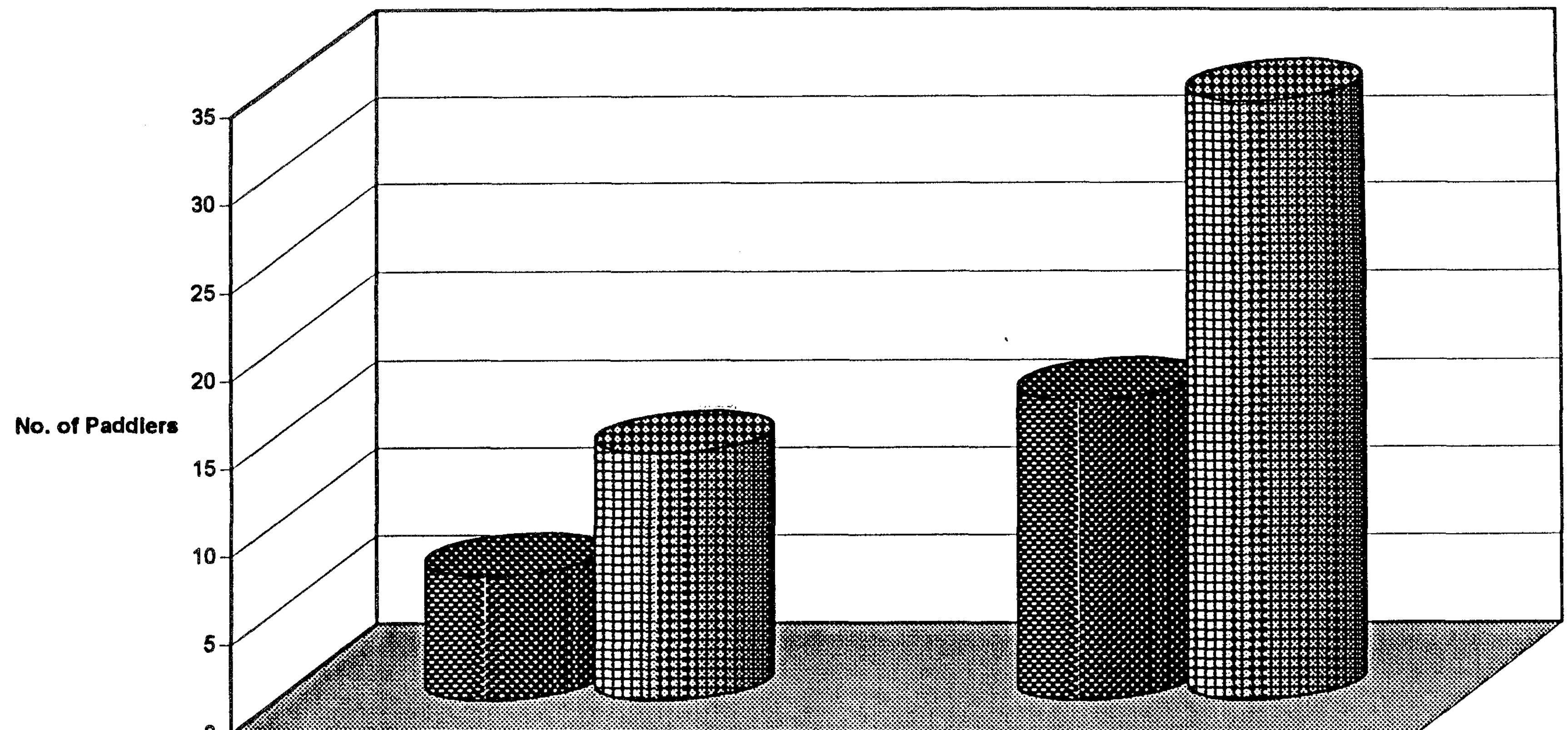

Waikiki Yacht Club
Rash / No Rash
No. of Paddlers
35
30
25
20
15
10
5
0
Rash
No Rash
Series1
15
33

FIGURE 4-1.

Outrigger Canoe Club
Rash / No Rash



	Rash	No Rash
4 Weeks	7	17
Estimated 8 Weeks	14	34

FIGURE 4-2.

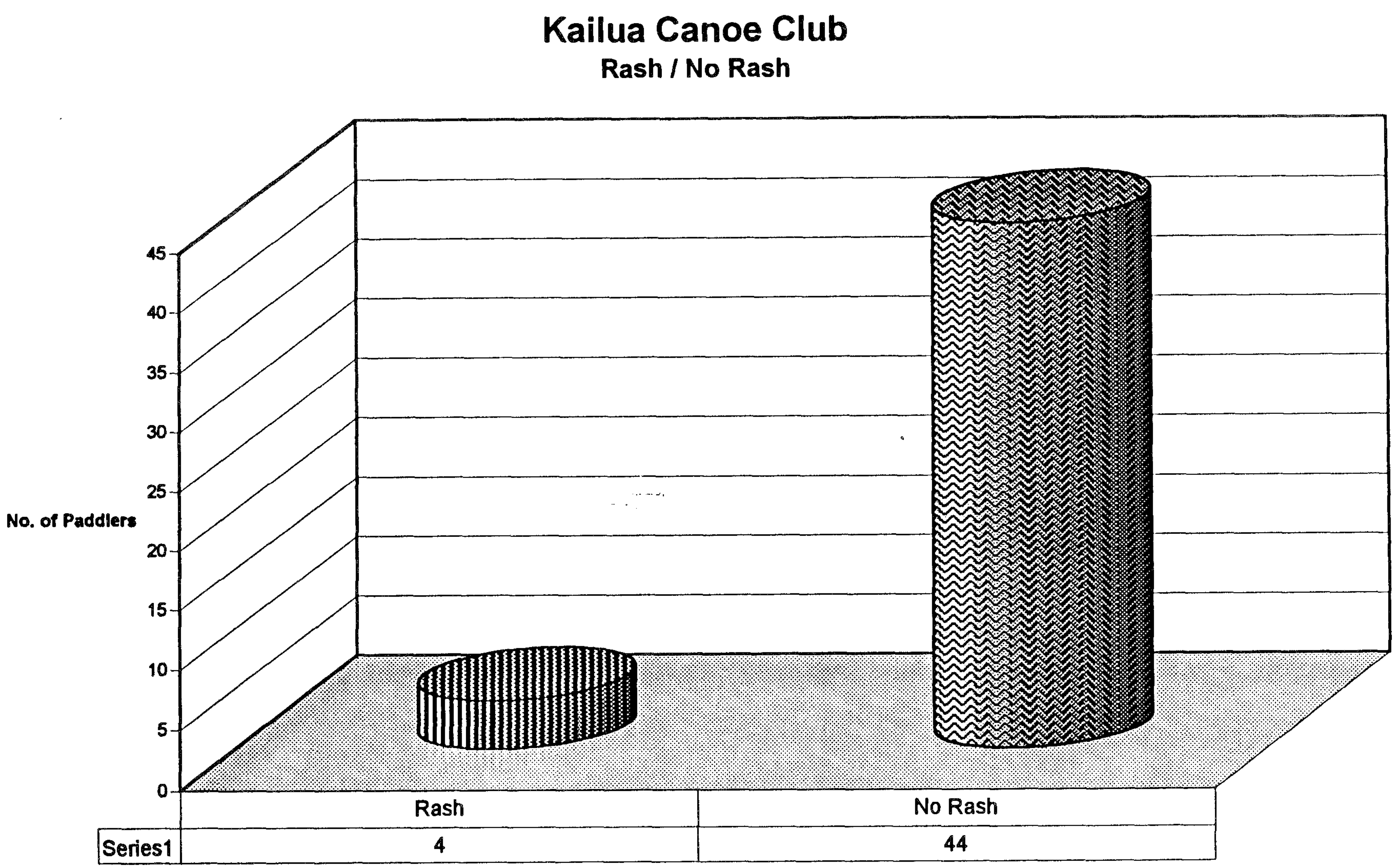
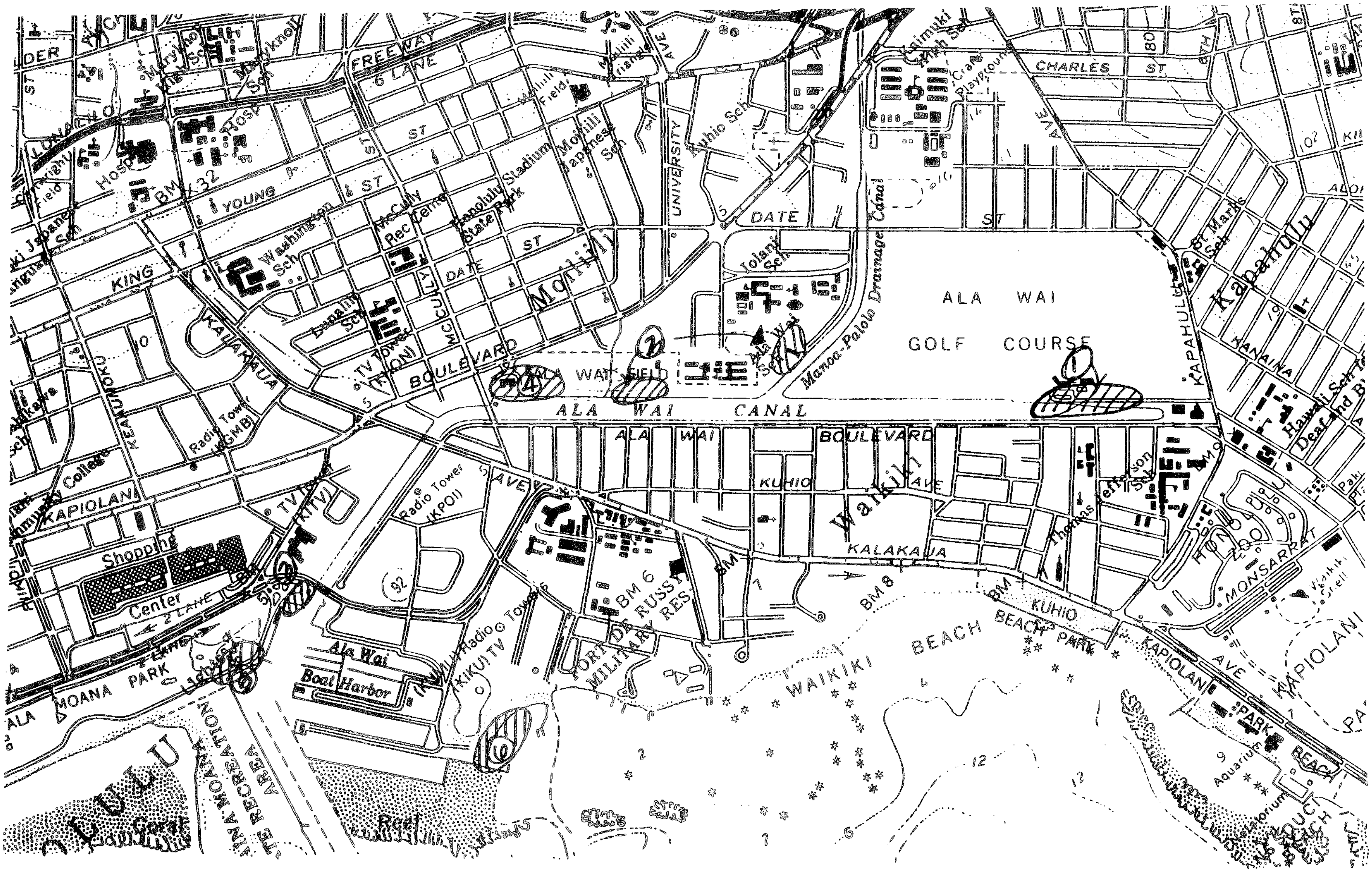

Kailua Canoe Club
Rash / No Rash
No. of Paddlers
45
40
35
30
25
20
15
10
5
0
Rash
No Rash
Series1
4
44

FIGURE 4-3.

APPENDIX D

MAPS 1-2

The Ala Wai Canal and Canoe Club Locations

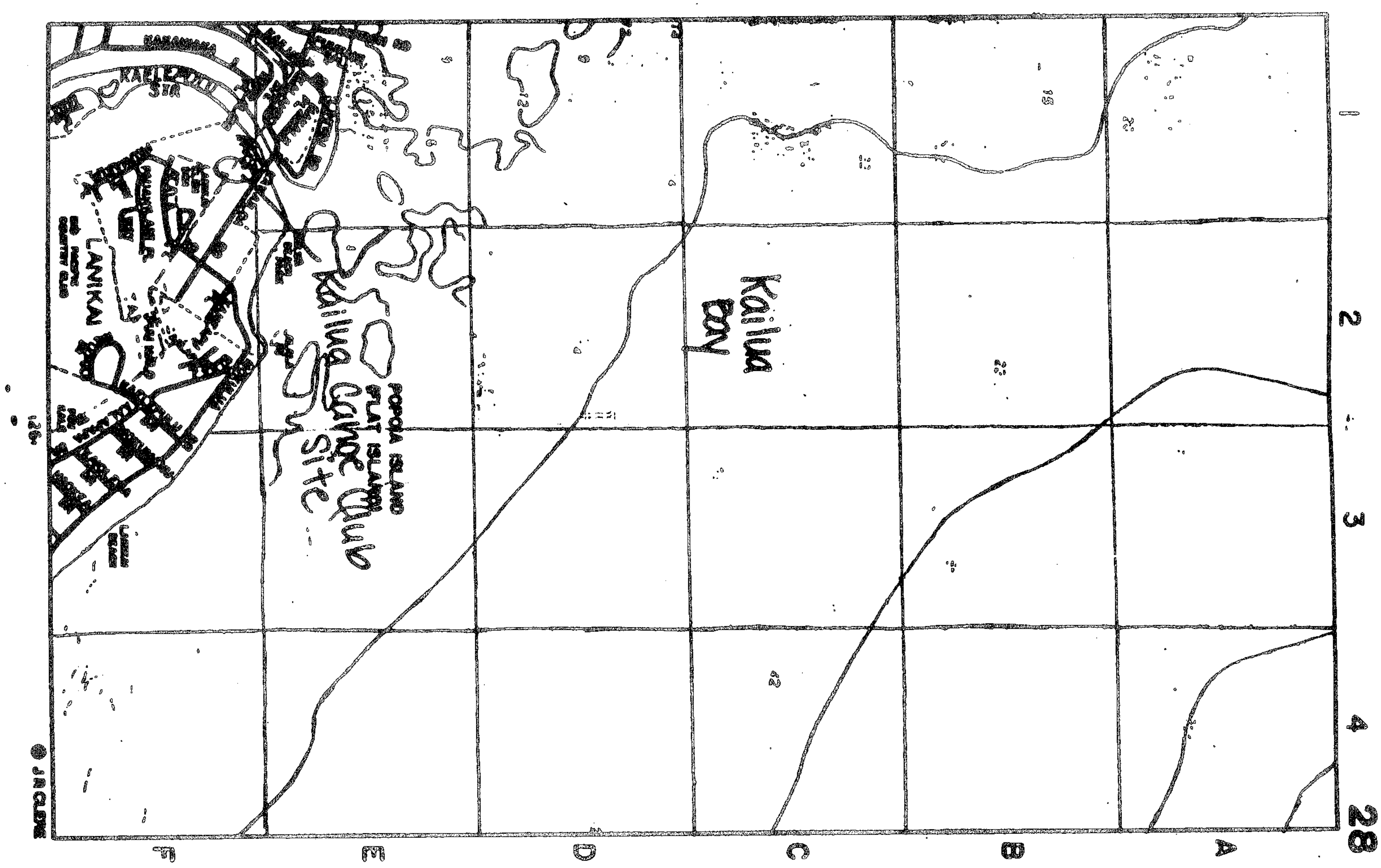


U.S. Geological Survey. Honolulu Quad.

Map # 1

Map No. 2

Map of Kailua Canoe Club Location



Brian's Sectional Maps O'ahu 1996 Edition page 28.

APPENDIX F

FISH CONSUMPTION RISK ASSESSMENT

Draft Screening Risk Evaluation for Consumption of Fish from the Ala Wai Canal

April 23, 1998

Barbara Brooks, Ph.D., and Gina Ling, Ph.D. , Department of Health

In 1991, a study conducted by Hawaii DOH showed that fish from the Ala Wai Canal contained elevated levels of several organochlorine pesticides and lead. The study was repeated by DOH in September 1997, to assess the nature and extent of organochlorine pesticide and lead contamination in fish from the Ala Wai Canal.

Ninety eight tilapia were collected from the "Kapahulu end" of the Ala Wai Canal using seine nets. The average length of the fish was approximately 15 cm, and the average weight was 120 gm. Fish samples were grouped into 14 replicate composites sets consisting of seven fish in each composite. Sevens sets were filleted and sevens sets were processed whole. Organochlorine pesticides, and PCBs were analyzed in whole fish and fish fillets using method 8080. Lead was measured in whole fish and fish fillets using method 6010, and lipids were analyzed using method 945.44.

Three organochlorine pesticides, DDE, dieldrin and endosulfan were detected in whole fish samples, while DDE and dieldrin were detected in fish fillets. PCBs, chlordane and several other organochlorine pesticides were not detected. Lead was detected in both whole fish and fish fillets. A summary of the tissue sampling results are shown in the table below.

Table 1 Contaminant Concentrations (mg/kg) in Fish Tissues from the Ala Wai Canal[1]

Contaminant	Whole Fish			Fillets		
	Mean	Maximum	RME[2]	Mean	Maximum	RME[1]
DDE	0.12	0.21	0.15	0.01	0.03	0.02
Dieldrin	0.09	0.15	0.12	0.02	0.03	0.02
Endosulfan	0.10	0.42	0.42	Non detect	Non detect	Non detect
Lead	2.95	3.74	3.74	0.53	0.83	0.63

[1] Concentrations based on wet weight

[2]RME=reasonable maximum exposure concentration is the lesser of the 95% Upper Confidence Limit of the mean and maximum value detected.

A comparison of the current study with the previous DOH study conducted in 1991 is summarized below:

- DDE and dieldrin were similar to levels measured in the 1991 study
- Chlordane was not detected in this study, but was the risk driver in fish from Manoa Stream
- Lead levels were higher compared to fish from Manoa Stream (from DOH, 1991)

Calculation of Risk-based Consumption Limits

Risk-based fish consumption limits were calculated to determine the allowable number of fish meals that may be consumed over a given time period (EPA,1997). The meal intake limit depends upon the chemical concentrations in the fish tissue, the size of the meal and the "acceptable" lifetime risk level. The consumption limits were prepared using default exposure assumptions presented in the EPA guidance document and are based on the excess cancer risk range of 10^{-4} to 10^{-6} and/or a hazard quotient of 1.

Below is the equation to calculate consumption limits based on cancer and non cancer end points.

Cancer end point equation:

$$CR_{\lim} = \frac{RL \cdot BW}{SF \cdot C_m}$$

where:

$CR_{\lim}$ = Maximum allowable fish consumption rate (kg/day)

RL = Maximum acceptable risk level (unitless)

BW = Consumer body weight (kg)

SF = Cancer slope factor, usually the upper 95% confidence limit on the linear term in the multistage model used by EPA $[(mg/kg\text{-}d)^{-1}]$

C_m = Measured concentration of contaminant *m* in a given species of fish (mg/kg)

Non Cancer Endpoint Equation:

$$CR_{\lim}=\frac{RfD \cdot BW}{C_m}$$

Where
RfD = Reference dose (mg/kg-d)

Intake limits expressed as the allowable number of fish meals per month can be written as follows:

$$No.meals/month=\frac{CR_{\lim} \cdot (dy/month)}{MS}$$

where:
MS = Meal size (kg fish/meal)
dy/month = 365.25 days/12 months, that is 30.4 days/months

Table 2 shows the risk based consumption limits for endosulfan, dieldrin and DDE in whole fish and fillets based on an 8 oz meal. The definition of unsafe fish consumption is a consumption limit of less than one meal every two months. This is represented by "NONE" in the fish consumption limit tables.

As shown in Table 2, dieldrin concentrations resulted in the most stringent risk-based consumption limits. For whole fish, consumption limits ranged from 0.5 meals per month to none. For fillets, consumption limits ranged from 2 meals per month to none.

Table 2-Monthly Intake Limits for DDE, Endosulfan and Dieldrin

Analyte	Tissue Type	Chemical Concentration [1] (mg/kg)	Health Intake Limit Meals Per Month			
			Non Cancer	Cancer Risk Level		
			HQ=1	10^{-4}	10^{-5}	10^{-6}
Endosulfan	whole	0.42	1	NA	NA	NA
Dieldrin	whole	0.12	4	0.5	None	None
Dieldrin	fillet	0.02	23	2	None	None
DDE	whole	0.15	31	13	2	None
DDE	fillet	0.02	31	No limit	14	1

[1] RME concentration
No Limit is more than 1 meal/day
None is less than 0.5 meal per month

Health Risk From Lead

Risk from exposure to lead was evaluated using USEPA's Lead Uptake Biokinetic model which predicts blood lead levels in children zero to seven years of age and a percentage of children with blood lead levels above 10 ug/dL, resulting from exposure to lead in diet, air, dust/soil and water.. For this assessment, a lead exposure dose that results in over five percent of the population exceeding the blood lead level of 10 ug/ dL (i.e. 95 percent of the children are protected) was used as the level of concern.

To assess the risk from lead exposure in children, the model suggests selecting 30 g/day for the average fish consumption rate and 140 g/day for the worst case. For this assessment, a 30 g/day fish consumption rate was used to assess the risk, which corresponds to approximately eight 4 oz meals per month. The predicted blood lead levels and percentage of children with blood levels above 10 ug/dL are shown in the table below. Default values were used to estimate lead exposure from air, soil/dust and water.

Table 3 Predicted blood levels in children consuming 30 g/day of fish from the Ala Wai Canal

Tissue Type	RME Lead Concentration (mg/kg)	Blood Lead Level Geometric Mean	Percent children above the mean
Whole	3.74	9.48	40.85
Fillets	0.63	4.23	0.64

As shown in Table 3, consuming fish fillets (30 g/day or about 8 meals per month) poses a minimal risk from lead exposure. The model predicts that less than 0.64 percent of children consuming 30 g/day fish fillets from the Ala Wai would have blood lead levels exceeding 10 ug/dL. In contrast, consuming whole fish would result in a significant risk. The model predicts that over 40 percent of children consuming 30 g/day whole fish would have blood lead levels exceeding 10 ug/dL.

Comparison of Lead Levels in Urban Streams on Oahu

In order to determine whether the elevated lead level measured in tilapia from the Ala Wai Canal are typical of levels found in streams potentially impacted with industrial activities, available fish sampling information was reviewed and summarized. Table 4 presents a preliminary analysis of readily available information.

Table 4 Comparison of maximum lead concentrations (mg/kg) in fish from urban streams on Oahu[1,2]

Tissue Type	Ala Wai Canal (1997)	Ala Wai Canal (1991	Manoa Stream (1991)	Kumumauu[3] Canal	Manuwai[3] Canal	Canal at Kaneohe Yacht Club[3]
Whole	3.74	1.4*	0.23	2.73	2.91	0.97
Fillets	0.83	0.1	0.1		NA	

[1] Based on wet weight.
[2] Measured in tilapia unless otherwise noted
[3] Draft Informal Technical Information Reports for site SD02 and SD03, Air Force Center for Technical Excellence, 1998
*Thalamita crenata

As shown in Table 4, maximum lead levels in tilapia from the Ala Wai Canal are higher than levels measured in the 1991 DOH studies and from fish in the canal adjacent to Kaneohe Yacht Club, but similar to levels measured in the Kumumauu and Manuwai Canals. Because a limited number of samples were taken for the Air Force studies, no statistical analysis was performed.

The Manuwai and Kumumauu Canals drain surface water and storm water runoff from Hickam Air Force Base. The canal adjacent to the Kanehoe Yacht Club was the reference area for the Air Force study and believed to have limited contamination from man-made sources.

The Air Force studies also sampled mullet and crab from the three sites. In all cases, lead levels in whole tilapia were higher (as much as 10 times) than in the other fish and shellfish species sampled.

Ala Wai Canal Survey

A recent survey conducted by Lisa Chau (1998) found that several species of fish were routinely consumed from the Ala Wai Canal. These species include Blue Pincer Crab, Samoan Crab, papio, barracuda, awa, and aholehole. Barracuda was the most commonly consumed fish during the survey period. Table 4 shows the summary information obtained by Ms. Chau during the survey period. Additionally, we calculated the "estimated consumption rate" assuming an 8 oz meal size. There is most likely a large degree of uncertainty in estimating the consumption rate from the limited survey, therefore the calculated monthly consumption rates should be viewed as estimates.

Table 4 Summary of Catch Consumed by Fishermen at the Ala Wai Canal (Nov. 1997 -Jan., 1998)

Type of Catch	Parts Consumed	No. Of People Consuming Catch	Estimated Catch Consumed Per Person/Year (lb/yr)	Estimated Consumption rate[1] (meal/month)
Blue Pincer Crab	Whole	11	19.3	3
Samoan Crab	Whole	4	50.	8
Papio	Flesh and Head	13	28	5
Barracuda	Flesh and Head	16	74	12
Awa	Flesh and Head			infrequent catch
Aholehole	no data	1	24	4

[1]Based on an 8 oz meal.

As shown in Table 4, several species of fish were caught and consumed from the Ala Wai Canal. Barracuda represented the largest catch during the survey period. Consumption rates for the various fish species ranged from 12 meals/month to less than 3. Tilapia were not caught during the survey period.

SUMMARY

A summary of the findings are presented below:

- DDE, dieldrin, endosulfan and lead were found in tilapia from the Ala Wai Canal.
- In adults, consuming more than 0.5 meal per month of whole fish or 2 meals of fish fillets could present an unacceptable cancer risk. The risk is expected to be even higher for children due to their lower body weight.
- Lead in whole fish posed a risk to children who consume more than 8 meals per month.
- Lead levels in fish from the Ala Wai were similar to other streams located in industrial areas on Oahu.

RECOMMENDATIONS

The study indicates that organochlorine pesticides and lead are present in fish at levels that may pose a risk to human health. These levels may be typical of concentrations found in fish from other urban streams on Oahu. An island wide fish advisory for streams in urban areas on Oahu warning of the presence of lead and pesticides in fish, may be warranted. The advisory should warn against consuming whole fish due to their higher level of contamination. Additional sampling of fish commonly consumed from the Ala Wai Canal and other urban streams may be warranted to confirm and extend the results of this study.

EPA 1997. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2-Risk Assessment and Fish Consumption Limits, Second Edition. EPA 823-B-97-009. July.

Lisa Chau. 1998. Fishers Consuming Catch at the Ala Wai Canal, November 1997 to January 1998

APPENDIX G

FISH CONSUMPTION ADVISORY

APPENDIX H

ABANDONED AUTOMOTIVE BATTERY SURVEY

SOURCES OF LEAD INTO THE WATERSHED OF THE ALA WAI CANAL FROM ABANDONED AUTOMOTIVE BATTERIES

RESEARCH REPORT

November 26, 1997

For

Ala Wai Canal Watershed
Water Quality Improvement Project
Eugene P. Dashiell
1314 South King Street, Suite 951
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Is 489
Environmental Practicum
University of Hawaii at Manoa

University of Hawai'i at Mānoa

Environmental Center
A Unit of Water Resources Research Center
2550 Campus Road • Crawford 317 • Honolulu, Hawai'i 96822
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January 5, 1998

Mr. Eugene Dashiell
Ala Wai Canal Watershed
Water Quality Improvement Project
1314 South King Street, Suite 951
Honolulu, Hawaii 96814-1354

Dear Mr. Dashiell:

IS 489 Environmental Practicum
Final Report

Enclosed is a copy of the final report on the *Sources of Lead into the Watershed of the Ala Wai Canal from Abandoned Automotive Batteries* prepared by Vance Igawa under your sponsorship, for the University of Hawaii, Environmental Practicum class (IS 489). Your guidance of Mr. Igawa is greatly appreciated and I believe his project provided an excellent introduction to the issues and occasional difficulties involved in conducting environmental research.

For many of our students, the practicum class is their first opportunity to work with professionals in the field of their choice. Thank you for the time, effort, and encouragement you have given them to make this collaborative program so rewarding. I hope that you have found the experience equally productive and that you will consider participating in our program again in the future.

Many thanks, once again.

Sincerely,

Jacquelin N. Miller

Jacquelin N. Miller, Ph.D.
Environmental Studies Advisor

Abstract

The goal of this project is to locate and map abandoned vehicle batteries found within the Ala Wai Canal watershed which could indicate possible sources of lead found in the canal's water and sediments. The watershed was divided into four geographical sections (low density single-family homes, high density single-family homes, commercial areas, and apartments). Data was collected by surveying the area either on foot or by bicycle on streetways and sidewalks of approximately quarter mile grids of each geographical section. The results have found low numbers of abandoned vehicle batteries within each studied section. These low numbers of abandoned batteries found in each sampled area indicate excretions of lead from these batteries are minimal and that other non-point sources are probably the main contributors to the Ala Wai Canal's high lead concentrations.

I. Introduction

High concentrations of lead in the waters and sediments of the Ala Wai Canal have been an environmental problem for many years. Many people presume that one of the major sources of lead to the canal is due to abandoned vehicle batteries that are left near curbs and drainage systems within the watershed (figure 1). Since vehicle batteries contain corrosive materials and heavy metals, excretions of these materials (such as lead) may contaminate soil and ground or surface water if disposed improperly.

Ala Wai Canal Watershed

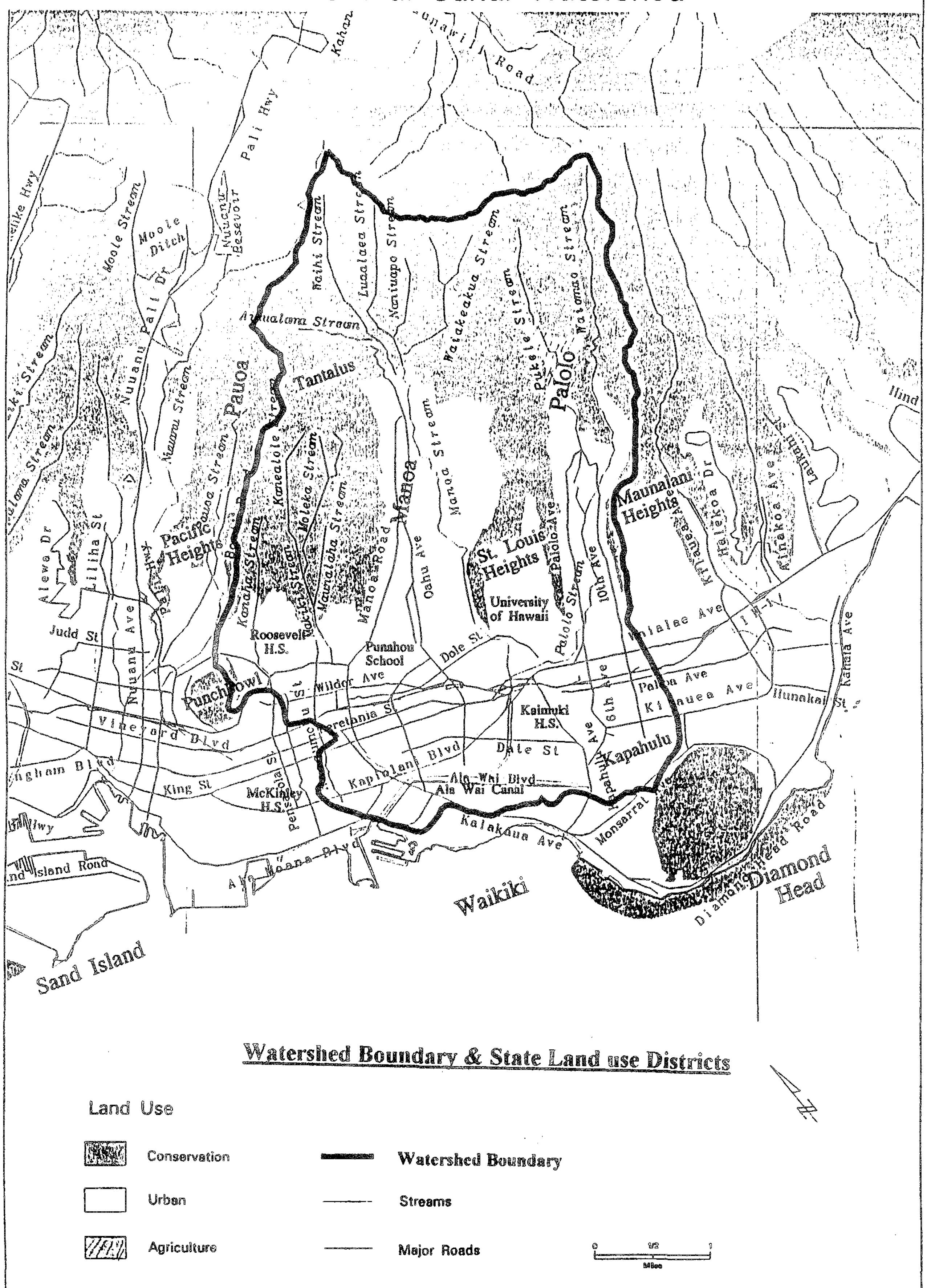


Figure 1. Map of the Ala Wai Canal watershed from the the Ala Wai Canal Watershed: Water Quality Improvement Project.

The objective of this study is to locate and map abandoned vehicle batteries found within the Ala Wai Canal watershed which could indicate possible sources of lead found in the canal's water and sediments. Within the urban region of the watershed, four sample areas of low density single-family homes, high density single-family homes, apartments, and commercial areas have been examined. These sample sites were divided into areas of quarter mile grids. The total number of abandoned vehicle batteries which were found in each sample site provides the basis for estimating the numbers present throughout the watershed.

Background on the Ala Wai Canal Watershed

The Ala Wai Canal watershed with an area size of 16.20 square miles, encompasses the greater part of the Honolulu area (Dashiell, 1997). This watershed is located on the southern side of Oahu, Hawaii and starts near the upper slopes of the Koolau Mountain Range and extends seaward to the famous Waikiki district. The general topography of the Ala Wai Canal watershed in the low lying area is highly urbanized with both high and low density housing, apartments, and commercial areas. At the mountain side of this watershed, vegetation is extensive. Cover in the upland area consists mainly of wooded, brushlands with steep mountainous terrain and very few man-made structures.

The Ala Wai Canal (figures 2,3), a man-made tidal estuary, is located about a half mile inland of Waikiki beach within the Ala Wai Canal watershed. The canal is described in the report, The Ala Wai Canal from Wetlands to World-Famous Waikiki by Lum and Cox (1991) as a canal that:

" runs parallel to the beach for a mile and a half and makes a 45 degree bend at the western end at McCully Bridge, extending another half mile

to the open sea. From the open ocean to the 45 degree bend, the canal is 150 ft (46 m) wide. Beyond the bend, the canal is 250 ft (76 m) wide for one mile (1.6 km) then tapers from 250 to 90 ft (76m to 27 m) for the last half mile at the eastern end near Kapahulu Avenue."

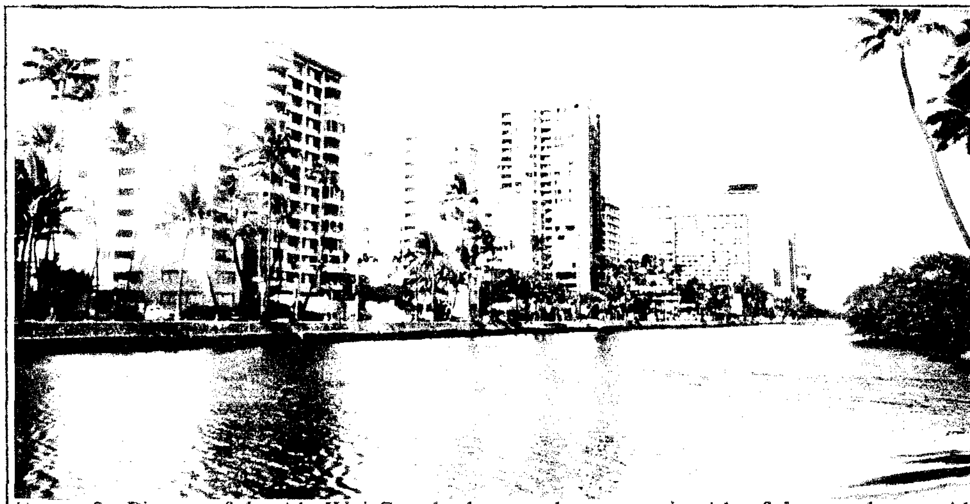
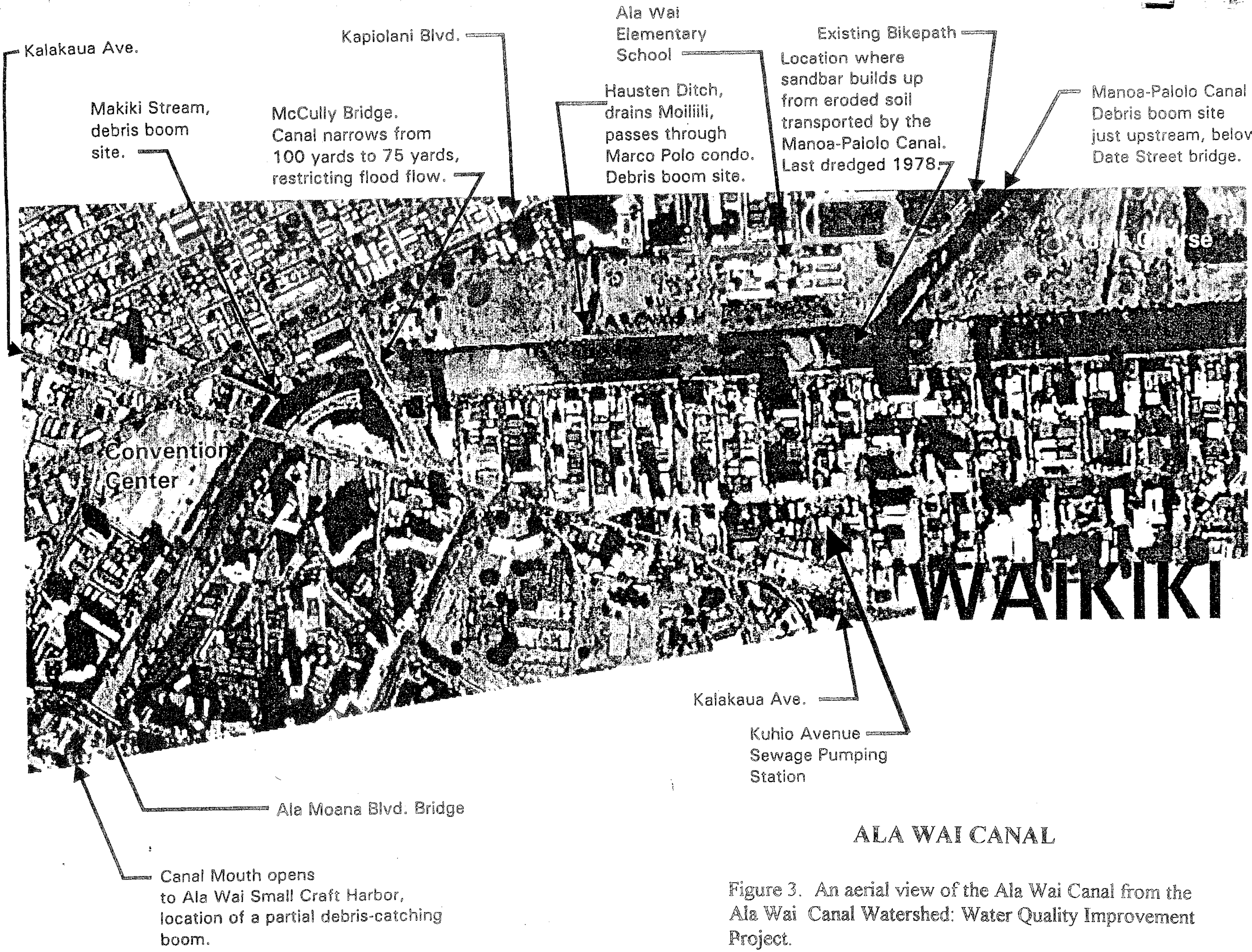


Figure 2. Picture of the Ala Wai Canal taken on the mountain side of the canal, near Ala Wai Golf Course.



ALA WAI CANAL

Figure 3. An aerial view of the Ala Wai Canal from the Ala Wai Canal Watershed: Water Quality Improvement Project.

Constructed in 1906 to 1926, the Ala Wai Canal was built to provide drainage and diverge stream flows away from Waikiki for the purpose of beautification. The four main streams that were diverted from the watershed to the canal are: Makiki, Kanaha, Manoa, and Palolo stream (figure 1). These streams, fed by drainage systems under street-ways, travel through a low lying, high density, urbanized region of Oahu.

Water quality in the canal tends to be high in suspended solids, nutrients, and metal content due to non-point sources coming primarily from urbanized areas. With the natural silting of the canal, there is a dramatic increase in silt fluxes and run-off due to urbanization associated with construction in the watershed (Miller, 1975). Sources of lead entering the Ala Wai Canal include: residual soils, lead paint, lead dust from automotive brake pads, pesticides, vehicle batteries, etc. Although lead-acid vehicle batteries are a potential non-point source of lead entering the canal, a study by Eric DeCarlo and Khalil Spencer, researchers at the University of Hawaii, on the Records of Lead and Other Heavy Metal Inputs to the Sediments of the Ala Wai Canal, Oahu, Hawaii (1995) have determined that residual soils, with high lead concentrations found near and around roadsides from automotive use (mainly leaded fuels), are a major source of lead to the Ala Wai Canal.

Background on Vehicle Batteries

The primary purpose of vehicle batteries, also known as starter or automotive batteries (figure 4) is to start a gasoline or diesel engine, reliably and repeatedly, with a reserve capacity to power services on the automobile when the engine has stopped (Tuck, 1991). Specifications on vehicle batteries are usually lead and acid based. There are no substitutes for lead-acid batteries in terms of convenience, power, and cost-effectiveness. Other substitutes are either too large, too expensive, too complex, or require extreme temperatures in order to operate efficiently (Virginia Waste Minimization Program, 1995).

Lead–acid batteries

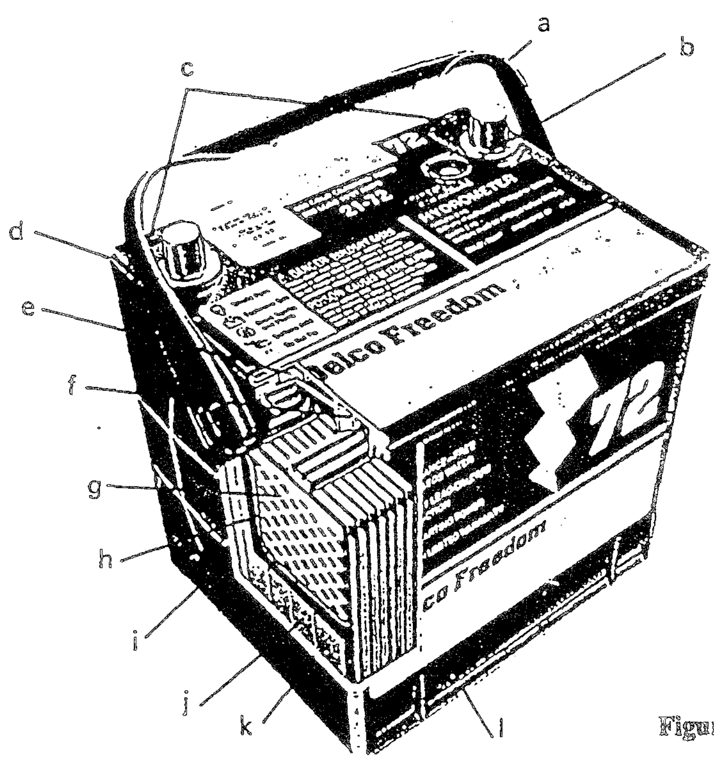


Figure 4.

— The construction of an SLI battery. (a) Flexible fold-down handle; (b) Built-in hydrometer; (c) Moulded symbols; (d) Heat-sealed covers; (e) Built-in flame arrestor vents; (f) Liquid-gas separator; (g) 'Small window' wrought lead-calcium grid; (h) High-density plate paste; (i) Polypropylene case; (j) Separator envelopes; (k) Reinforced case end wall; (l) Hold-down ramp. (Courtesy of AC Delco.)

Lead-acid batteries are used in cars and marine vehicles. These batteries present a potential threat to the environment due to their contents. Each battery is constructed of a plastic shell containing several inner cells composed of lead and lead plates immersed in sulfuric acid (Health Service Agency, 1997). These batteries contain approximately 18 pounds of toxic lead and lead compounds, one gallon of sulfuric acid, and three pounds of plastic (VWMP, 1995). The lead, acid, and plastic found in vehicle batteries are all recyclable.

The environmental problem with automotive batteries is improper disposal. The corrosiveness and heavy metal content (lead) found in lead-acid batteries may endanger both human health and the environment. These batteries are characterized as hazardous waste due to their lead and acid content. Improper disposal of automotive batteries in non-hazardous waste landfills, abandoned in street-ways, or an empty field, may cause contamination of soil, ground, and surface water from the hazardous contents found in these batteries (figure 5).

ABANDONED VEHICLE BATTERY

Figure 5. Picture of abandoned vehicle battery. (Courtesy of Eugene Dashiell.)

Lead-acid vehicle batteries in the State of Hawaii, may be returned to any merchant selling or handling these batteries for proper disposal. Costs for the disposal of vehicle batteries varies with dealers. However, in a phone conversation with a person who wants to remain anonymous in the Department of Health (DOH) of the Solid and Hazardous Waste Branch, every merchant selling new lead-acid vehicle batteries, must except the old batteries in return. The ratio for the trade-off between the merchant and consumer is one for one. Merchants are required by the State to include a core charge or service charge within each sale of approximately five to six dollars to increase the percentage of lead-acid batteries returned.

Health Concern

Health problems associated with lead and acid contamination of sediments, soil, ground, and surface water include: fatigue, impaired central nervous system functions, and impaired hearing. A human recreational activity, such as fishing, around the Ala Wai Canal and in the tributary streams is of concern. Fishes and bottom feeders, such as crabs, prawns, crayfish, etc. inadvertently ingest lead through their feeding cycles and habitat, which is later transferred up the food web. Humans who eat these organisms are at higher risk of lead contamination, especially infant children. Health problems associated with lead poisoning include: anemia, kidney damage, reproduction, and the negative effects on children's growth and mental development.

The Ala Wai Canal is not only an important resource to manage the flow of water from the watershed, but a valuable recreational resource as well. Recreational activity within the canal and near the mouth of the canal (for example, canoe-paddling, kayaking, surfing, swimming, fishing, etc.) plays an important role in the Honolulu community, if not the entire island. Surf meets, canoe races, etc. are just a few of many community activities held in or near the canal. Due to the high numbers of human activities, particularly fishing, in and near the Ala Wai Canal, the high lead content in the canal is of public health concern. Thus, the interest and need to determine if abandoned vehicle batteries may be a significant source of lead to the watershed should be addressed..

II. Methods/Procedures

Literature on the construction and content of lead-acid vehicle batteries was located at the University of Hawaii Hamilton Library. Books, reports, and journal articles describing environmental hazards (human health effects, transmission, impacts on wildlife and fisheries, groundwater contamination), and probable releases of lead in the environment included studies by Laws (1993) and DeCarlo & Spencer (1995). Other sources of hazards to the environment from lead in vehicle batteries were located through the internet via Netscape. Information included dangerous environmental affects of improper vehicle battery disposal from the Health Service Agency and Virginia Waste Minimization Program's home pages. The Department of Health's (DOH) Solid and Hazardous Waste Branch and DOH's Clean Air Branch provided information on state requirements on the handling and disposal of vehicle batteries and the health problems associated with lead contamination. No information on the quantities of lead released from vehicle batteries could be located. Telephone inquiries to Environmental Chemists, Frank Sansone (Associate Professor in Oceanography at UH) and Hans-Jurgen Krock (Chair, Ocean Engineering Director, Look Lab/Associate Professor, & Associate Researcher at

UH), as well as literature searches, and internet sources failed to locate specific information on the quantities of lead that might be released by vehicle batteries.

The Ala Wai Canal watershed was divided into four geographical sections within the urban region. These areas included: low density single-family homes, high density single-family homes, commercial areas, and apartments. The location and classification of sample areas were as follows:

Sample Areas	Location	Classification
Sample #1	Manoa	Low density single-family homes
Sample #2	Kapahulu	High density single-family homes
Sample #3	Kaimuki	Commercial area
Sample #4	Waikiki	Apartments

Information on the numbers and location of abandoned vehicle batteries have been collected in four of these square sample areas. The areas were surveyed approximately quarter mile either by foot or bicycle on street-ways and sidewalks. Data collected includes: location (street names), dates, times, weather, alignment (upright, sideways, or upside-down), and condition (good, fair, or bad) of abandoned vehicle batteries (tables 1-4 in appendix).

The four main streams (Makiki, Kanaha, Palolo, and Manoa) that feed the canal have been highlighted and labeled on a Ala Wai Canal watershed street map. Abandoned vehicle batteries found in each sample area were plotted on sectional street maps of the Honolulu area. Estimated total areas of each urban geographical sections (low density single-family homes, high density single-family homes, commercial areas, and apartments) were highlighted and labeled by color.

Estimates on the total number of abandoned vehicle batteries found within the watershed were determined by adding the total number of abandoned vehicle batteries from each geographical section (low density single-family homes, high density single-family homes, commercial areas, and apartments). Based on the number of abandoned vehicle batteries found in the representative sample areas, the estimated total number of abandoned vehicle batteries of each geographical section was estimated based on the size of the sample area relative to the size of the total geographical section.

III. Results

Four geological sections within the Ala Wai Canal watershed were sampled to determine the number of abandoned vehicle batteries left near streetways and drainage systems for each particular section (figure 6). A total of eight batteries were located in approximately 16.1 miles traveled.

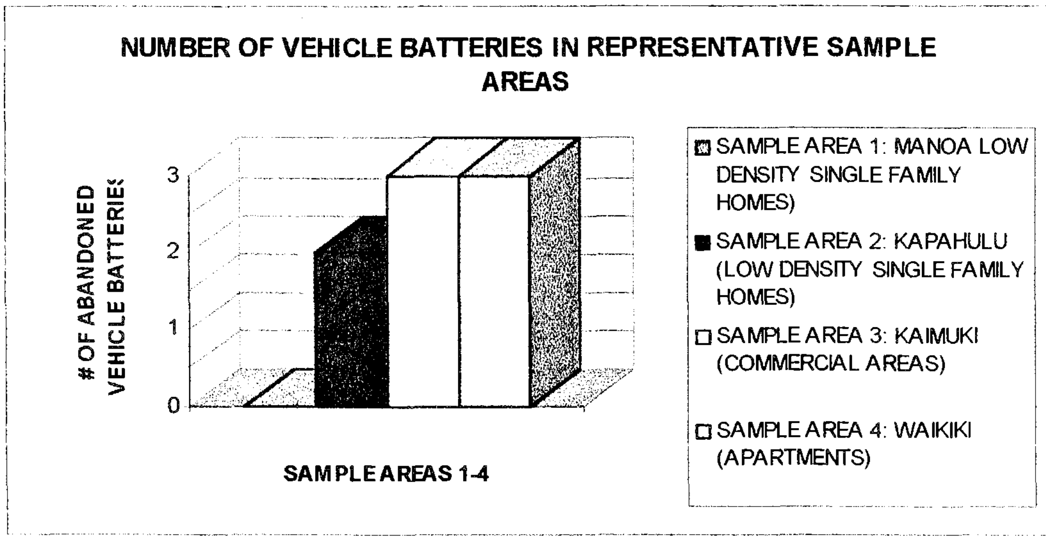
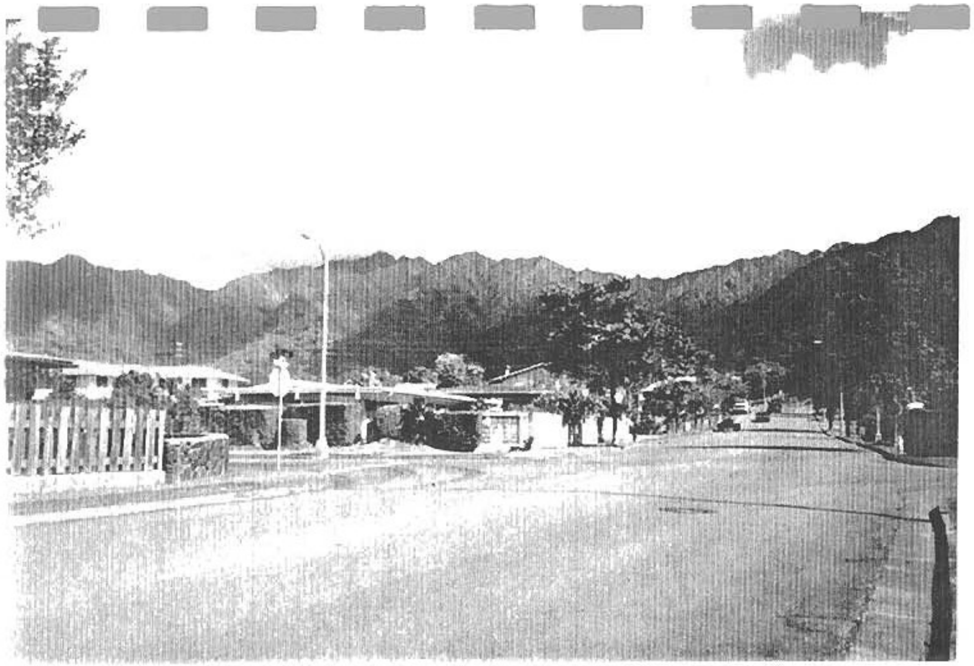


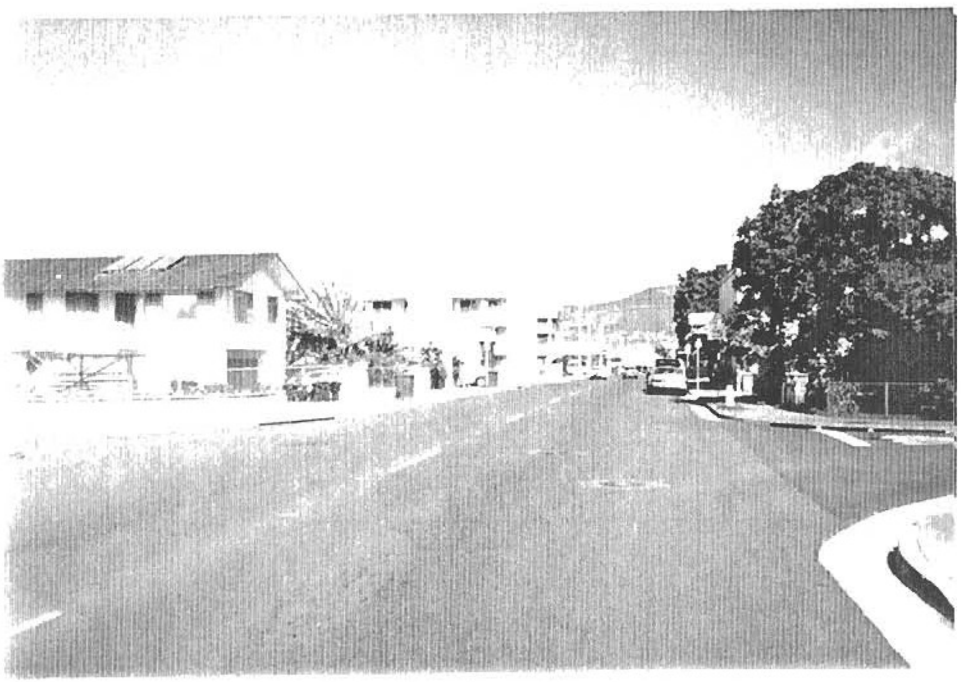
Figure 6.

Characteristics of the neighborhoods where the surveys took place are shown in pictures 1, 2, 3, & 8. An abandoned battery was observed near the curb where any acid that might be released would likely flow into the storm drain system (picture 4). Other batteries were seen at the edge of yards or just outside garages (pictures3, 6, 7, & 9).

PICTURES



Picture 1. Picture taken of Manoa (sample area 1).

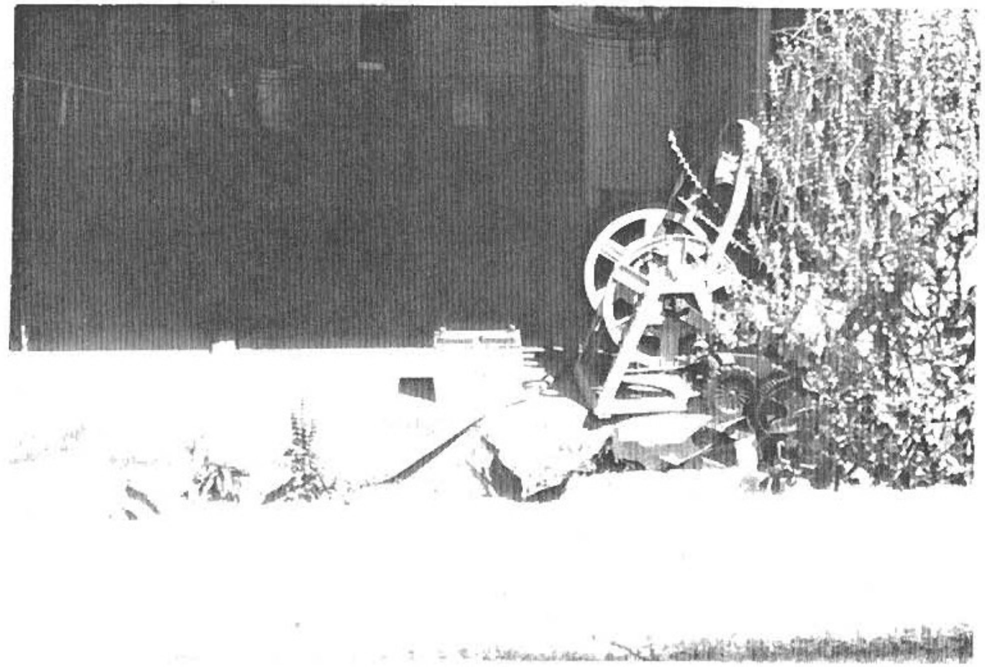


Picture 2. Picture taken of Kapahulu (sample area 2).

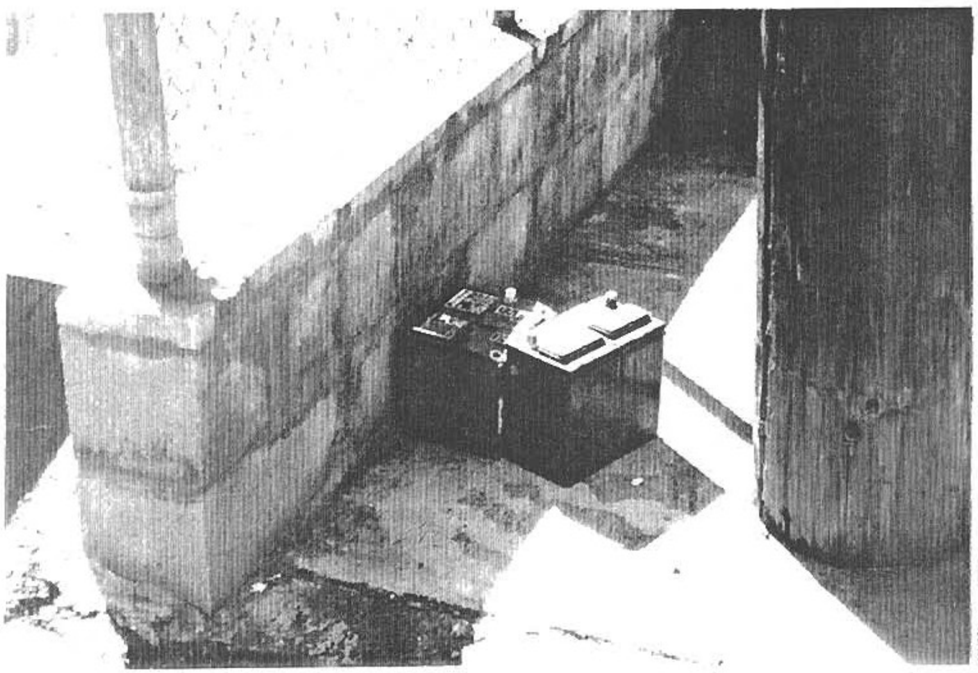
Picture 3. Picture taken in sample area 2 of abandoned vehicle battery left near house.

Picture 4. Picture taken in sample area 2 of abandoned vehicle battery left near curb.

Picture 5. Picture taken in Kaimuki (sample area 3).



Picture 7. Picture taken in sample area 3 of abandoned vehicle battery left in garage.



Picture 6. Picture taken in sample area 3 of abandoned vehicle batteries left near curb.

Picture 8. Picture taken of Waikiki (sample area 4).

Picture 9. Picture taken in sample area 4 of an abandoned vehicle battery left near tree.

The results, as shown in figure 7, indicate the majority of abandoned vehicle batteries found within the represented sample areas were aligned upright, compared to the batteries side, or upside-down.

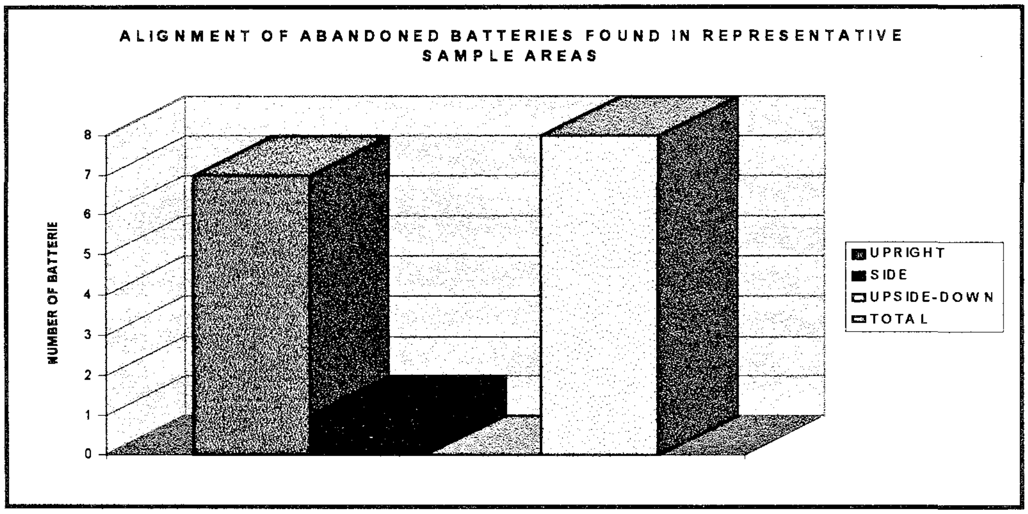


Figure 7.

Of the total abandoned vehicle batteries found in represented geographical sections in sample areas 1-4, the majority of vehicle batteries were in fair condition (figure 8), making it almost impossible for the internal, lead-based acid solution from seeping into the watershed.

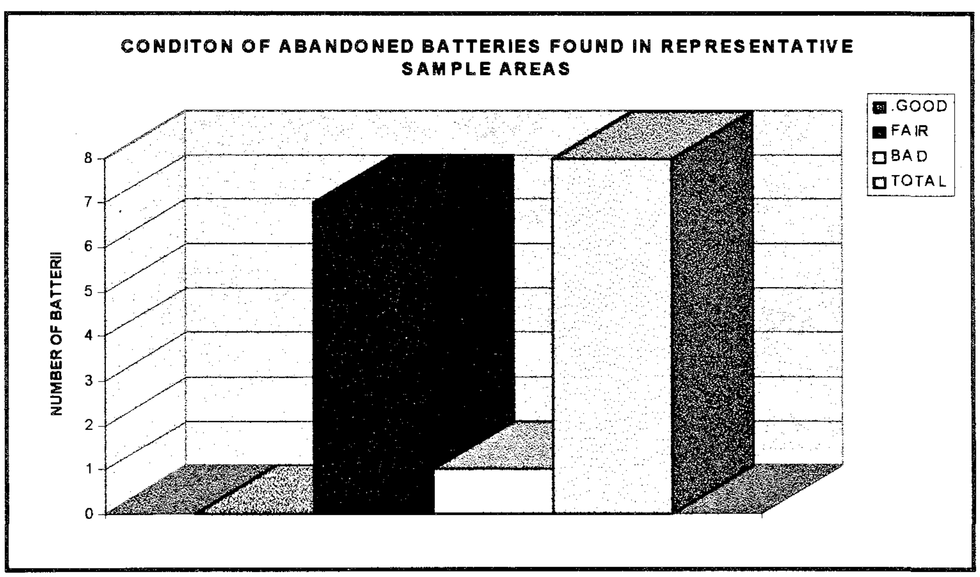


Figure 8.

Estimated distances traveled within approximately quarter mile grids of each sample area are as follows: sample area one ≅ 3.65 miles (figure 9), sample area two ≅ 5.3 miles (figure 10), sample area three ≅ 2 miles (figure 10), and sample area four ≅ 5.15 miles (figure 11). As shown in figure 12, different densities of streetways were found in each geographical section.

STREET MAPS WITHIN THE ALA WAI CANAL WATERSHED OF REPRESENTED SAMPLE AREAS SURVEYED

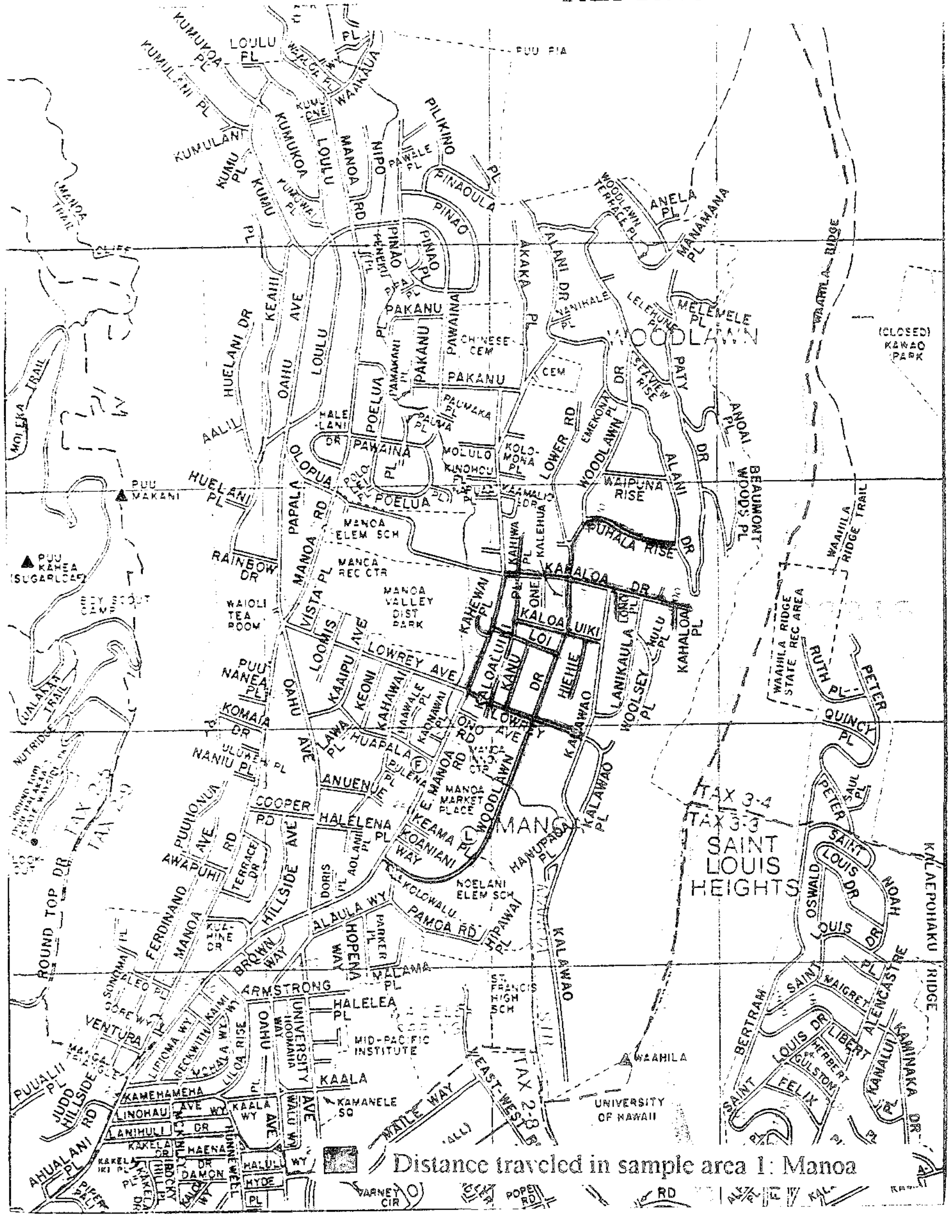


Figure 9.

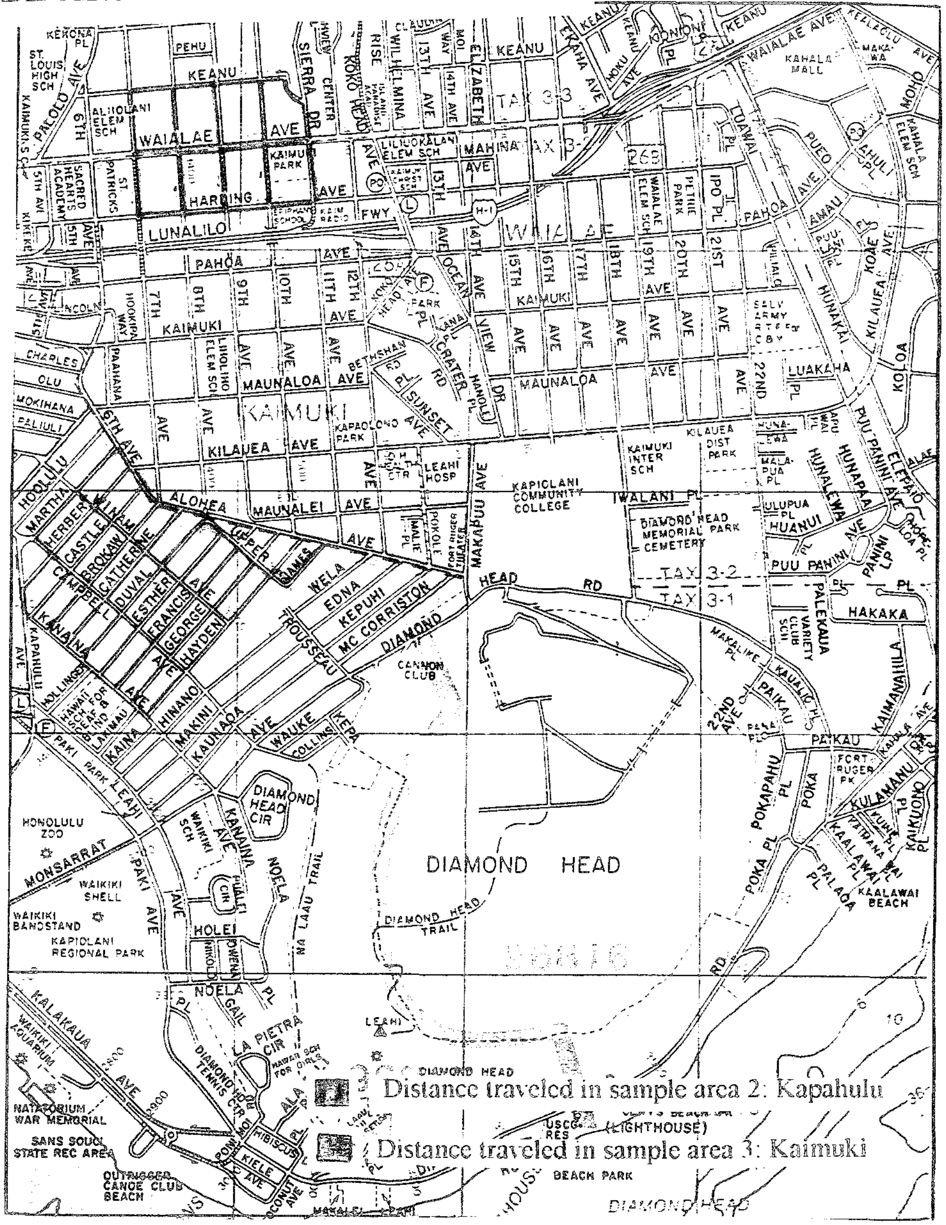


Figure 10.

Figures 9 & 10. Street map of distances traveled in sample areas within the Ala Wai Canal watershed. Scale is 1 inch = 0.4 mile.

STREET MAP WITHIN THE ALA WAI CANAL WATERSHED OF REPRESENTED SAMPLE AREAS SURVEYED

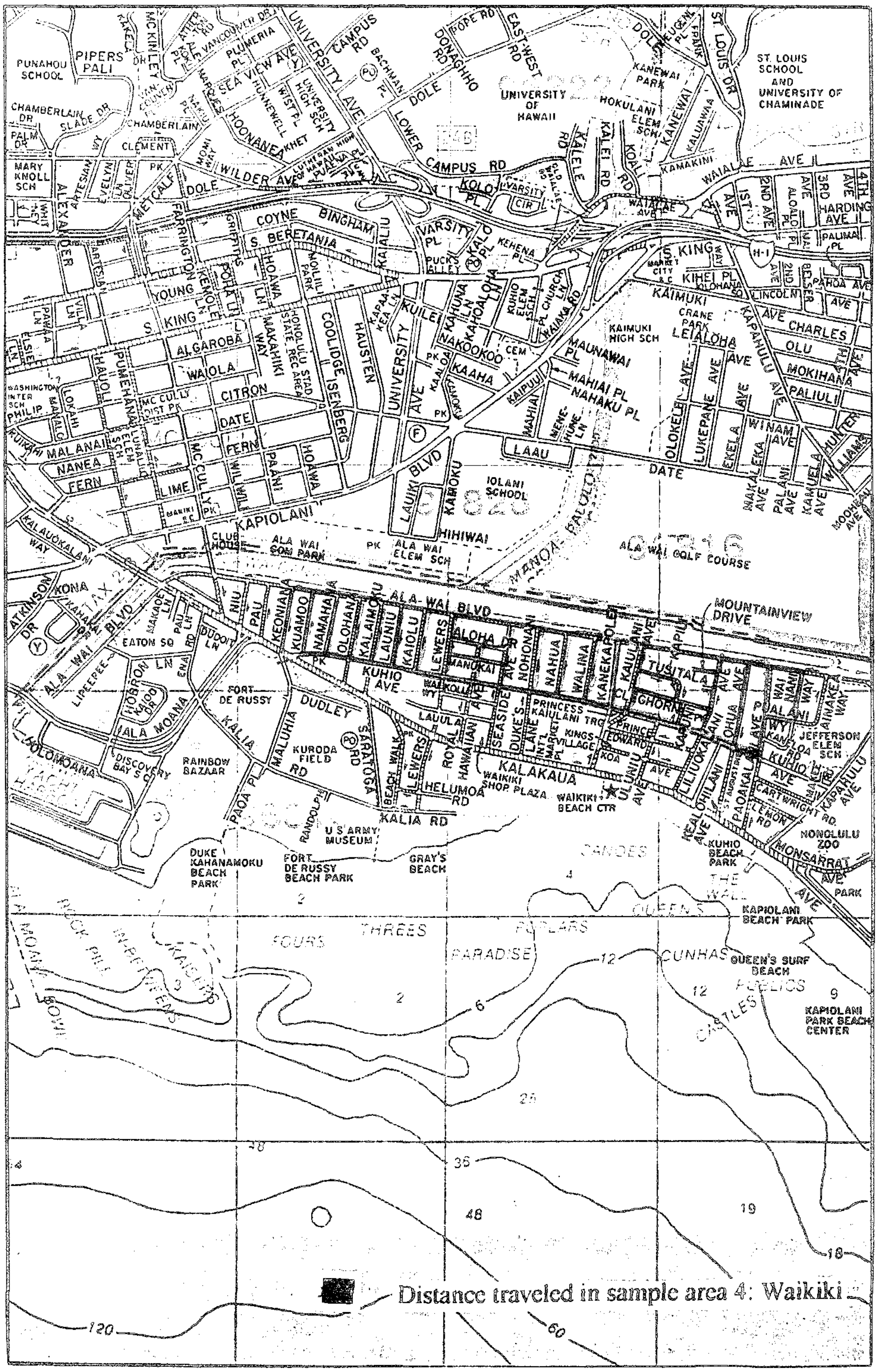


Figure 11.

Figure 11. Street map of distances traveled in sample areas within the Ala Wai Canal watershed. Scale is 1 inch = 0.4 mile.

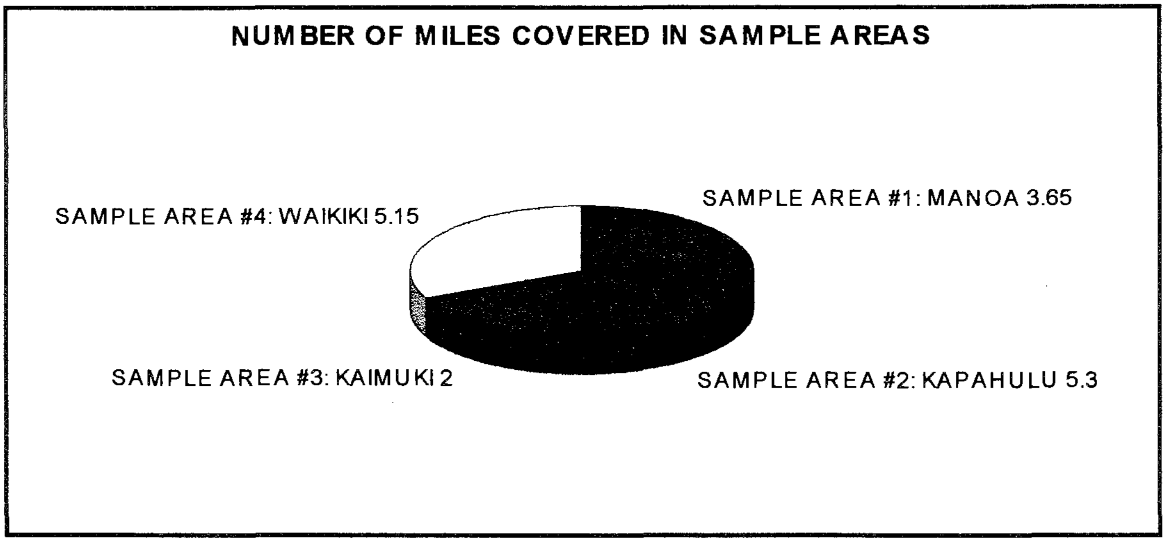


Figure 12. The number of miles covered within each geographical section of the represented sample area.

The estimated areas of land use within the Ala Wai Canal watershed (figure 13) are as follows: low density single-family homes ≅ 1.25 square miles (5 square quarter miles), high density single-family homes ≅ 3.0 square miles (12 square quarter miles), commercial area ≅ 0.24 square miles (1 square quarter mile), and apartments ≅ 2.85 square miles (11.5 square quarter miles). The total estimated land use area of urban regions equals approximately 7.34 square miles (29.25 square quarter miles), which is 45% of the entire watershed (Figure 14).

Ala Wai Canal Watershed

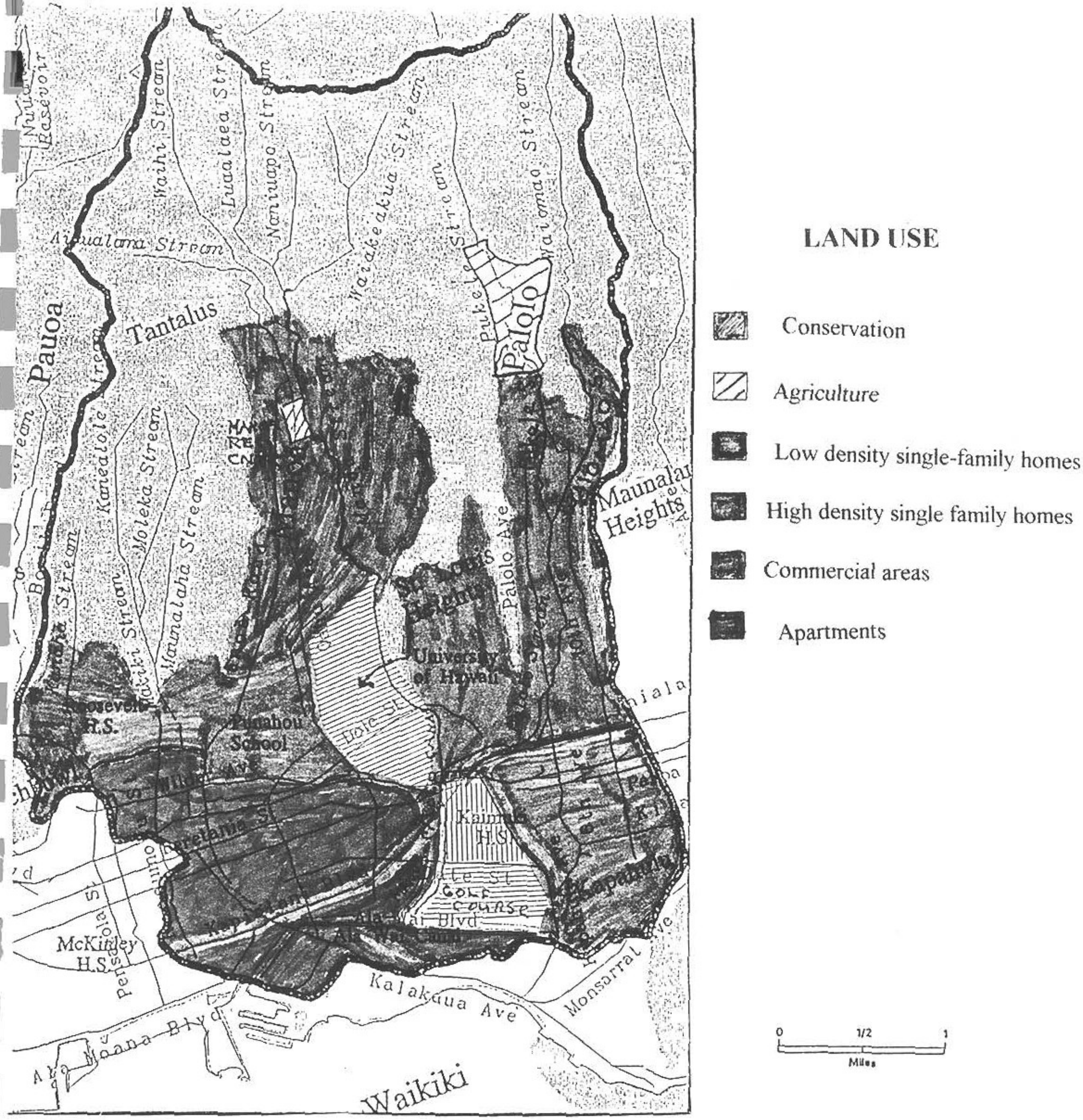


Figure 13. Colored map of land use in the urban areas of the Ala Wai Canal watershed.

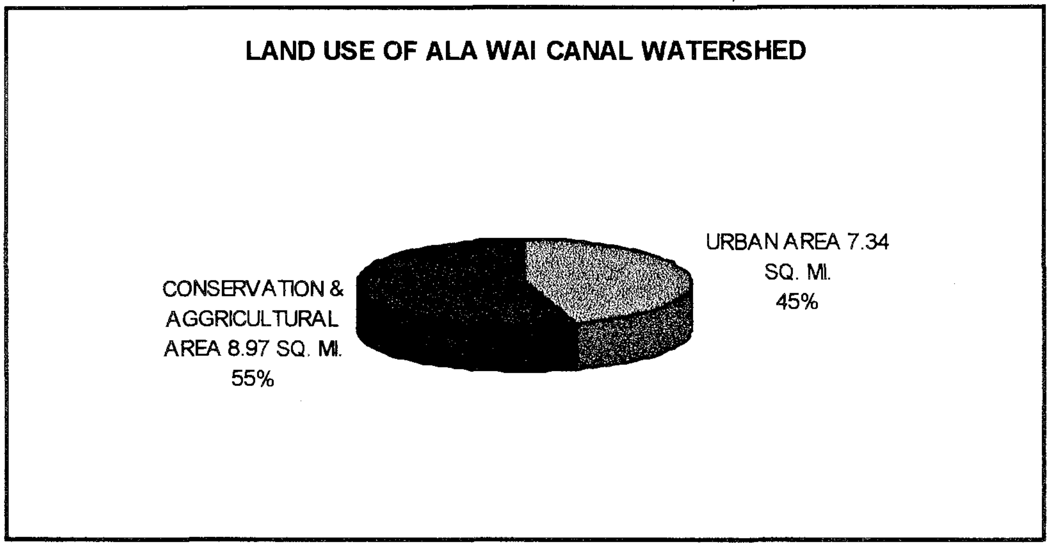


Figure 14.

Determination on the total number of abandoned vehicle batteries within the watershed was done by multiplying the total number of abandoned vehicle batteries found in the representative sample areas of each geographical section with the total estimated square miles of the four geographical sections within the urban areas of the watershed. The results are as follows:

# of Batteries Found in Representative Sample areas	·	Square Quarter Miles of Geographical Sections	=	Total # of Batteries
(Sample area 1) **0**	·	(Low density single-family) **5 sq. quarter miles**	=	**0**
(Sample area 2) **2**	·	(High density single-family) homes **12 sq. quarter miles**	=	**24**
(Sample area 3) **3**	·	(Commercial areas) **1 sq. quarter mile**	=	**3**
(Sample area 4) **3**	·	(Apartments) **29.25 sq. quarter miles**	≅	**88**

Estimated total # of batteries within the watershed (0 + 24 + 3 + 88) is 115 batteries

IV. Discussion

Streets in four of the represented geographical sample areas were all similar in description. The street ways were paved from curb to curb, with storm drainage systems for water run-off. The roads were approximately 25-35 ft. in width and concrete sidewalks on each end. Only in sample areas 3 & 4 on Waialae Ave. and Ala Wai Blvd., street ways were wide and ranged from four to six lanes. Numbers of parked vehicles varied with location, with higher numbers in the geographical sections of apartments and high density single family homes.

Data recorded on the weather, dates, and times of the representative surveyed sample area were charted for any future studies done on this subject. The information recorded may be of importance in correlation of the number of abandoned vehicle batteries found to the time of day, weather, or date.

The total numbers of abandoned vehicle batteries found within each representative sample area of the geographical sections (low density single-family homes, high density single-family homes, commercial areas, and apartments) were very low. Of the four areas surveyed, sample areas 3 and 4 had the most abandoned batteries, with three found in each area. This perhaps reflects the greater use of batteries in these commercial and high density apartment areas. Although, the estimated total number of abandoned vehicle batteries within the entire urban region of the watershed was 115 batteries, this is minimal in comparison to the population and vehicles located within this region. Furthermore, according to Frank Sansone, lead from vehicle batteries is not likely to be a major source of lead traveling into the Ala Wai Canal watershed because lead components of vehicle batteries will stay in a solid form. Acid solution from vehicle batteries will only excrete the highest percentage of lead when the battery is fully charged. Abandoned vehicle batteries are usually have little to no charge, making lead excretions minimal. In conclusion, very few abandoned vehicle batteries were found within the four geographical sections (low density single-family homes, high density single-family homes, commercial areas, and apartments). Thus, this survey suggests that abandoned vehicle batteries are not a major source of lead entering the Ala Wai Canal.

Appendix

SAMPLE AREA 1: MANOA (LOW DENSITY SINGLE-FAMILY HOMES)

DATE	WEATHER	TIME	LOCATION BY STREET	ALIGNMENT	CONDITION	# OF BATTERIES
11/5/97	CLOUDY	11:55 AM	LOI ST.	N/A	N/A	0
11/5/97	CLOUDY	12:00 PM	KAHALOA DR.	N/A	N/A	0
11/5/97	CLOUDY	12:15 PM	KAHIWA PL.	N/A	N/A	0
11/5/97	CLOUDY	12:21 PM	KAHALOA PL.	N/A	N/A	0
11/5/97	CLOUDY	12:31 PM	KALOALUI PL.	N/A	N/A	0
11/5/97	CLOUDY	12:43 PM	KANU ST.	N/A	N/A	0
11/5/97	CLOUDY	12:58 PM	WOODLAWN DR. (1/4 MI. SEC.)	N/A	N/A	0
11/5/97	CLOUDY	1:05 PM	HIEHIE ST.	N/A	N/A	0
11/5/97	CLOUDY	1:10 PM	KAHEWAI PL.	N/A	N/A	0
11/5/97	CLOUDY	1:18 PM	LONO PL.	N/A	N/A	0
11/5/97	CLOUDY	1:26PM	PUHALA RISE	N/A	N/A	0
						TOTAL: 0

Table 1. Information collected on sample area 1 was done by bicycle and includes: date, weather, time, location, alignment (upright, side, or upside-down), and condition (good, fair, bad).

SAMPLE AREA 2: KAPAHULU (HIGH DENSITY SINGLE-FAMILY HOMES)

DATE	WEATHER	TIME	LOCATION BY STREET	ALIGNMENT	CONDITION	# OF BATTERIES
10/22/97	SUNNY	11:50 AM	MARTHA ST.	N/A	N/A	0
10/22/97	SUNNY	11:55 AM	HOOLULU ST.	N/A	N/A	0
10/22/97	SUNNY	12:03 PM	CAMBELL AVE.	N/A	N/A	0
10/22/97	SUNNY	12:20 PM	HERBERT ST.	N/A	N/A	0
10/22/97	SUNNY	12:30 PM	CASTLE ST.	UPRIGHT	FAIR	1
10/22/97	SUNNY	12:32 PM	BROKAW ST.	N/A	N/A	0
10/22/97	SUNNY	12:45 PM	CATHERINE ST.	N/A	N/A	0
10/22/97	SUNNY	12:58 PM	DUVAL ST.	N/A	N/A	0
10/22/97	SUNNY	1:05 PM	ESTHER ST.	N/A	N/A	0
10/22/97	SUNNY	1:23 PM	FRANCIS ST.	N/A	N/A	0
10/22/97	SUNNY	1:32 PM	GEORGE ST.	UPRIGHT	FAIR	1
10/22/97	SUNNY	1:40 PM	HAYDEN ST.	N/A	N/A	0
10/22/97	SUNNY	1:43 PM	JAMES ST.	N/A	N/A	0
10/22/97	SUNNY	1:48 PM	UPPER ST.	N/A	N/A	0
10/22/97	SUNNY	1:58 PM	WINAM AVE.	N/A	N/A	0
10/22/97	SUNNY	2:10 PM	KANAINA AVE.	N/A	N/A	0
						TOTAL: 2

Table 2. Information collected on sample area 2 was done by bicycle and includes: date, weather, time, location, alignment (upright, side, or upside-down), and condition (good, fair, or bad).

SAMPLE AREA 3: KAIMUKI (COMMERCIAL AREA)

DATE	WEATHER	TIME	LOCATION BY STREET	ALIGNMENT	CONDITION	# OF BATTERIES
11/6/97	SUNNY	11:00 AM	KEANU ST.	N/A	N/A	0
11/6/97	SUNNY	11:25 AM	WAIALAE AVE.	UPRIGHT	FAIR	2
11/6/97	SUNNY	11:53 AM	7TH AVE.	N/A	N/A	0
11/6/97	SUNNY	12:08 PM	8TH AVE.	N/A	N/A	0
11/6/97	SUNNY	12:27 PM	9TH AVE.	N/A	N/A	0
11/6/97	SUNNY	12:45 PM	10TH AVE.	N/A	N/A	0
11/6/97	SUNNY	1:18 PM	HARDING AVE.	UPRIGHT	FAIR	1
11/6/97	SUNNY	1:32 PM	SIERRA DR.	N/A	N/A	0
						TOTAL: 3

Table 3. Information collected on sample area 3 was done by foot and includes: date, weather, time, location, alignment (upright, side, or upside-down), and condition (good, fair, or bad).

SAMPLE AREA 4: WAIKIKI (APARTMENTS)

DATE	WEATHER	TIME	LOCATION BY STREET	ALIGNMENT	CONDITION	# OF BATTERIES
10/17/97	SUNNY	11:30	ALA WAI BLVD.	N/A	N/A	0
10/17/97	SUNNY	11:32 AM	KEONANA ST.	N/A	N/A	0
10/17/97	SUNNY	11:34 AM	KUAMOO ST.	N/A	N/A	0
10/17/97	SUNNY	11:35 AM	NAMAHANA ST.	N/A	N/A	0
10/17/97	SUNNY	11:38 AM	OLOHANA ST.	N/A	N/A	0
10/17/97	SUNNY	11:40 AM	KALAIMOKU ST.	SIDE	BAD	1
10/17/97	SUNNY	11:43 AM	LAUNIU ST.	N/A	N/A	0
10/17/97	SUNNY	11:45 AM	KAIOLU ST.	SIDE	BAD	1
10/17/97	SUNNY	11:47 AM	LEWERS ST.	N/A	N/A	0
10/17/97	SUNNY	11:49 AM	ALOHA ST.	N/A	N/A	0
10/17/97	SUNNY	11:50 AM	ROYAL HAWAIIAN ST.	N/A	N/A	0
10/17/97	SUNNY	11:51 AM	MANU KAI ST.	N/A	N/A	0
10/17/97	SUNNY	11:53 AM	SEASIDE AVE.	N/A	N/A	0
10/17/97	SUNNY	11:54 AM	NOHONANI ST.	N/A	N/A	0
10/17/97	SUNNY	11:56 AM	NAHUA ST.	N/A	N/A	0
10/17/97	SUNNY	11:57 AM	WALANI ST.	N/A	N/A	0
10/17/97	SUNNY	12:00 PM	KANEKAPOLEI ST.	N/A	N/A	0
10/17/97	SUNNY	12:01 PM	KAIULANI AVE.	N/A	N/A	0
10/17/97	SUNNY	12:03 PM	CLEGHORN ST.	N/A	N/A	0
10/17/97	SUNNY	12:05 PM	TUSITALA ST.	N/A	N/A	0
10/17/97	SUNNY	12:08 PM	LILIOKALANI AVE.	N/A	N/A	0
10/17/97	SUNNY	12:10 PM	OHUA AVE.	N/A	N/A	0
10/17/97	SUNNY	12:12 PM	PAOAKALANI AVE.	N/A	N/A	0
10/17/97	SUNNY	12:15 PM	WAI NANI WAY	N/A	N/A	0
10/17/97	SUNNY	12:20 PM	KUHIO AVE.	N/A	N/A	0
10/17/97	SUNNY	12:35 PM	*OPPOSITE SIDE OF CANAL*	UPRIGHT	FAIR	1
						TOTAL: 3

Table 4. Information collected on sample area 4 was done by bicycle and includes: date, weather, time, location, alignment (upright, side, or upside-down), and condition (good, fair, or bad).

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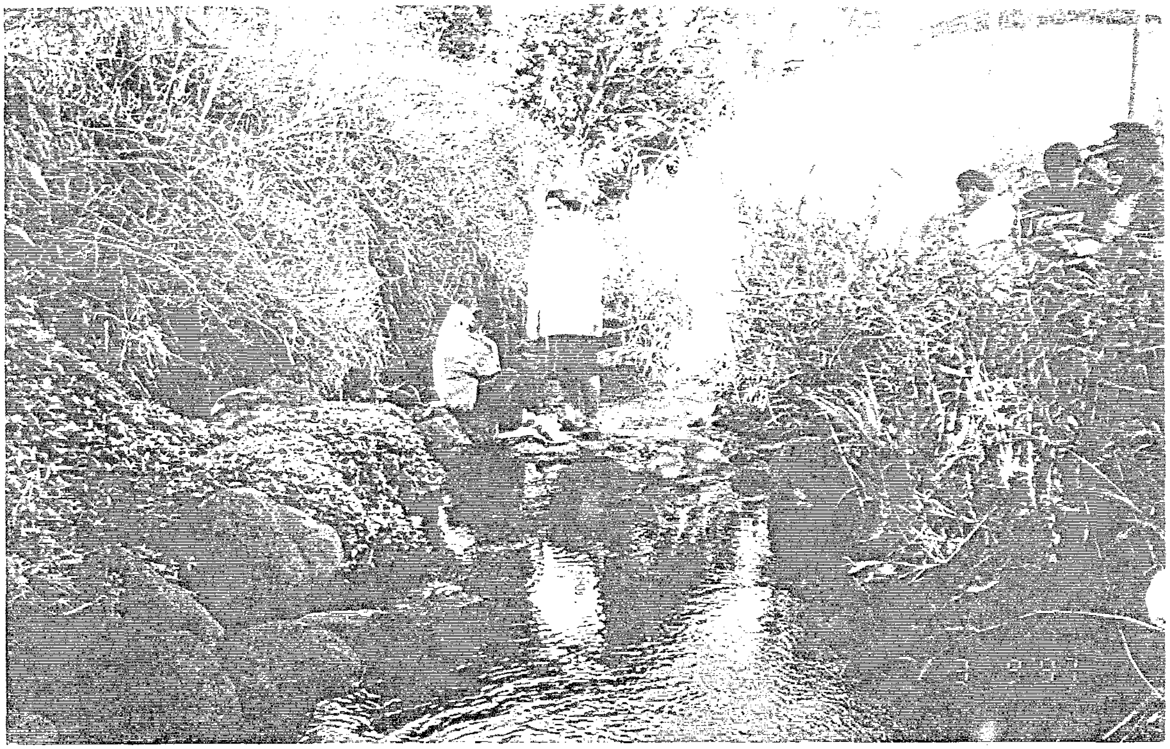
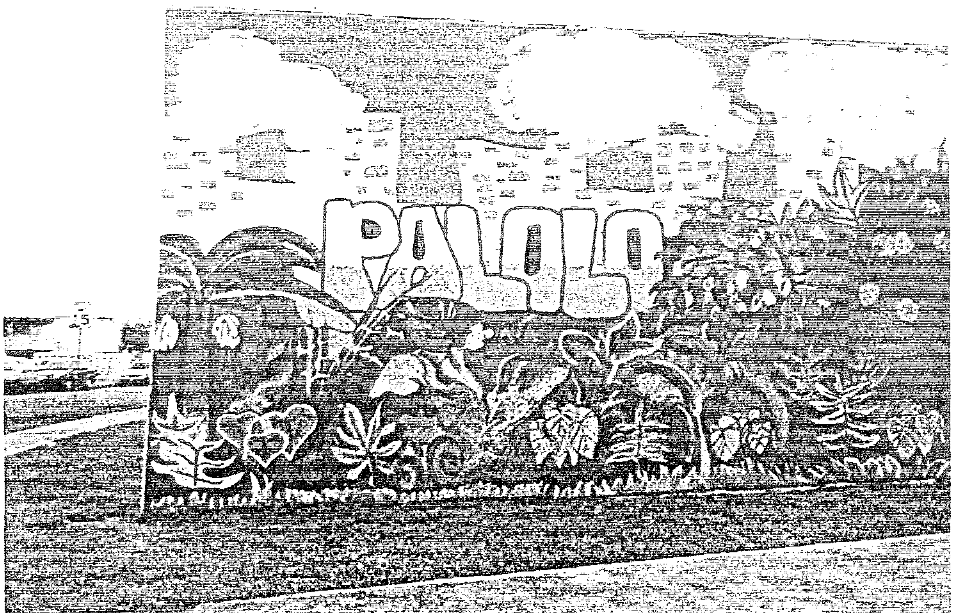
APPENDIX I

PALOLO VALLEY TENANTS ASSOCIATION KALO CLUB REPORT




PALOLO

Kalo Club

c/o Palolo Tenants Associaton
2195 Ahe Street
Honolulu, Hawaii 96816
Ph. #733-9121

Date: March 6, 1998
To: Eugene P. Dashiell , Coordinator & Chairman
Ala Wai Canal Watershed Water Quality Improvement Project
Fr: Dahlia Asuega , President Palolo Tenants Association
Kalo Club member

Aloha Gene,

Here's a breif discription of what Kalo Club members has been involved with and what kinds of future projects we plan to continue in the efforts of cleaning and maintaining the Palolo Watershed. Kalo Club was funded $3,000.00 to help purchase a computer to set up office in "Ka Halau Ola O Palolo" (life of Palolo) a community center that is being leased rent free to the Palolo Tenants Association from Hawaii Housing Authority a first time in history lease agreement. The purpose of asking for this fund was to have a base where we the residents of Palolo Housing and the broader community could meet, plan, net work, store data, and do what needs to be done to clean and protect our enviroment. Since July of last year when monies were approved, we've purchased a computer system for about $2,600.00 and the balance was used for office supplies such as paper, cartriges, hanging folders, etc.While all of these meetings were going on to get funding, the PTA had just completed a Community Stream Clean-up on April 12, 1997 and already planning Palolo Pride Community Celebrtion 1997 held on October 11, to include enviromental and information booths, Kalo Club, Ho'olaulima HECO issue, History of Palolo and our sacred sites, Ahupua'a Action Alliance, Life of the land, cultural crafts, and others in support of a cleaner enviroment to promote a healthier community.
Today, a year after meeting with Gene and 7 months after being funded the struggle never ends, but the work goes on by committed residents who volunteer endlessly in hopes to make a difference. Through the Ala Wai Watershed Project it has inspired another group in the housing, the Plantation Hui that cares for a parcel of land (TMK 3-4-03:30) on the Waimao side of Palolo streams. Since the stream clean-up that parcel and the stream has been maintained by residents of Palolo Housing, clearing brush, planting, and revitilaizing the streams banks.

Projects in planning with other groups and organizations:

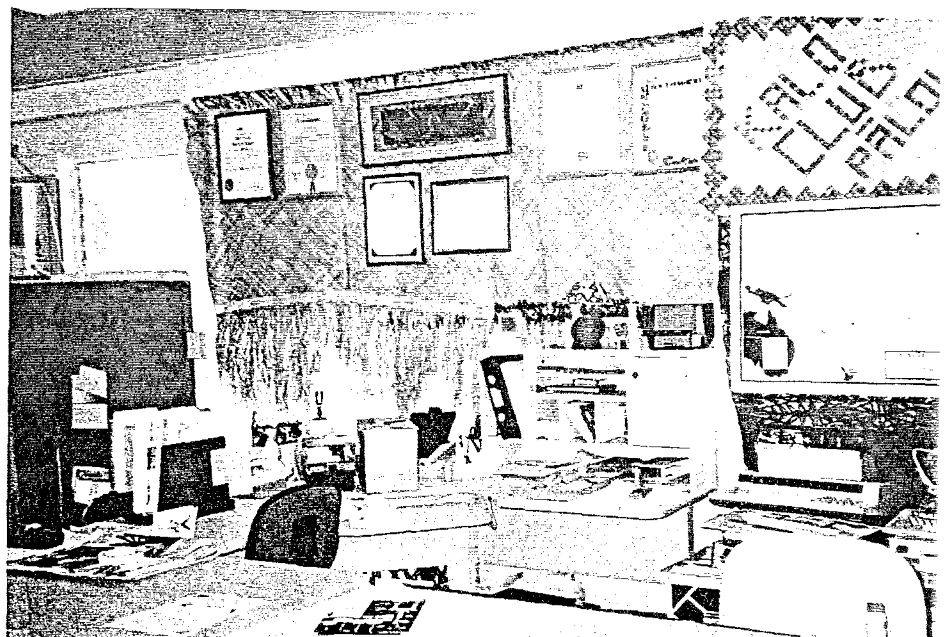
* 2nd Palolo Community Stream Clean-up - April 18, 1998 frm. 8a - 12pm Potluck to follow.
* 4th Palolo Pride Community Celebration - focused theme: Enviromental Awareness
* Restoring a Lo'i along Pukele stream - in planning now.
* Having access to the Waimao stream - in the works w/HHA : Will this benefit community ??
* Reopening trails in the valley - in discussion
* Mapping Palolo Valley - forming a data base

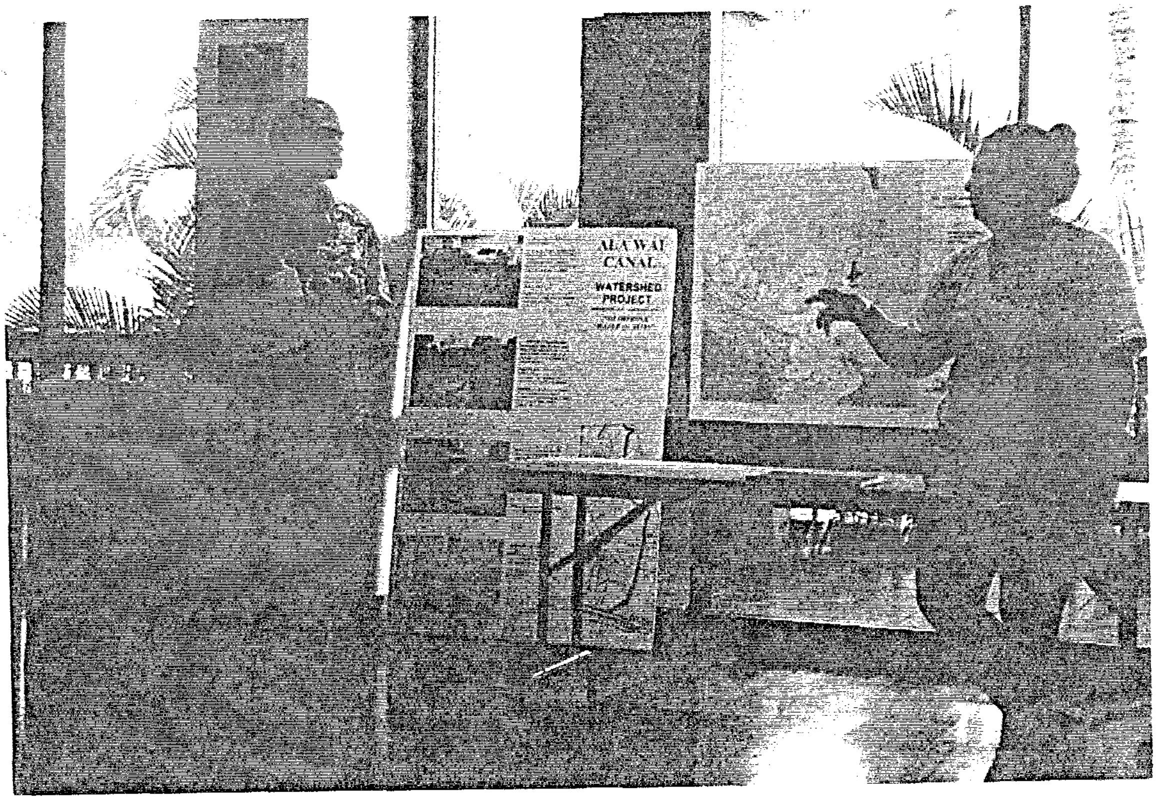
* Outreach and Palolo Valley's assets - in the works
* Future clean -up projects - grounds, trails, streams, graffitti, etc.
* Community Beautification - landscaping around Halau Ola O Palolo (PTA community center) and near the streams with native plants. Collecting donated plants from community.

These are a few things that are happening or are in planning and hope that we and other neigboring communities can come together to share our ideas, projects, and learn from eachother of what's working and what's not.The Palolo Tenants Association, Kalo Club, Plantation Hui, and Cultural Clubs, of Palolo Housing would like to extend our deepest appreciation in being funded to start a base of what is so important to us, the community ,and caring for our enviroment. Mahalo, Gene for your knowledge in guiding us, making things simply understandable for myself and residents. Social technique is very important when working with grassroots or should we say "Kaloroots" organizations, you've got it. It's been my privledge to meet you. I've enjoyed our meetings and although our group may understand "action" v.s. sitting in "meetings" to be more productive, we try patiently to understand the process.

Mahalo A Hui Hou,

Dahlia Asuega
PTA President
Kalo Club Rep.




ALA WAI CANAL
WATERSHED PROJECT


AUTHORIZED
Aptiva


RESERVED
PARKING
007
HONOLULU

Palolo ceremony

The Palolo Tenants Association Community Center opened yesterday. Above, left to right, association President Dahlia Asuega talks to artist Meleanna Meyer, while Kekuni Blaisdell and Maile Meligro enjoy the moment. Right, Asuega listens as Hina Wong, David Vaovasa and John Lake conduct a blessing. Below, Wong and Vaovasa chant.

PHOTOS BY DENNIS ODA, Star-Bulletin

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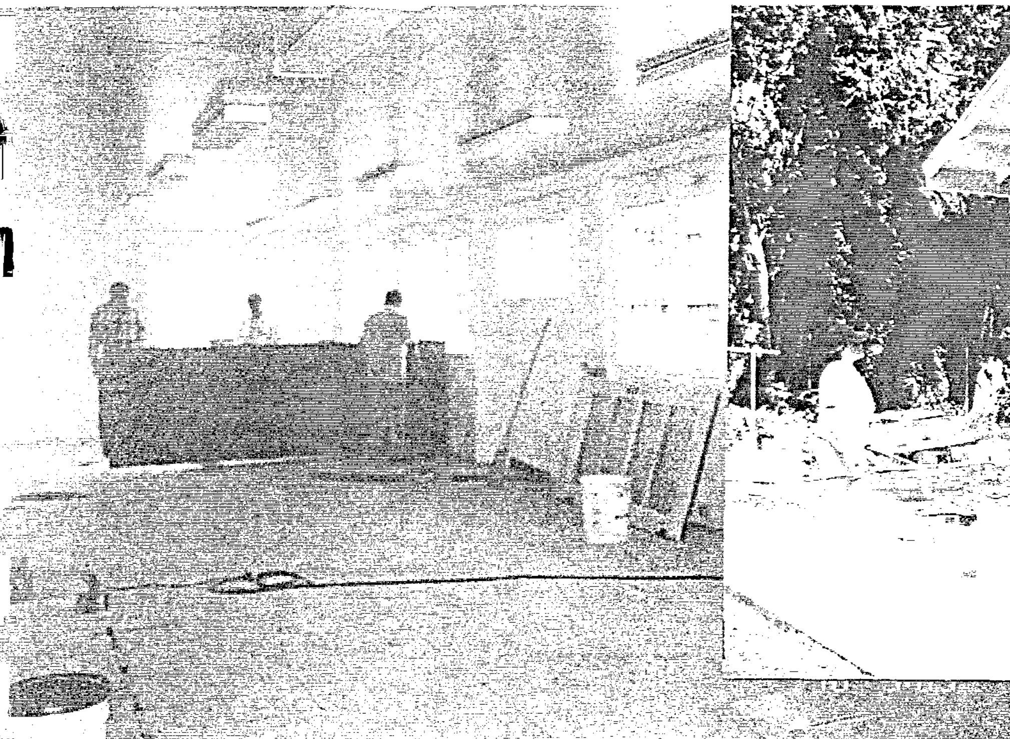
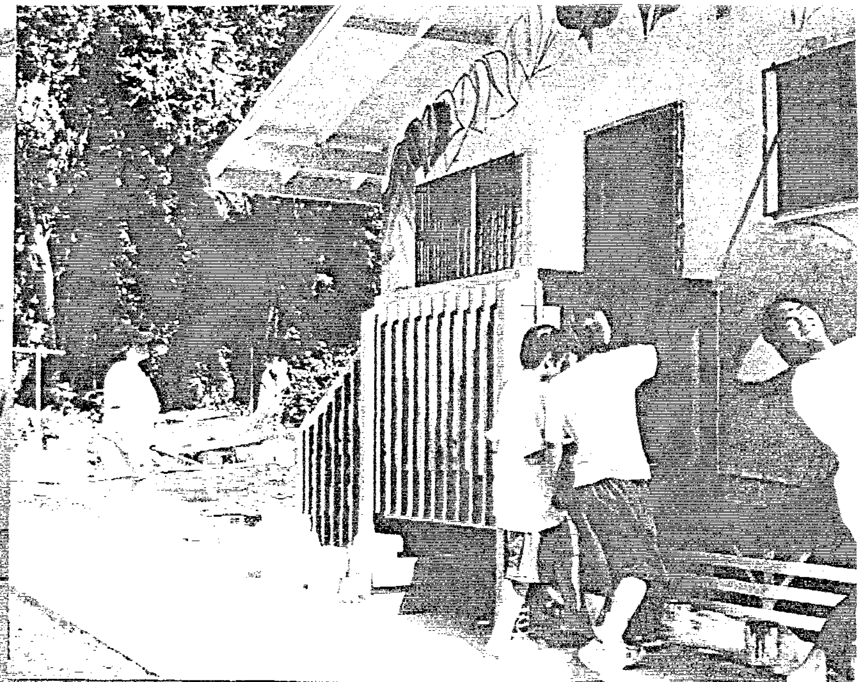
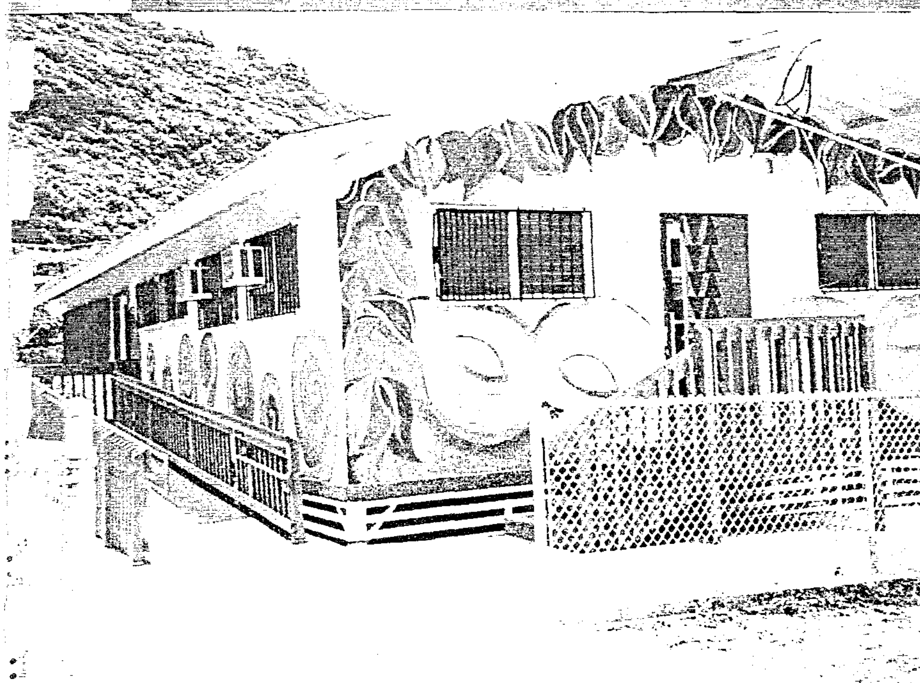
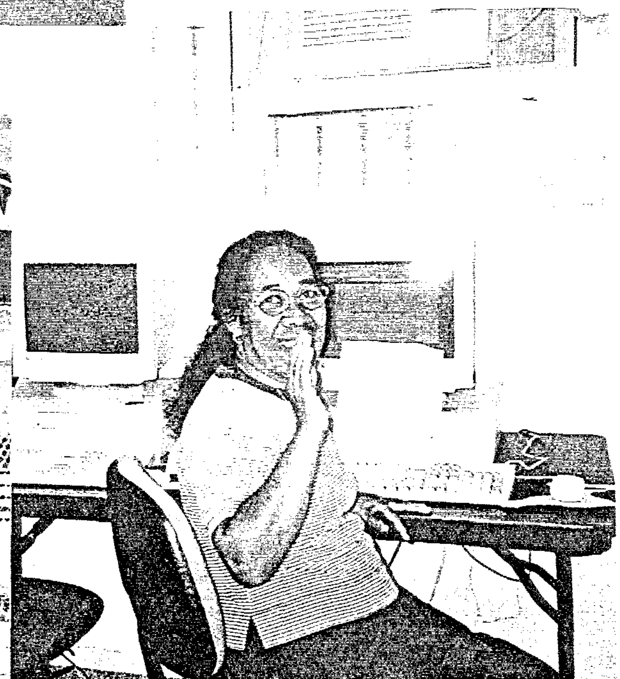
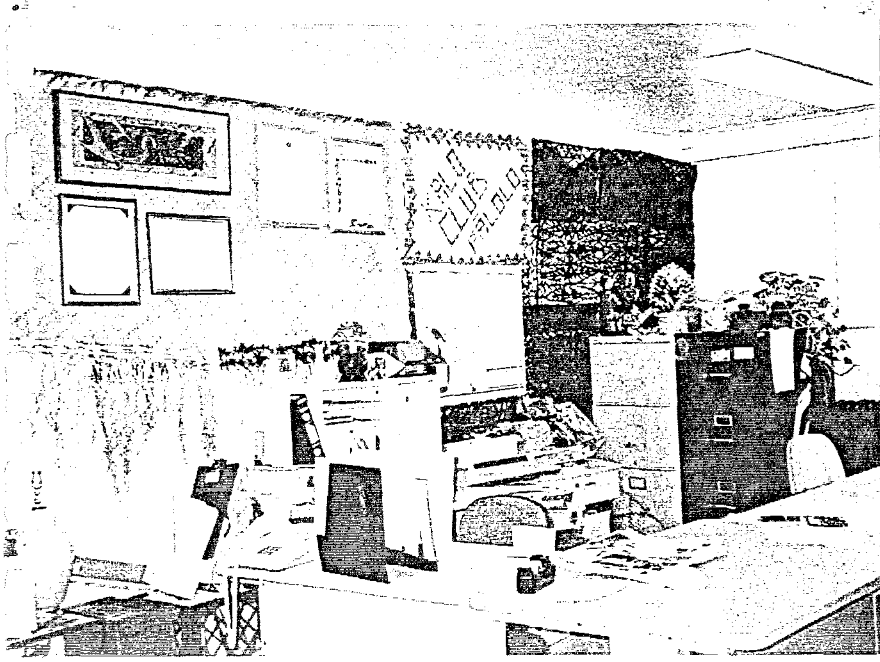
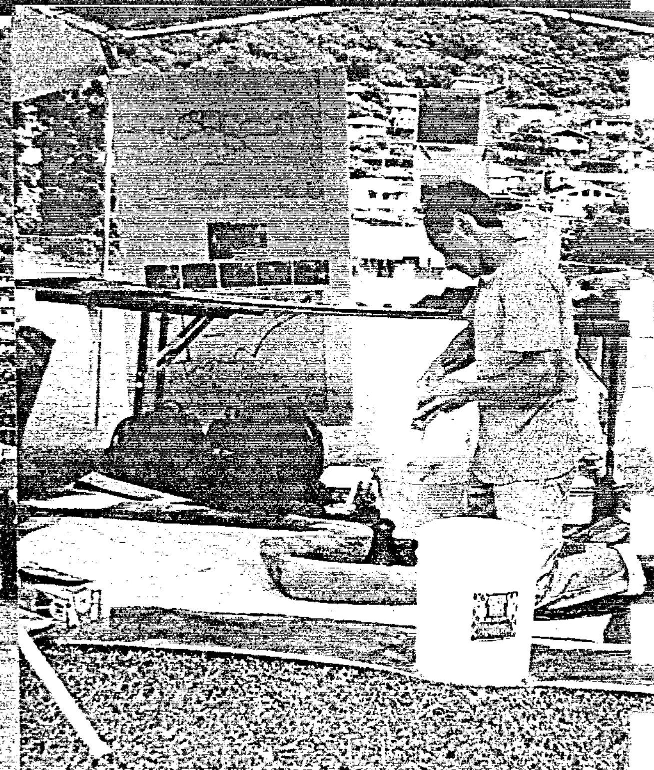
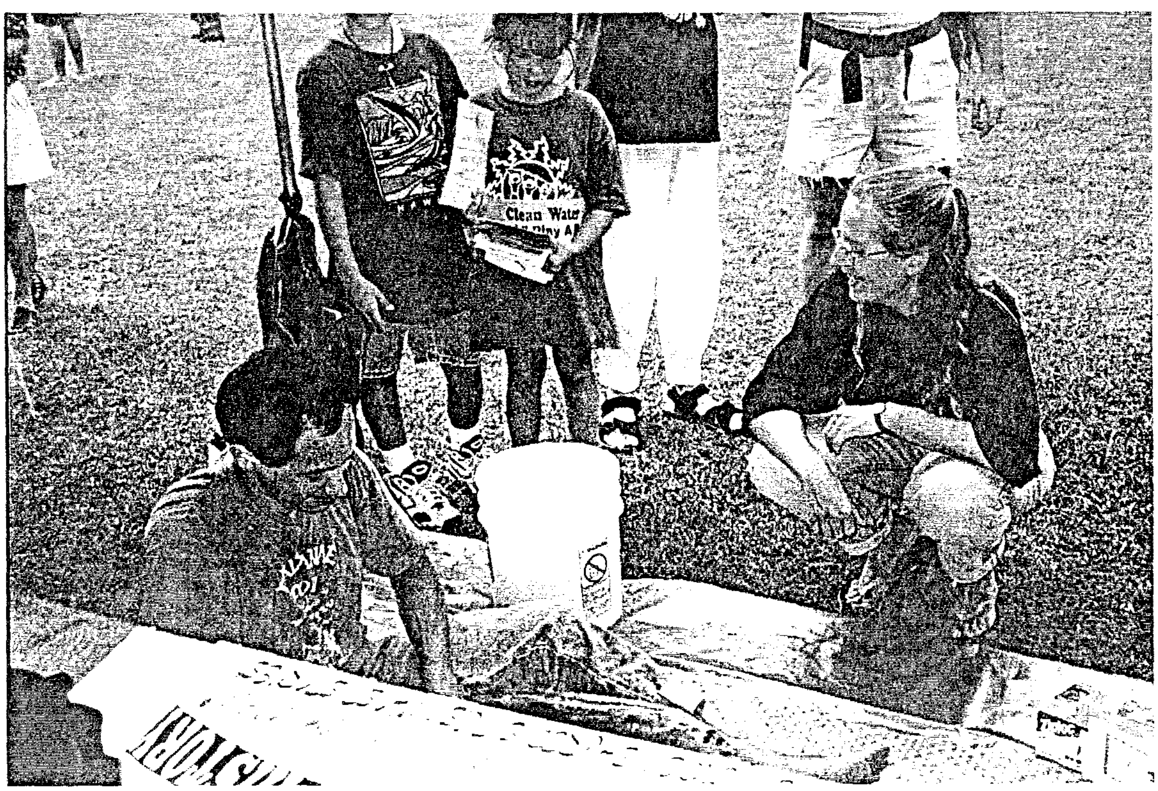





CLUB
PALOLO


Ahupua'a
Action
Alliance


Clean Water

KALO CLUB

C/O 2187 #27-A Ahe Street
Honolulu, Hawaii 96816

Phone 732-6795

July 16, 1997

To: Eugene Dashiell
Ala Wai Canal Watershed Project
1314 King Street Suite No. 951
Honolulu, HI. 96814

SUBJECT: SETTING UP PALOLO VALLEY RESOURCE CENTER

Aloha,

The mission of The Kalo Club (Taro Club) is to renew and support the well-being of our community through Hawaiian cultural values and practices.

The Kalo Club along with The Palolo Tenant Association and Ahupua'a Action Alliance and other community groups have gotten together to clean and adopt our streams in Palolo Valley. To come together and work on a project as this has encouraged community residents to put together a resource center in Palolo.

The resource center will be used to: 1) Continue our work with Anuenue School to clear overgrowth to make a lo'i (taro patch) that will help revitalize the environment (e.g. stream, aquaculture, local plants); 2)Continue to conduct stream clean-up events in the Palolo community; 3)Initiate local history and research about the community in order to educate ourselves about the culture, environment, history and identify sacred places in Palolo; and 4)Through these volunteer programs we shall develop deepr community partnerships with residents and service organizations, which improve both the social and physical environment of Palolo Valley.

We want to involve our community as full participants in keeping our stream and environment vital and healthy. By cleaning the environment, we show our respect for the land and water which supports all live in The Valley. By participating in the stream clean-up, working on the lo'i and learning about our local history, we will become teachers and learners for each other about our shared history. We will learn more through our practices and actions how to keep the connection alive between the environment and our community.

Your support of the resource center will help us achieve these goals. We are requesting for use in the resource center in Palolo Valley the following: office equipment, supplies, file cabinets, assistance with telephone/electric costs, liability insurance, and computer training . If you can assist us with any/or all of this request, your support is greatly appreciated.

How wonderful it would be, if all communities could benefit with access to a resource center run by community volunteers -- a place where they can network and support each other to work on cleaning our environment and activities which enhance the environmental quality of life in Palolo Valley.

Mahalo A Hui Hou,

Dahlia Asuega
Palolo Tenant Association President
Kalo Club member

KALO CLUB
2171 #C AHE ST.
HONOLULU, HAWAII
96816

PURPOSE OF THE CLUB: TO RENEW AND SUPPORT THE WELLBEING OF OUR COMMUNITY THROUGH HAWAIIAN CULTURAL VALUES AND PRACTICES

IDEAS AND FEELINGS TOWARD THE MEANING OF THE CLUB

VISION

PRESERVE OUR CULTURE
PASSING IT ON
TEACHING CRAFTS
HAWAIIAN MEDICINE
BUILDING SELF ESTEEM
KEEP THE CULTURE ALIVE
SHARING BEYOND THE HAWAIIAN COMMUNITY
LOMILOMI
LEARNING
RECLAIMING PRIDE IN OUR IDENTITY
SHARING THE MEANING BEHIND THE PRACTICE AND ARTS
POSITIVE IMAGE OF WHERE WE COME FROM
PRESERVING, KEEPING ALIVE, PASSING IT ON AND SHARING OUR CULTURE

HOW COME WE HAVE TO RECLAIM?
HOW DO WE ADVOCATE BALANCE?
HOW CAN WE MAKE IT HAPPEN?

MAKING IT OKAY TO TALK, LEARN ABOUT OUR HISTORY AND OUR CULTURE
BUILD COMMUNITY - SO ITS OKAY
WANT TO SEE HAWAIIAN IN EVERYTHING HERE

PUTTING EVERYTHING TOGETHER

WHAT IS THE KALO CLUB ABOUT?
BUILDING A COMMUNITY BASED ON HAWAIIAN CULTURAL VALUES AND PRACTICES FOR ......
TO RENEW AND HEAL AND MOVING FORWARD
SUPPORT COMMUNITY WELLBEING/WHOLENESS
BUILDING, GROWING HAWAIIAN CULTURAL VALUES AND PRACTICES
* TO RENEW AND SUPPORT THE WELLBEING OF OUR COMMUNITY THROUGH HAWAIIAN CULTURAL VALUES AND PRACTICES*

WHAT DO WE WANT TO DO?

KALO HUI - TARO EXCHANGE/TARO BANK
PALOLO PRIDE - OUR OWN BOOTH/CRAFTS/FOOD/POI DEMONSTRATION
TENTATIVE DATE FOR PALOLO PRIDE IS OCT. 11 OR 18
T-SHIRTS - TO ADVERTISE, TO RAISE MONIES, TO REIMBURSE
FINDING LO I/PLACES TO PLANT
ESTABLISH BETTER COMMUNICATION WITH THE HHA MGMT.
LEARN HAWAIIAN LANGUAGE, MEDICINES, CHANTS
FUNDRAISE
EDUCATIONAL TRIPS - NEIGHBOR ISLANDS
EDUCATIONAL PROGRAMS
STREAM CLEAN UP

HULA HALAU
HAWAIIAN THEATRE/CONCERT

PRIORITIES
FUNDRAISE - T SHIRTS, PALOLO PRIDE, GRANT WRITING
STREAM CLEAN UP
COMMUNICATION WITH HHA MGMT
EDUCATION - TRIPS, LANGUAGE, CRAFTS, MEDICINE, HULA, SOVEREIGNTY, GARDENING
PALOLO PRIDE, LOMILOMI, CHANTS
PLANTING - FINDING PLACES TO PLANT, KALO BANK
HULA HALAU - AS TRAINING, COMMUNITY BUILDING

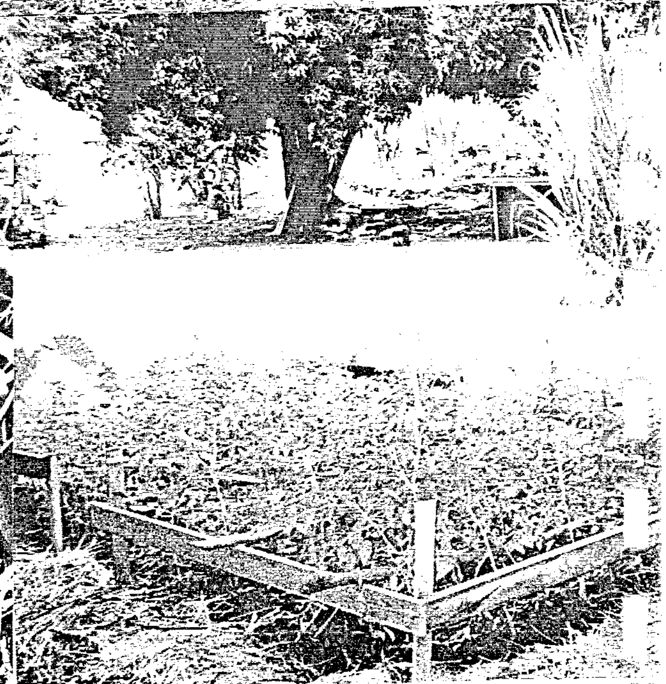
THINGS TO THINK ABOUT
WHAT DO YOU NEED TO DO?
WHAT DO YOU NEED TO MAKE IT HAPPEN?

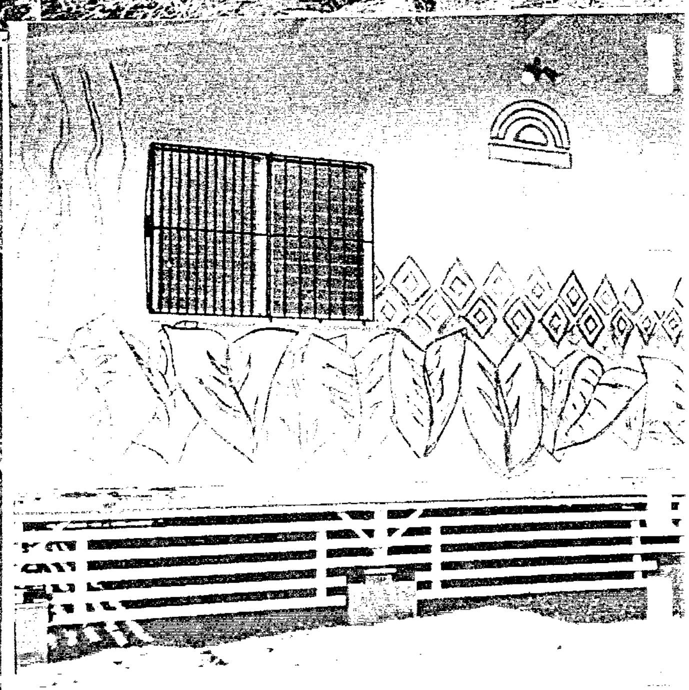
KALO CLUB MEETING HELD ON MARCH 8, 1997
THOSE WHO ATTENDED:

DAHLIA ASUEGA	SHIRLEY RODRIGUES
LYNETTE CRUZ	NOHEA AIPIA
DENISE KOA	GENEVA CARDEN
KUULEI KOA	KRISTINE CARDEN
PETE KALEINAMOKU	PENNY
FAYE NEWFIELD	

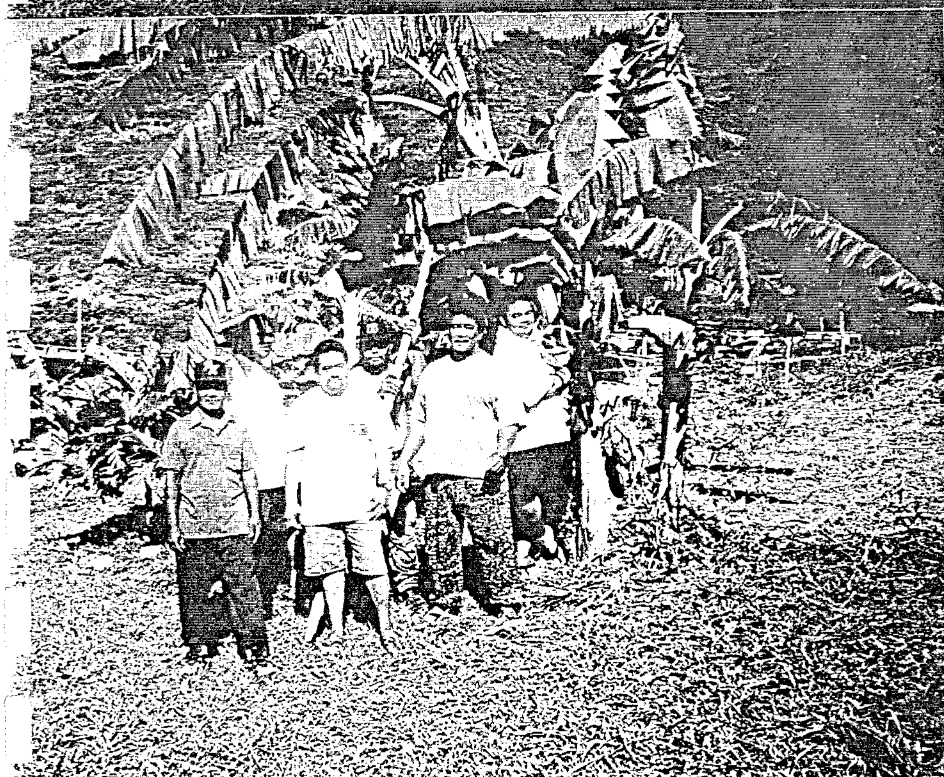
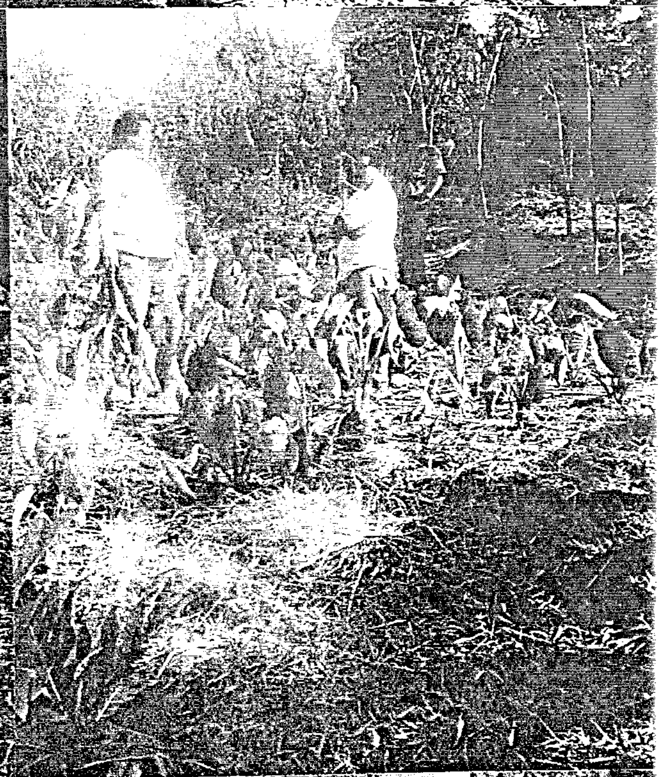
monday (Hawaiian language - april 5:30 pm)
saturday (shirt printing about 3:00 pm 29th)

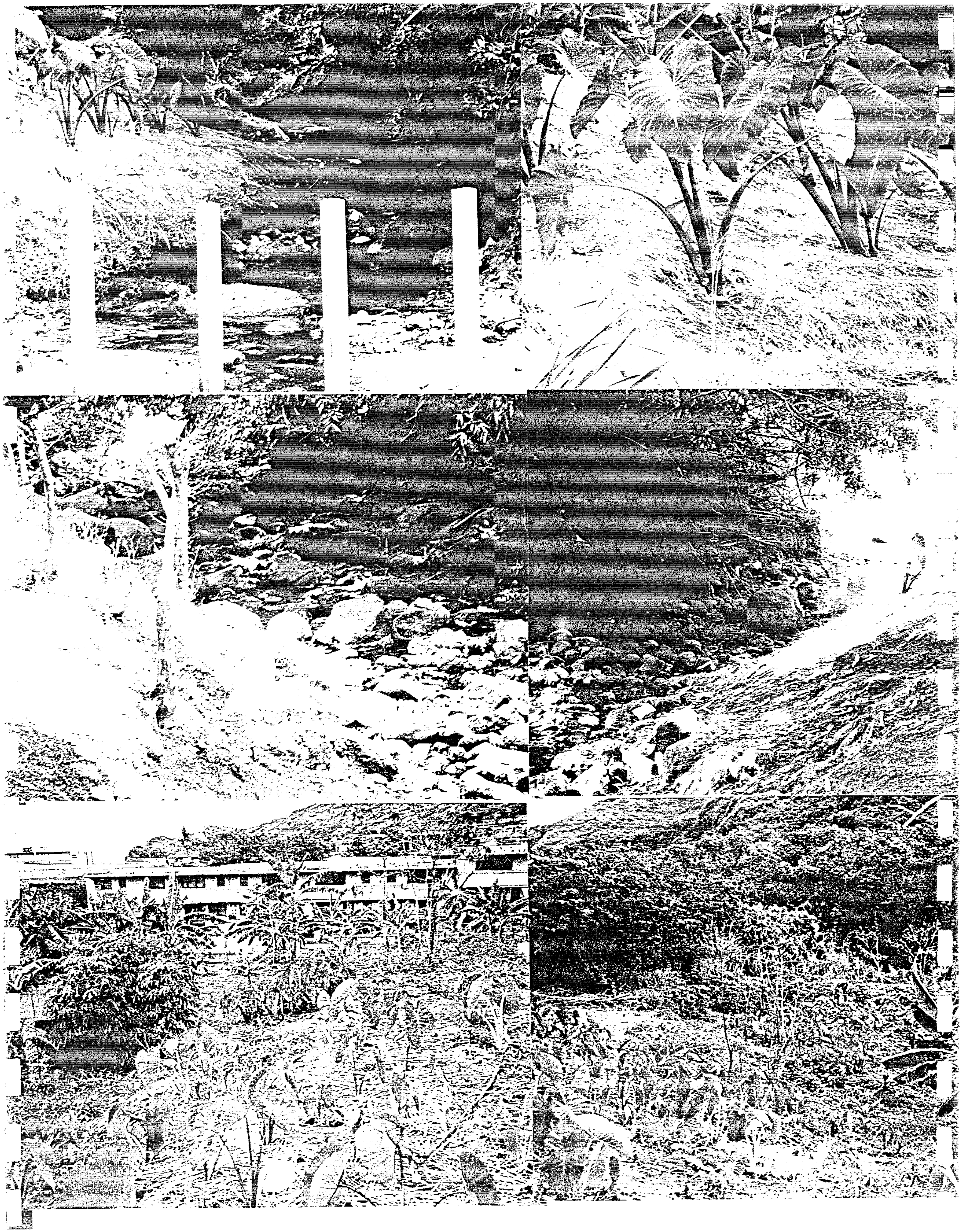


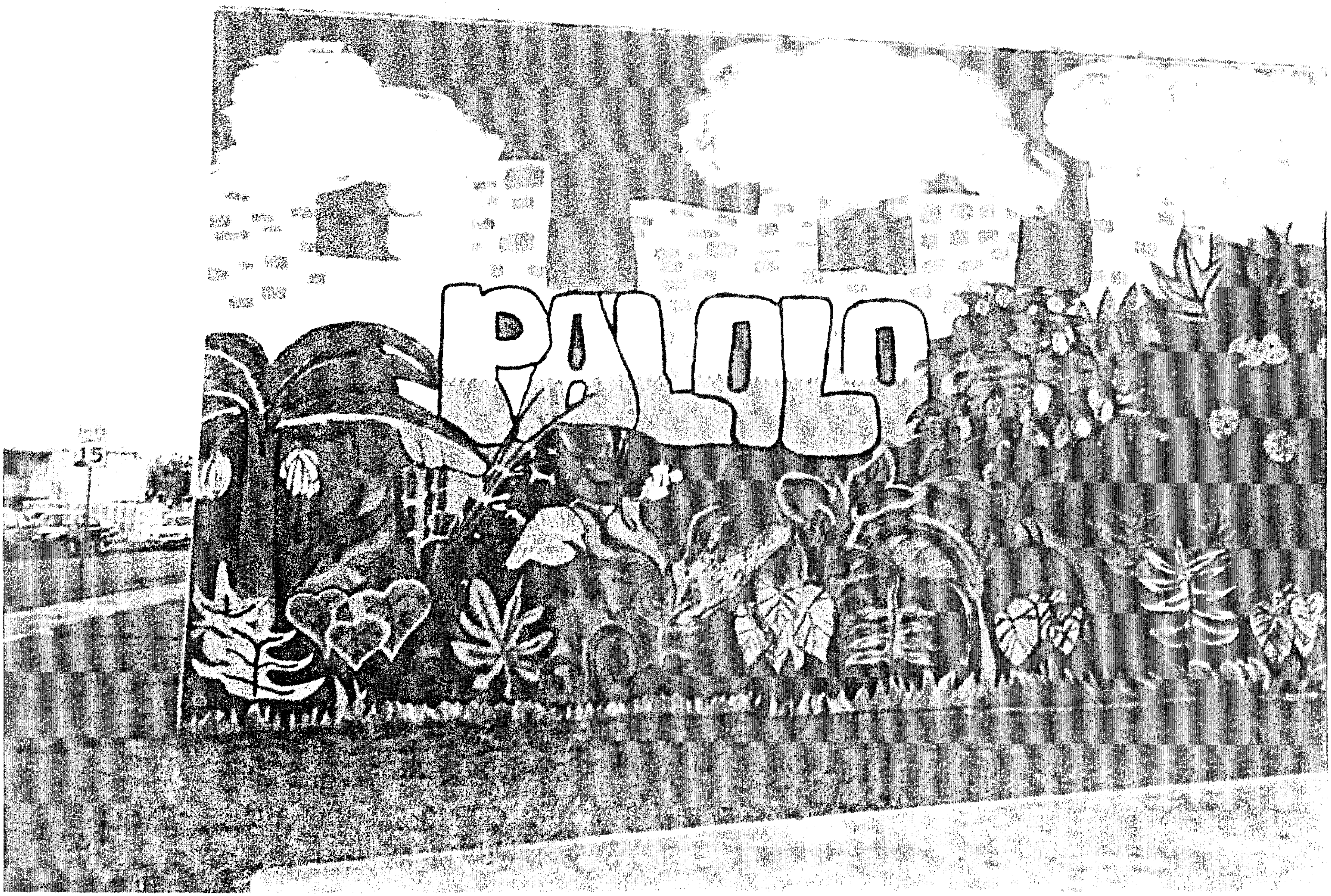










PALOLO
15

APPENDIX J

BENEFIT/COST ANALYSIS
MANOA STREAM
RESTORATION
&
BIKE PATH
PROJECT

BENEFIT/COST ANALYSIS: MANOA STREAM RESTORATION AND BIKE PATH PROJECT

Submitted by:

Bob Alexander
Jason Chang
Joey Cones
Jeanmarie Foy
Reid Nouchi
Piya Sereevinyayut
Dean Watase

A Class Project
AREC 458 Project Evaluation and Resource Management

Under the direction of Professor Gary Vieth
University of Hawaii at Manoa

Fall 1997

SECTION 1

INTRODUCTION AND REPORT ORGANIZATION

1.1 INTRODUCTION

The University of Hawaii at Manoa's Fall 1997 Agricultural and Resource Economics 458 (Project Evaluation and Resource Management) class, for its group project, has decided to do a benefit/cost analysis for the Manoa Stream Restoration and Bike Path Project (Project). The Project has been proposed as a best management practice (BMP) plan to improve water quality in the Manoa Stream and Ala Wai Canal. This could be accomplished as the Project proposes to: (1) reduce soil erosion that contributes to the increased depositing of sedimentation in the Streams and Ala Wai Canal and (2) reduce the dumping of debris and toxic materials along the river banks that ultimately affects water quality in Manoa Stream and the Ala Wai Canal. The Project is one component of the larger Ala Wai Canal Watershed (AWCW) Water Quality Improvement Project.

A benefit/cost analysis is an effective method to systematically determine if the proposed project would provide a sufficient value for the use of the public's money. Simply stated, a benefit/cost analysis measures the economic benefits and costs of a project or program. A methodology is developed that appropriately discounts future benefits and costs so that a side-by-side comparison is made. Through such an analysis, the feasibility of a project or program can be determined. The benefits of a project or program are defined as the values of the outputs of goods and services. While the costs of a project or program are defined as the resources used by the project.

This report presents a benefit-cost analysis of the Manoa Stream Restoration and Bike Path Project.

1.2 REPORT ORGANIZATION

The report is organized as follows. Section 2 presents the Executive Summary for this report. Section 3 details the project setting of the Manoa Stream Restoration and Bike Path Project. In this section, the problem concerned is identified and the proposed solution is revealed. Section 4 presents the methodology of the benefit-cost analysis. Section 5 discusses the conclusions of the report.

SECTION 2

EXECUTIVE SUMMARY

This Project is a best management practice plan that intends to improve water quality in the Manoa Stream and Ala Wai Canal. The construction of a pathway will reduce sedimentation of the Manoa Stream and the Ala Wai Canal by reducing soil erosion. This project intends to increase environmental awareness of the surrounding population.

This benefit/cost analysis was conducted to determine the willingness-to-pay (WTP) for the construction of this pathway. WTP helps evaluate the public benefits derived from improvements from a project. Sample populations surveyed include both student and non-student residents in the following areas: Waikiki, Kaimuki, Manoa, Makiki, McCully, Kapahulu, and Moiliili. Two major population groups were identified: students and non-students. Within our target area we estimated there are 14,000 students and 66,000 non-students, a total of 80,000 residents. The survey showed that , in average, each student was willing to contribute $3.48 per month, while each of the non-student population was willing to pay $8.15 per month. Therefore, the total monthly contribution from both groups was $786,360. According to the Ala Wai Watershed Report, the estimated cost of the project totaled $200,000. Within the project cost, there is the assumption that volunteer labor would be used. Based on these findings it is obvious that the benefit exceeds the construction cost. As a result, this project is found to be economically beneficial.

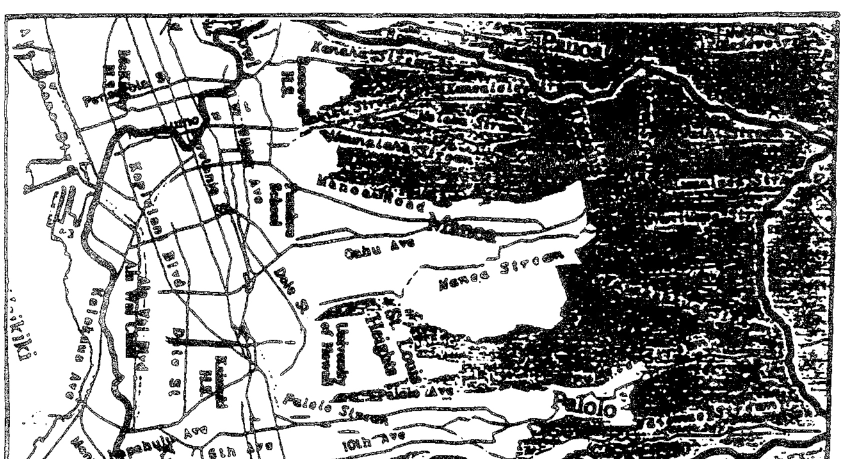
SECTION 3

PROJECT SETTING, PROBLEM IDENTIFICATION, AND PROJECT DESCRIPTION

3.1 PROJECT SETTING

The Manoa Stream is located in the Ala Wai Canal Watershed on the Island of Oahu. It is a natural system of streams running southward that drains Manoa Valley Conservation District into the Ala Wai Canal. At the northern most portion of the system, it is fed by the Waiakeakua, Naniupao, Luaalaea, Waihi, and Aiaualama Streams at the base of Manoa Valley. Towards the middle of the system, it is fed by the Palolo Stream and it becomes known as the Manoa-Palolo Canal. However, for the purposes of this report, Manoa Stream and the Manoa-Palolo Canal will be referred singularly as the Manoa Stream (Figure 1 below).

FIGURE 1
The Ala Wai Canal Watershed



(Source: Dashiell, 1997)

3.2 PROBLEM IDENTIFICATION

The Project is a small part of the larger Ala Wai Canal Watershed Water Quality Improvement Project. The mission of the AWCW Water Quality Improvement Project is to (City-DOH; 1995):

Improve the quality of both surface waters and ground waters in the drainage basins for Manoa, Palolo and Makiki Streams, and in the Ala Wai Canal through a long term, community-based, public-private program of non-point source management activities in the watershed.

To accomplish this, a number of best management practices are proposed. The plans with the greatest potential for success are selected, implemented, and monitored to measure outcomes. A number of plans may be considered including (City-DOH, 1995):

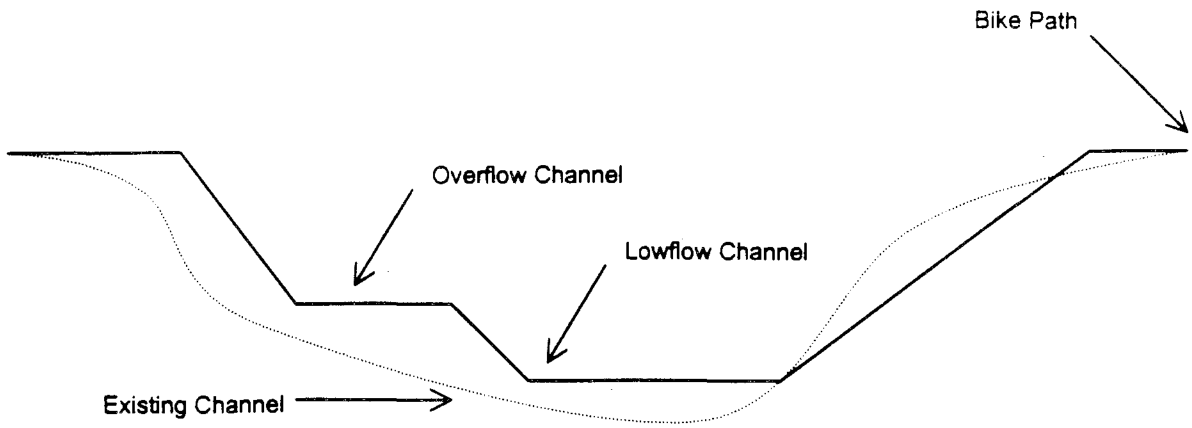
(1) Controlling and reducing erosion and sediment.
(2) Reducing use of fertilizers and pesticides.
(3) Reducing illegal dumping and litter accumulations in the stream.
(4) Re-vegetating stream banks where possible.
(5) Inspecting and enforcing municipal stormwater permit conditions and grading-and-grubbing permit conditions.
(6) Dredging of the Canal.
(7) Increasing flushing rates in the Canal.
(8) Minimizing raw sewage leaks or spills, and sewering areas on cesspools or septic systems.
(9) Coordinating with the Department of Health (DOH) School-based Volunteer Water Quality Monitoring Project.

The Manoa Stream Restoration and Bike Path Project means to reduce soil erosion and the depositing of debris as public awareness and education is increased. Ultimately, as a result of the Project, this should reduce dredging costs and improve water quality for the Ala Wai Canal.

3.3 PROJECT DESCRIPTION

The Project location is between Date Street and the University of Hawaii at Manoa (UH). The proposed plan would reconfigure the stream bank along the Manoa Stream so that a path would be incorporated along the stream. At the same time, the stream would be reconstructed so that a low flow and an overflow channel are built into the stream (Figure 2).

FIGURE 2
Proposed Cross Section

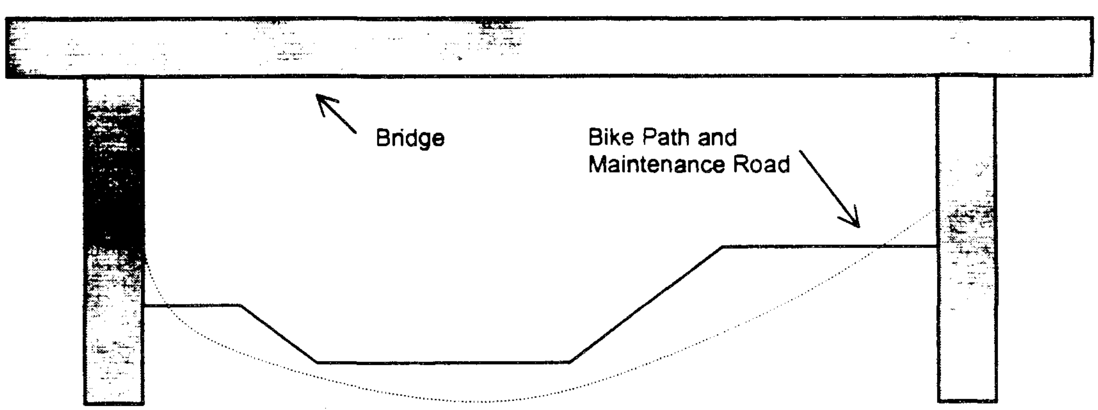


(Source: Dashiell, 1997)

The proposed pathway begins at Date Street and continues northward towards the University of Hawaii at Manoa (UH). At the Date Street Junction, there is already an existing path along the Ala Wai Canal and Golf Course built by the City. This would link the Waikiki area to UH and provide residents with access. Although the original proposed path extended past UH towards Woodlawn Drive, the group decided that the pathway should terminate at UH due to the physical constraints that are present along the Manoa Stream beyond the Dole Street Bridge. More specifically, substantial environmental alteration would be necessary to construct a bike path through this area.

The bike path would be routed under the existing bridges along the way (Figure 3 below). Since much of the proposed land on the bike trail is public, the feasibility of the project is high.

FIGURE 3
Proposed Cross Section of the Bike Path Under Bridge



(Source: Dashiell, 1997)

SECTION 4

METHODOLOGY & ANALYSIS

4.1 METHODOLOGY

The Contingent Valuation Method (CVM) was the technique chosen to estimate the value of the Manoa Bikeway/Path Project. A carefully worded survey was used to directly question consumers and elicit the value each respondent would place on the project. The Willingness-to-Pay (WTP) procedure, a form of the Contingent Valuation Method was used to measure individual preferences. WTP is an appropriate measure when an individual is asked about an improvement from the present state. Estimates are made by inferring what an individual's behavior would be from the answers he or she expresses in a survey framework. This approach may not always yield precise estimates but they do provide an order-of-magnitude estimate which can be very valuable. (Dixon, et al, 1988).
In order to enhance our analysis, the WTP technique was chosen. Rather than focus on certain benefits and in turn disregard others, WTP allows the consumer to reveal their preferences and encompass all the individual advantages they will derive. The study thus becomes broader in scope and reflects a more realistic monetary estimation of benefits.

A representative random sample of the affected population was asked to complete a direct question survey. The questions progressed to stimulate active thinking and evoke realistic responses. Two distinct and relevant groups were sampled. One population was the University of Hawaii including staff, faculty and students, and the second group, residents of the surrounding communities consisting of Waikiki, Kaimuki, Manoa, Makiki, McCully, Kapahulu and Moiliili.

Much analysis and thought was put into deciding what was the relevant area to be sampled. The whole of Oahu was obviously unrealistic. The question was how many square miles surrounding the Pathway should be studied. The population from this area would be used to extrapolate a dollar figure thus obtaining a willingness-to-pay amount. Portions of statistical study areas found in the *Hawaii Data Book 1995, A Statistical Abstract* were chosen to be included in the survey (Appendix D). The Ala Wai Canal watershed is 16.3 square miles, and the Urban District is nearly 9 square miles. The residential population in this watershed is a little over 150,000 persons with a residential density of 16,700 persons per square mile (Dashiell, 1997). The chosen survey area covers slightly over 4.5 square miles with an estimated population of 80,000 persons. This compares realistically with the figures obtained by Dashiell.

Survey Area		Population
Area 5 (one-half)		10,430
Area 7		20,834
Area 8		28,465
Area 9		19,757
Total Residential Population	78,486	

Due to budget constraints, the survey was physically administered at various distribution points selected to include residents from the entire designated survey area. According to the results, respondents include a random selection of residents that live throughout the chosen area. Ideally, a more random sample such as a large scale postal mailing or going door to door would be desireable but unrealistic due to the money and student factor involved in this project.

Those surveyed were given the choice between assigning a monthly monetary value, committing volunteer hours, or neither money or time. The option of volunteer hours was included because of the large group of students in the targeted population. The college years are undeniably a unique time affecting earning capacity. The study did not want to eliminate or seriously underestimate the preferences of students. It is widely accepted that willingness-to-pay is constrained by income. Also, the dollar figure extrapolated is normally viewed as the upper bound that people are realistically willing to pay. This upper bound reflects the 'consumer's surplus' of a public good such as the Project. Actual amounts charged, for example, an admission fee, will generally be lower.

The average dollar amount the consumers surveyed were willing to pay per month was extrapolated to the target population of 80,000 people. Questions were asked to elicit a per month dollar amount and how many volunteer hours each respondent was willing to contribute to the Project. The results were analyzed and income figures used to place a dollar amount on the volunteer hours of the two different population groups - students and non-students.

There were 16 protest bids recorded from the survey analysis. Those that included protest bids were discarded in the final analysis. Various reasons were given by protesters including the belief that taxes should cover the costs of providing the environmental help needed by the Canal and its sources, the main Ala Wai Canal should be improved first, and that other projects were more appropriate in these hard economic times.

In addition, a pretest of the survey was conducted, facilitating its refinement. Some sections and questions needed to be deleted or reworded. The value of pretesting was initially questioned. The findings quickly reaffirmed the importance of this device. The pretest was conducted at an Ala Wai Canal cleanup effort on "Make A Difference Day." Unfortunately the group was found not to be representative of the targeted population or area. Much useful information regarding some very basic problems with the survey was gained from this initial attempt but another pretest was later administered to further improve the study.

Other Concerns. One of the toughest problems the cost/benefit analysis posed was the selection of factors to evaluate in order to place the proper value on the benefits gained. Choosing between alternative variables was important due to limited funds. The scope of the study needed to be streamlined and the methods appropriate to insure its accuracy and reliability.

Lost benefits of opportunity costs resulting from the project were negligible. The plan would not restrict or change any present usage. Many attributes are hard to measure and certainly not realistically reflected in the current analysis. Certainly, safety factors, the value of a reduction in possible crimes due to greater activity in the area is not measured or accounted for in the study. Such benefits may only be realized after careful reflection.

The aesthetic value of landscaping may not be perceived by respondents as separate issues worthy of monetary assignments. The addition of plantings may not be viewed in terms of erosion control but the normal method of constructing a bikeway/path. There are studies that are solely restricted to estimating soil erosion using the Universal Soil Loss Equation statistical model.

Evaluating the project using a travel-cost equation was explored. The basic and local nature of the Project along with the limited travel area, the physical reality of the size of Oahu, made this approach unrealistic.

The bikeway/path will surely reduce transportation costs. This is reflected not only in the study but by obvious consideration of the presence of the University of Hawaii. Thousands of students and employees must access the campus daily. Many people currently drive autos because of safety concerns. Dangerous situations occur on a daily basis involving bicycle riders and even pedestrians. Any discussion with the University population assures one of the widespread knowledge of this potentially dangerous situation.

A transportation analysis should ideally look at a reduction in the use of gasoline, air pollution and costs. This methodology was abandoned because of the relatively short distance of the bikeway/path and the necessity to focus on safety. How does one place a price on saving one life, on preventing one debilitating accident? We attempt to deal with economic factors and eliminate the compassionate, humanitarian viewpoint. The obvious inclusion of the aesthetic value of this project while discounting the value of safety or health was a major concern.

ANALYSIS

PROJECT COSTS

Externality Costs. From discussion of the proposed pathway site with local experts, it appears that there are no externality costs from construction and use of the pathway. Rather than costs of environmental degradation, benefits from environmental improvement are expected. Other potential costs include noise to neighbors, solid pollution in the stream, and increased risk of injury to users of the pathway. These costs were considered negligible due to offsetting reductions.

In the Date Street to Dole Street area, residents should not be significantly affected by any increases in noise from increased traffic along the stream. The only housing near enough to the stream to be affected seems to be those residents along the stream near Kaimuki High School. These residents already contend with the daily noise of students and traffic. Any changes associated with the proposed pathway may be deemed insignificant. Possible land valuation changes were thus also ignored.

Kaimuki High School has recently erected a fence and a gate to eliminate transients on their grounds. It may be perceived that this path may adversely affect this effort. Offsetting benefits to Kaimuki High School, however, include an improved environment alongside the school. This improvement might increase the quality of the neighborhood and decrease vandalism as well as possibly improving the learning environment.

Pollution to the stream is already an issue, even without any pathway construction and use. People we surveyed conveyed thoughts that ranged from seeing the path as potentially improving this situation to having a negligible effect. Either way, for the purpose of this study, it seems that there should be no pollution externality costs.

Some residents may worry that the path may lead to increased risk of injury and/or death. Especially if it is to be a bike path. There seem to be offsetting concerns that walking and biking along the streets in this area are already quite dangerous such that the new bike path would actually decrease such risks. Posting signs of the risk of drowning in the stream may also help to diminish this risk. Thus, estimates of the costs or benefits of changes in risk from use have also been omitted.

Direct Project Cost. Direct project costs were obtained from the existing Ala Wai Canal Watershed: Problems and Projects. This report estimated total construction costs of $200,000 for a pathway from Date Street to Manoa Falls, including the Date Street to Dole Street portion which we have considered. Along with concrete and porous paving blocks, there would also be necessary engineering costs of modifying the stream channels and dealing with stream meanders. It has been stated that the biggest cost of this project may be time and effort since much negotiation with city and state officials would need to precede and accompany actual work on the path construction itself. Within this cost estimate, there were assumptions of significant contributions of volunteer time and effort.

Perceptions of the pathway to be built range from restoring historic footpaths to engineered bike paths and maintenance roads. Though no estimates of costs were actually estimated for this study, it was assumed that this $200,000 figure is actually at the low end of costs of a path that meet the desires of our respondents. It was decided that this $200,000 figure should be used as a lower bound of the cost of construction of the proposed portion of the pathway. Thus, if benefit estimates are lower than this figure, any thoughts of construction should be abandoned. If however, the potential benefits exceed this cost lower bound by a significant margin, then specific cost figures can be estimated to determine the viability of the project.

PROJECT BENEFITS

TABLE 1
Willingness To Pay Survey

Average Contribution	Money ($)	Time (hr)	Value of Time ($/hr)	Total ($)
Student	2.57	1.41	3.48	7.47
Non-Student	4.79	0.68	8.15	10.33

Calculation:

(Average) Value of Time:

- (Average) Difference of Money if No Time ($/month/person) =
  Only Money ($/month/person) – Money with Time ($/month/person)

- (Average) Value of Time ($/hr.) =
  Difference of Money if No Time ($/month/person) ÷ (Avg.) Time (hrs./month/person)

Student:

$7.47/month/student -$2.57/month/student) ÷ (1.41 hrs./month/student)
= $3.48/hr.

Non-Student:

($10.33/month/person-$4.79/month/person) ÷ (0.68 hrs/month/person)
= $8.15/hr.

TABLE 2
Summary of Willingness To Pay

	Number of People In Population	Total Population's Monthly Contribution ($)
Student	14,000	104,580
Non-Student	66,000	681,780
Total	80,000	786,360

Aside from reduced stream bank erosion, other benefits include improved landscape around Kaimuki High School, potential decreased road traffic, and cultural restoration of historic footpaths may also result from its construction and use. As mentioned in the cost analysis, any of these external and/or secondary benefits from use or existence of the pathway are assumed to offset perceived externality costs from its use. Thus, the willingness to pay survey was used to analyze direct benefits and compare these to the aforementioned direct costs of provision of the pathway.

Data was compiled for such respondent demographic characteristics as area of residence, age group, gender, income group, and occupation. Breakdowns of some of these responses are included. Since the affected population is divided between students and non-students and since data is available for student and resident populations in the proposed pathway area. Therefore, the occupation grouping was chosen as the basis for calculation of willingness to pay.

Refinements of the original methodology were needed to construct estimations from this data. First, the total affected population needed to be divided into student and non-student populations such that each could be multiplied by its respective estimated willingness to pay from the data. Over half of our respondents were students while less than a quarter of the area's residents are students, it was deemed that this division would better reflect the differences in willingness to pay of these two groups with significantly different willingness to pay in terms of both time and money. From survey data, it was evident that approximately two-thirds of the student population lives in the area near the pathway. With an estimated total area population of 80,000 and the University of Hawai'i at Manoa student population of 21,000, it was estimated that 14,000 of this 80,000 are students and the remaining 66,000 are non-students.

Another refinement was in the form of elimination of respondent data which was deemed irrelevant for inclusion in the analysis. Protest bids and other such replies of no willingness to pay were deemed misleading if they corresponded to respondents who expressed interest in the project. Thus, these respondent replies were dropped from the analysis. Of the 93 total respondents, there were a total of 16 of such protest bids eliminated. What remained for analysis was 42 students and 35 non-students.

Calculations and resulting tables of remaining respondent willingness to pay are included to summarize analysis. Students were estimated to be willing to contribute an average of $2.57 per month and 1.41 hours per month. They were willing to contribute $7.47 per month if time was not an option, each hour of their time was estimated to be worth $3.48. This figure was deemed reasonable, considering students' opportunity cost of their time and their income level. Therefore, the total monthly willingness to contribute from students was estimated to be $104,580. Non-students were estimated to be willing to contribute an average of $4.79 per month and 0.68 hours per month. Since they were willing to contribute an average of $10.33 per month if time was not an option, each hour of their time was estimated to be worth $8.13. Considering their time away from the office and the opportunity cost of their leisure time, this figure was deemed reasonable. Thus, non-student total monthly willingness to contribute was estimated to be $681,780. Total population estimated monthly willingness to contribute was thus $786,360.

Due to the inherent drawbacks of the willingness to pay method, it is expected that this estimation would exceed the actual willingness to pay of the area residents. Thus, this monthly estimated figure is to be used as an upper bound on their actual willingness to pay. But, even if only half of these benefits were realized (leaving almost $400,000 per month) and costs were actually twice the lower bound of $200,000, costs of the pathway would be matched by benefits in only one month! In conclusion, it seems that this project is worthy of further analysis.

In addition to some of the benefits derived from the survey mentioned previously, the project is also expected to help improve a present traffic condition by promoting the use of a bike or walk instead of car, and also provide the safe and convenient environment for pedestrians and bicycle-commuters. There are also external benefits said to be involved, such as the reduction of soil erosion which causes the depositing of sedimentation in the stream and the Ala Wai Canal, and the restoration of the Hawaiian historical footpath.

Because the contribution to the depositing of sedimentation by this pathway is less than 25% of the present state, and that the project itself seems not to be a real restoration of the historical footpath, we decided to exclude them from this benefit analysis.

SECTION 5

CONCLUSION

5.1 CONCLUSION

The idea for a pathway along the Manoa stream was first presented in the early '70's. In recent years the plan was adopted by the community group, Malama O Manoa. The planning of this project can be done by the Office of Waikiki development, the DPR, or the DTS.

Our survey gave a result that, in average, each student was willing to make a $3.48 contribution per month, while the each of the non-student population was willing to pay $8.15 per month. In total, the student population within the target area was willing to pay $104,580 per month. And for the non-student population, each was willing to pay a total of $681,780. Combining the figures from both groups, the total monthly contribution for the whole population in the target area was $786,360. According to the Ala Wai Watershed Report, the estimated cost of the project totaled $200,000, with the assumption that there would be volunteer labor involved. This result clearly demonstrated that the benefit outweighs the construction cost. Hence, the project is found to be economically beneficial.

As we approach the turn of the century there is an increasing need for environmental conservation and more efficient transportation in Hawaii. The Manoa Stream Project will reduce sedimentation of the Ala Wai Canal and provide a right of way for pedestrians. The proposed pathway will extend from the Ala Wai Canal along the Manoa-Palolo Canal, and up the Manoa Stream ending at Dole Street. This project will provide a valuable addition to Honolulu's urban landscape. Construction of this pathway would improve transportation between Manoa and Waikiki, while highlighting the existing semi-natural water features for residents and tourists.

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Appendix A

Survey Data Sheet

	1	2)walk	2)bike	2)visual	2)recreation	2)other	3	4	5a	5b	6	7 Manoa	Makiki	McCully	Kaimuki	Waikiki	other
1	4				1		0	0	0	0						1	
2	4		1		1		0	0	0	0	tax	1					
3	5	1	1		1		0	5	0	1	0			1			
4	4	1	1				0	8		8							1
5	4				1		0	0	0	0		1					
6	5	1	1	1	1		40	0	10	0	10				1		
7	5	1				1	10	0	2		2				1		
8	5	1	1	1	1	1	0	4			time			1			
9	4		1				0	4		2	0			1			
10	5	1	1	1			0	12		4	0				1		
11	5	1		1			150	8	10	2	10					1	
12	5		1		1		0	0		4	0				1		
13	2						25	5	0	0						1	
14	4	1					100	25	4		4			1			
15	5	1					125	8	20		20			1			
16	4			1			0	0	10		10						1
17	3	1	1				0	0	0	0	0					1	
18	3				1		0	0	0	0	no money				1		
19	5	1	1	1			15	0	5	0	5			1			
20	4			1			0	2	10	0	10				1		
21	3				1		0	0	0	0				1			
22	3	1					0	0	0	0	0 no money			1			
23	3						0	15	0	0	no info						1
24	4	1			1		0	5	0	1			1				
25	4	1		1			0	0	0	0		1					
26	4		1		1		0	0	0	0				1			
27	4	1		1			0	20	0	0	no info		1				
28	4	1		1	1		0	8	0	2					1		
29	5		1		1		0	5	0	2		1					
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31	4	1					0	18				1					
32	3	1		1			20	0	15	0	15						1
33	4	1	1				0	0				1					
34	4	1					0	0	0	0		1					
35	4	1		1			0	40	0	0	protest						1
36	3						0	0	0	0	no info	1					
37	3						30	4	0	0							1
38	4	1	1	1			10	8		4		1					
39	4	1					0	10		10		1					
40	5	1		1	1		0	4		4		1					
41	4	1					5	2	2	1	4	1					
42	4	1					2	0	0	0	no time			1			
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47	4	1					20	0	2	0	2	1					
48	3						0	0	0	0		1					
49	4	1					25	10	0	0	0 protest						1
50	4	1					0	0	0	0	protest						1
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58	5	1	1				75	0	15	0	15 tax				1		
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93	3						0	0	0	0					1		
	3.956989247	63	31	32	25	5	21.34946237	4.440860215	3.392405063	1.027108434	8.695652174	24	6	16	21	6	20
	1	2)walk	2)bike	2)visual	2)recreation	2)other	3)$	4)hr	5a)$	5b)hr	6)$	7 Manoa	Makiki	McCully	Kaimuki	Waikiki	other

0-18	19-25	26-55	56+	male	female	0-24k	25k-48k	49k+	student	staff	faculty	other	
	1				1	1			1				1
	1			1		1			1				2
	1			1		1			1				3
	1				1				1				4
	1				1	1			1				5
	1				1		1					1	6
			1		1		1					1	7
		1			1			1			1		8
	1			1		1						1	9
1					1	1						1	10
		1		1				1				1	11
	1			1		1						1	12
			1		1	1						1	13
			1		1	1						1	14
		1			1			1				1	15
		1		1			1					1	16
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1				1		1			1				18
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	1				1	1						1	64
	1			1		1						1	65
		1		1			1					1	66
		1			1		1					1	67
	1			1		1			1				68
	1			1		1			1				69
		1			1	1						1	70
			1	1			1				1		71
	1			1		1			1				72
		1			1	1			1				73
			1	1			1					1	74
	1				1	1			1				75
		1		1				1	1				76
	1			1		1			1				77
	1				1	1			1				78
	1				1	1			1				79
	1			1		1			1				80
	1				1	1			1				81
	1			1		1			1				82
		1		1		1					1		83
		1		1		1			1				84
	1				1	1			1				85
1				1		1						1	86
		1			1		1					1	87
			1		1			1				1	88
		1		1		1						1	89
		1		1			1					1	90
		1			1		1			1			91
			1	1				1				1	92
		1			1		1					1	93
7	46	29	11	55	38	62	20	9	52	4	3	34	
0-18	19-25	26-55	56+	male	female	0-24k	25k-48k	49k+	student	staff	faculty	other	

Appendix B

Survey with Map of Proposed Pathway Location

MANOA STREAM RESTORATION AND PATHWAY PROJECT SURVEY

We are conducting a survey on the **Manoa Stream Restoration and Pathway Project** (see map attached) as a part of our class assignment. Our group will be performing a benefit-cost analysis to determine the merits of such a project.

The **Manoa Stream Restoration and Pathway Project** proposes to stabilize the stream banks along the Manoa Stream and to add a pathway and landscaping between Date Street and UH. Where possible, the pathway will run under bridges to avoid dangerous traffic conditions.

All information will be kept confidential.

(1) If a pathway was constructed as indicated on the map, what would be your interest?

(circle one)

very opposed	opposed	indifferent	somewhat interested	very interested

(2) If interested, how would you enjoy it?

___ walking
___ bicycling
___ visual pleasure
___ recreational activities
___ if other, please specify ____________

(3) How much money **per month** do you contribute to charities?

$ ____________

(4) How many hours **per month** do you contribute to volunteer activities?

____________ hours

(5) How much money and how many hours would you contribute **per month** to add this pathway?

$ ____________ and ____________ hours

(6) If hours is greater than "0" in question 5 and if contributing time is not a choice, how much money are you willing to contribute to add this pathway?

$ ____________

(7) If willing to give neither money or time, please exp in why.

____

BACKGROUND INFORMATION

(1) What area do you live in?

___ Manoa
___ Makiki
___ McCully
___ Kaimuki
___ Waikiki
___ if other, please specify ____________________

(2) What age group do you belong to?

___ up to 18
___ 19-25
___ 26-55
___ 56 plus

(3) What is your gender?

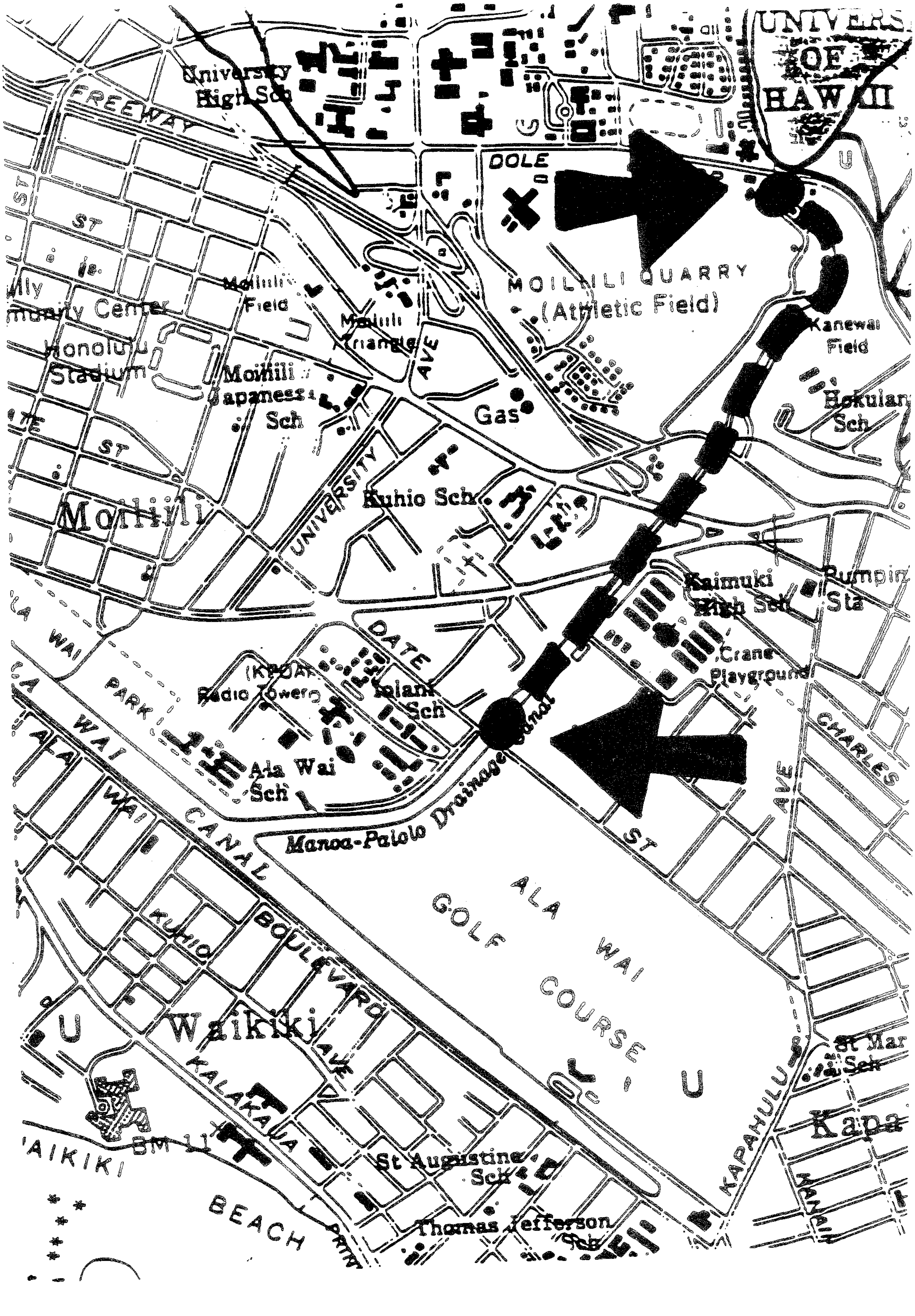
___ male
___ female

(4) What is your annual income group?

___ up to $24,000
___ $25,000 to $48,000
___ $49,000 plus

(5) If you are associated with the UH, how?

___ student
___ staff
___ faculty


UNIVERS
OF
HAWAII
University High Sch
FREEWAY
DOLE
ST
Moiliili Field
Community Center
Honolulu Stadium
Moiliili Triangle
Moiliili Japanese Sch
MOILIILI QUARRY
(Athletic Field)
Kanewai Field
Hokulani Sch
Gas
AVE
UNIVERSITY
Kuhio Sch
Moiliili
Kaimuki High Sch
Pumping Sta
Crane Playground
DATE
(KPOA) Radio Tower
Iolani Sch
Ala Wai Sch
WAI
PARK
ALA WAI
CANAL
Manoa-Palolo Drainage Canal
ST
CHARLES
AVE
ALA WAI
GOLF COURSE
BOULEVARD
KUHIO
Waikiki
AVE
KALAKAUA
BM 11
WAIKIKI
BEACH
St Augustine Sch
Thomas Jefferson Sch
KAPAHULU
St Mary Sch
Kapa

Appendix C

Survey Data Summary

Question 3- $ contribute to charity

Male: $18.31 (per person out of 55 people).
Female: $25.73 (per person out of 38 people).

	Male	Female
up to 18:	$46 per/5	$0 per/2
19-25:	$4.34 per/25	$5.04 per/21
26-55:	$29.66 per/18	$57.45 per/11
56 plus:	$37.14 per/7	$51.25 per/4

Question 4-hrs. contribute to charity

Male: 3.25 hrs. per/55
Female: 6.15 hrs. per/38

	Male	Female
up to 18:	3.5 hrs. per/5	7.5 hrs. per/2
19-25:	3.7 hrs. per/25	4.9 hrs. per/21
26-55:	1.9 hrs. per/18	7.4 hrs. per/11
56 plus:	6 hrs. per/7	12.5 hrs. per/4

Question 5a-$ willing to pay

Male: $2.73 per/49
Female: $4.46 per/30

	Male	Female
up to 18:	$1.25 per/4	$0 per/1
19-25:	$1.72 per/22	$1.68 per/16

26-55:	$4.29 per/17	$10.55 per/9
56 plus:	$3 per/6	$3 per/4

Question 5b- hrs. willing to contribute

Male: 0.65 hrs. per/50
Female: 1.59 hrs. per/33

	Male	Female
up to 18:	0 hrs. per/3	2.5 hrs. per/2
19-25:	0.54 hrs. per/24	1.82 hrs. per/20
26-55:	1.08 hrs. per/17	0.91 hrs. per/9
56 plus:	0.16 hrs. per/6	1.5 hrs. per/2

Question 6- how much money if no time

Male: $6.27 per/29
Female: $12.82 per/17

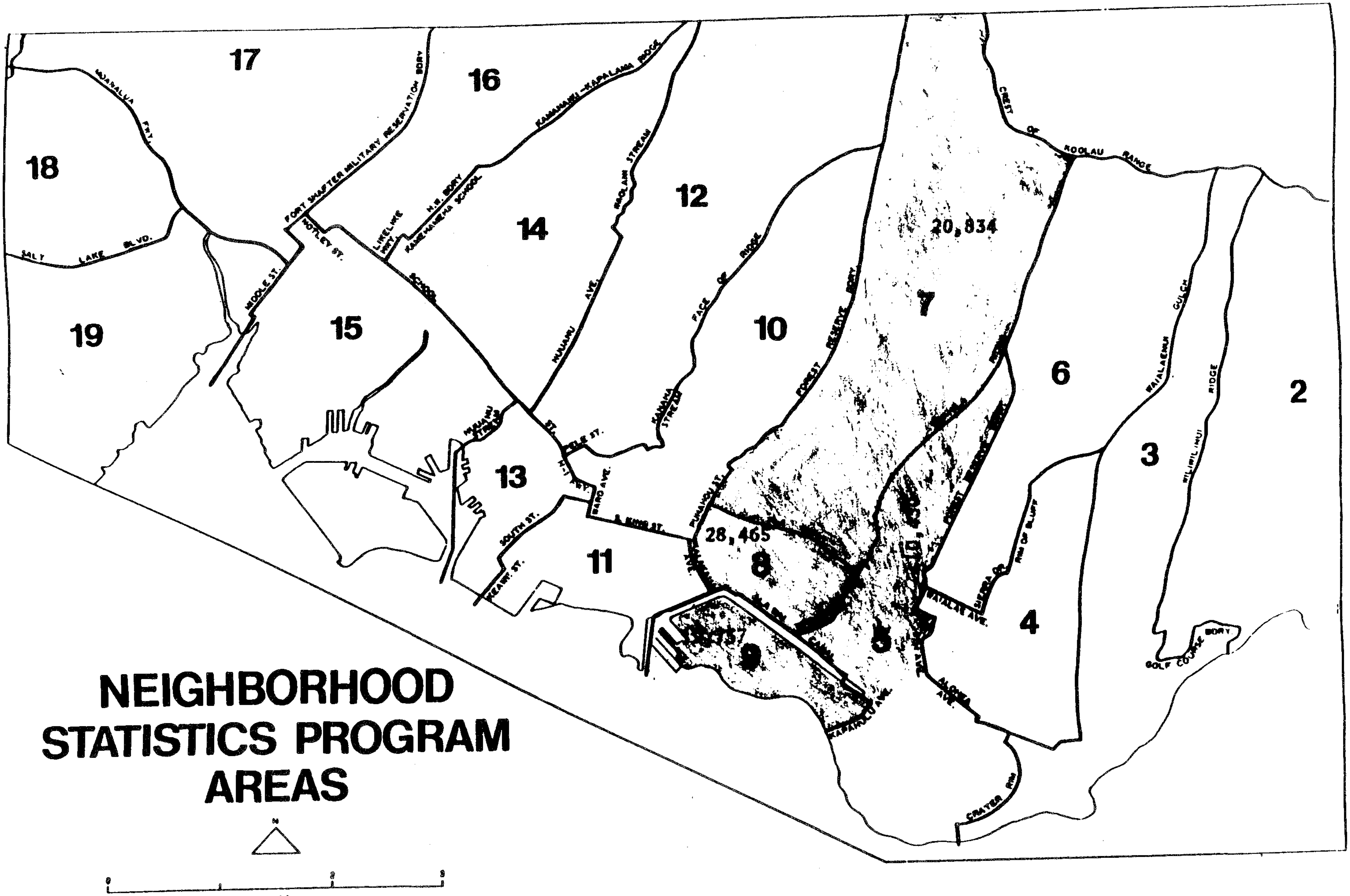
	Male	Female
up to 18:	$5 per/3	$5 per/2
19-25:	$5.55 per/9	$7 per/5
26-55:	$7.23 per/13	$18.14 per/7
56 plus:	$5.75 per/4	$15.33 per/3

Note........Total males are 55 and total females are 38. In questions 5a, 5b, and 6 numbers are lower because of the no response in answering the survey. Lower numbers are reflected in the sample regarding different age groups.

Appendix D

Map of Selected Population Areas

NEIGHBORHOOD STATISTICS PROGRAM AREAS



(Source: The State of Hawaii Data Book 1995, A Statistical Abstract)

Survey Area and Population

The relevant population area chosen to be included in the survey and used to extrapolate a dollar figure thus obtaining a willingness-to-pay amount was derived from portions of statistical study areas found in the *Hawaii Data Book 1995, A Statistical Abstract.* The Ala Wai Canal watershed is 16.3 square miles, and the Urban District is nearly 9 square miles. The residential population in this watershed is a little over 150,000 persons with a residential density of 16,700 persons per square mile (Dashiell, 1997). The chosen survey area covers slightly over 4.5 square miles with an estimated population of 80,000 persons. This compares realistically with the figures obtained by Dashiell.

Survey Area	Population
Area 5 (one-half)	**10,430**
Area 7	**20,834**
Area 8	**28,465**
Area 9	**19,757**
Total Residential Population 78,486	

Due to budget constraints, the survey was physically administered at various distribution points selected to include residents from the entire designated survey area. According to the results, residents that live throughout the area were successfully interviewed and representative of the targeted population.

Interest in the Pathway

Respondents were asked to rate their interest in the project by choosing between 5 different ratings - very opposed, opposed, indifferent, somewhat interested, or very interested. In the analysis, a numerical value of 1, 2, 3, 4, or 5 was assigned to each of the choices. Very Opposed was a "1" continuing upward until Very Interested was considered a "5". The average value derived from the survey of 93 people was 3.96 representing a rather strong interest in the project.

Very Opposed	Opposed	Indifferent	Somewhat Interested	Very Interested
2	1	22	42	26

Uses of the Pathway

The ways in which people would use the pathway were very evenly divided among the various choices except for the strong interest in using the path to bike. This interest was double that of any other choice. This preference may not seem very surprising with the popularity of bicycling occurring over the last few years. This may present problems to the future designers of the pathway because of safety concerns.

Walk	Bike	Visual	Recreation	Other
63	31	32	25	5

APPENDIX K

ADDENDUM TO THE ALA WAI CANAL WATERSHED WATER QUALITY IMPROVEMENT PROJECT – MANAGEMENT & IMPLEMENTATION PLAN

APPENDIX K. ADDENDUM TO THE ALA WAI CANAL WATERSHED WATER QUALITY IMPROVEMENT PROJECT – MANAGEMENT & IMPLEMENTATION PLAN

August 2025

Estimating Pollutant Load Reductions Resulting from Control and Removal of Invasive Plant and Animal Species and Establishment of Native Species

Introduction

This addendum has been developed by the Hawaii Department of Health (HDOH) to address additional considerations and updates relevant to watershed management efforts. This addendum supplements the Ala Wai Canal Watershed Water Quality Improvement Project – Management & Implementation Plan to include activities and additional guidance related to the removal of invasive plants and animals, as well as the reintroduction of native species. In addition to including these activities in the menu of best management practices (BMPs) that are eligible for 319 funding, this addendum provides an approach for calculating the pollutant reductions associated with these restoration activities. These pollutant reductions can be used by project managers and sub-grantees to develop individual project plans and by HDOH to calculate annual pollutant reductions for the broader NPS program.

Pollutant Loading from Invasive Species

Invasive plants and animals are an increasingly challenging source of pollution in many of Hawaii's watersheds. Invasive plants, such as miconia, have shallow root systems, which are unable to stabilize the soil and are susceptible to erosion and landslides during rainfall events. Invasive animals, such as feral hogs, are destructive grazers, uprooting plant material and exposing additional areas to erosion.

As a result, sediment is the primary pollutant of concern from invasive species, although other pollutants may also be transported during rainfall events (e.g., nutrients and bacteria). Sediment has been identified by HDOH as a pollutant of concern across the state and is a focus of water quality improvement efforts. This watershed-based plan already includes a discussion of pollutants of concern and the load reductions needed to return the impaired waters to attainment. This addendum supplements that discussion; invasive species are one of multiple pollutant sources to be addressed.

Pollution Control Practices

Across Hawaii, many organizations (including federal, state and local government, as well as watershed groups) are working to mitigate these problems. In many cases, this involves removing the invasive species and replacing them with native species. Native plant species[1] are better adapted to the soils and climate and provide improved soil retention, among other benefits. Excluding invasive animals, such as using fencing to block access to an area, allows vegetation to recover and thrive.

Table 1 below includes BMPs that can address pollutant loading caused by invasive species.[2] As shown by the large number of potential BMPs, vegetative plantings are a common element of many BMPs; ensuring that native species are used (and in the necessary quantities for establishment) will help to restore native plant communities. Managing invasive animal species is typically limited to exclusion or removal.

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[1] See, for example, https://dlnr.hawaii.gov/forestry/plants/ for a discussion of native plant species.

[2] The table shows only a selection of BMPs. Other BMPs may also accomplish the goals of invasive removal and re-establishment of native species. Watershed planners should consult with HDOH when developing project plans to ensure BMP eligibility.

Table 1. Selection of BMPs to Address Invasive Species

Management Practice	Description
Bioretention Cell (Rain Garden)	Depression consisting of native plant species and soil mixtures that receives stormwater flow and infiltrates to treat pollutants.
Channel Maintenance and Restoration	Practices used to control sediment and plant pollution into waterways during earthwork such as stream bank stabilization or habitat enhancement. Examples include floating booms and silt curtains extended across river or stream banks downstream of work.
Constructed Wetlands	Creation of an artificial wetland ecosystem to improve the quality of stormwater runoff or other water flows. A constructed wetland provides biological treatment in areas where wetland function can be created or enhanced. Constructed wetlands also can be used to treat runoff from agricultural land uses and stormwater runoff and other contaminated flows from urban areas and other land uses. The practice involves establishment of inlet and outlet control structures for an impoundment designed to accumulate settleable solids, decayed plant matter, and microbial biomass and support propagation of hydrophytic vegetation.
Critical Area Planting	Establishment of permanent vegetation in areas with heavy erosion problems. Particularly useful for areas that need stabilization before/after flood events.
Grassed Waterway	A shaped or graded channel that is established with suitable vegetation to convey surface water at a non-erosive velocity using a broad and shallow cross section to a stable outlet. Used to convey runoff from terraces, diversions, or similar; to prevent gully formation; and to protect or improve water quality.
Herbaceous Weed Treatment/Invasive Species Removal	The removal or control of herbaceous weeds, including invasive, noxious, and prohibited plants.
Sediment Basin	Captures and retains stormwater runoff until sediments settle out; water is released through engineered outlet.
Feral Ungulate Fencing	A structural conservation practice that prevents movement of ungulates across a given boundary. Within areas impacted by feral ungulate presence, fences prevent their movement into the forested lands. Ungulate fencing prevents direct contact of fecal matter with waterways, allows for restoration of vegetation, and reduces bacteria and nitrogen loadings and sediment input into waterways.
Feral Ungulate Removal	Hunting or trapping wild goats, pigs, and other non-native hoofed mammals to reduce erosion caused by trampling and vegetation removal, as well as nutrient and bacterial impacts from defecation in and around water bodies.

Through this addendum, these BMPs are now eligible for funding under Section 319 to address water quality concerns caused by invasive species (if the BMPs were not already identified in the original plan). Implementation of these BMPs will lead to a reduction in pollutant loading in the watershed. The original watershed-based plan may include information on specific locations or land use types that may be most appropriate for invasive species BMPs. Additional information can be found in other resources, such as the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service's *Field Office Technical Guide* for Hawaii.[3]

[3] https://efotg.sc.egov.usda.gov/#/state/HI/documents

Calculating Pollutant Reductions

Accounting for the total pollutant reductions is an important step in tracking water quality improvements. HDOH and watershed stakeholders develop watershed-based plans under the state's nonpoint source pollution (NPS) program; these plans include a projected level of pollutant reduction for the proposed project.

There are various models that can be used to calculate the pollutant reductions associated with BMP implementation. HDOH researched the advantages and disadvantages of each model, including the ease of use for watershed project managers and evaluating the model's appropriateness for use in Hawaii. After reviewing several models, HDOH selected the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model.

Description of the InVEST Model

InVEST is a suite of models focused on ecosystems and how they connect to downstream economics. This addendum is focused on the sediment delivery ratio model in the InVEST suite. The InVEST sediment delivery ratio model was chosen by HDOH because it is easy to use and its ability to estimate sediment loading both with current condition and with BMPs implemented. Additionally, the InVEST model can be modified to accommodate the unique geologic conditions in Hawaii.

The InVEST sediment delivery ratio model is focused on sediment loading and erosion. The model outputs a set of maps showing the sediment erosion, including the amount of sediment soil loss per pixel, and the amount of erosion that is prevented by the presence of vegetation per pixel. The effect of BMPs on sediment erosion can be measured by comparing model outputs ran under the current conditions against model outputs ran with BMPs implemented. To calculate the annual soil loss per pixel, the InVEST model uses the Revised Universal Soil Loss Equation (RUSLE; Renard et al., 1997). Along with the factors that are in the RUSLE equation (rainfall erosivity, soil erodibility, slope length gradient, cover management, and support practice), this addendum recommends including an additional terrain factor to accommodate for the geology of Hawaii. The inclusion of the terrain factor prevents the model from overestimating the soil loss in places with geologically new basaltic bedrock which has minimal soil cover (Falinski, 2016). The required data inputs for this model are integrated into the RUSLE equation. To determine the effects of BMPs on sediment load reduction and erosion, the model should be run with altered data inputs.

The required data inputs include GIS data, a table, and five additional values. These five inputs are described in detail in the Step-by-Step Procedure below. To measure the reduction in sediment load and erosion with BMP implementation, these inputs can be changed to integrate the increase in vegetation that would come along with BMP implementation. The Step-by-Step Procedure section of this addendum describes each of these required inputs in further detail along with recommended values and sources for GIS data inputs.

Step-by-Step Procedure

The step-by-step procedure begins with collecting and creating the proper data inputs for the current conditions in the watershed and running the InVEST model with those data inputs. After the first model run, the next step is to use multiple lines of evidence, including model outputs and other information, to determine the most appropriate areas in the watershed to implement BMPs. Next, the model should be run again with inputs that incorporate the impacts that BMPs would have on the land cover or support practices. The reduction in pollutant loading is the difference between the two model output runs. The steps to compile each data input and descriptions of each required data input are shown in Table 2. All GIS inputs must be the same coordinate reference system. The coordinate reference system must be projected and in linear units of meters.

Table 2. Required Data Inputs for the Invest Model

GIS Data Inputs		
Input Name and Description	**Data Type**	**Suggested Sources**
Digital Elevation Model: A digital elevation map (DEM) showing elevation in meters. The map should be clipped beyond the watershed boundary.	Raster	The 3D Elevation Program (3DEP) from USGS.[4] The best available resolution for the state is 1/3 arc-second.
		The Hawaii Statewide GIS Program's Digital Terrain Model.[5] Data is only available for portions of the state and as a JPEG or PNG, so it must be converted to a raster format. The resolution is 1 meter, and the elevation values are in meters.
Erosivity: A map of rainfall erosivity in units of MJ • mm/(h • ha • year). The map should illustrate both intensity and duration of rainfall.	Raster	For the island of Hawaii, NOAA's digitized version of the rainfall erosivity map from the Agriculture Handbook No. 703.[6] The units are US customary units, so the units must be converted by multiplying each value by 17.02 (Renard, et al., 1997).
		For the island of Oahu, NOAA's digitized version of the rainfall erosivity map from the Agriculture Handbook No. 703.[7] The units are US customary units, so the units must be converted by multiplying each value by 17.02 (Renard, et al., 1997).
		The rainfall erosivity map on page 57 of the Agriculture Handbook No. 703. This map must be digitized into raster data by a GIS specialist and units must be converted to SI by multiplying each value by 17.02 (Renard, et al., 1997).
		A rainfall erosivity raster can be made using precipitation from the Hawaii Climate Data Portal.[8] Rainfall erosivity can be calculated using the Roose equation (Renard and Freimund, 1994): $R = 0.5 \times P \times 17.02$, where R is the rainfall erosivity value in the proper SI units and P is the annual rainfall in mm/year.
Soil Erodibility: A map showing the soil erodibility in the watershed. Soil erodibility, also called K factor, is the likelihood of soil particles to erode and be transported downstream by precipitation or runoff. The	Raster	Soil data, including K factors, is available from the Soil Survey Geographic Database (SSURGO).[9] This database provides raster data of soil type in an area of interest, and a table showing the K factor of each soil type. Raster data of K factors in a projected coordinate system will have to be generated by combining the soil raster data and the K factor table.

4 https://apps.nationalmap.gov/downloader/
5 https://geoportal.hawaii.gov/datasets/HiStateGIS::hawaii-dtm-elevation/about
6 https://www.fisheries.noaa.gov/inport/item/48225
7 https://www.fisheries.noaa.gov/inport/item/48230
8 https://www.hawaii.edu/climate-data-portal/data-portal/
9 https://www.nrcs.usda.gov/resources/data-and-reports/soil-survey-geographic-database-ssurgo

soil erodibility raster must be in units of t · h · ha / (ha · MJ · mm).		
Land Use/Land Cover: A map showing the land use and land cover within the watershed. The C-CAP raster described below must also be combined with geology data. Each pixel should be categorized by its land use/land cover and geologic origin from the geology dataset. Every combination of land use/land cover and geologic origin should be assigned a unique LULC code.	Raster	NOAA has C-CAP high resolution land cover raster data available for the entire state of Hawaii from 2021.[10] NOAA's land cover data has a resolution of 1-meter and includes up to 25 classifications including forests and urban development.
		Geology data for the state of Hawaii is available for download from USGS.[11] This data is available as shapefiles, so it must be converted to raster data.
Watersheds: A map of the boundary of the watershed.	Vector (polygon/ multipolygon)	The USGS Watershed Boundary Dataset has vector watershed delineation data available at different hydrologic unit levels for the entire state of Hawaii.[12]
		The Hawaii Statewide GIS Program has vector watershed delineation data available that was created by the Division of Aquatic Resources (DAR).[13]
		The InVEST suite includes the Delineatelt tool, used for generating watersheds based on user inputs. This tool outputs a GeoPackage containing a vector with the model's estimated watershed delineations. More information on this tool can be found in the Delineatelt section of the InVEST suite.[14]
		Watershed delineations can be generated using a USGS StreamStats's tool.[15] Delineations can be downloaded as vectors.
Other Required Data Inputs		
Input Name and Description	**Data type**	**Suggested Input Value**
Threshold Flow Accumulation: The minimum number of pixels that flow into another pixel for it to be classified as a stream.	Number of pixels	This value should be determined by the user via trial and error. Users should test different values until the streams on the output maps resemble the streams in the watershed.

[10] https://coast.noaa.gov/digitalcoast/data/
[11] https://pubs.usgs.gov/of/2007/1089/
[12] https://www.usgs.gov/national-hydrography/watershed-boundary-dataset
[13] https://geoportal.hawaii.gov/datasets/HiStateGIS::watersheds-dar-version/about
[14] https://storage.googleapis.com/releases.naturalcapitalproject.org/invest-userguide/latest/en/delineateit.html
[15] https://www.usgs.gov/streamstats

Borselli k Parameter: A calibration parameter in the sediment delivery ratio equation.	Number	This value is based on watershed location. Table 3 shows the Borselli k Parameter by location.
Maximum SDR Value: The maximum sediment delivery ratio a pixel is allowed to have.	Number between 0 and 1	For all watersheds in the state of Hawaii, the value should be 0.5 (Falinski, 2016).
Borselli IC_0 Parameter: A calibration parameter in the sediment delivery ratio equation.	Number	For all watersheds in the state of Hawaii, the value should be 0.1 (Falinski, 2016).
Maximum L Value: The maximum allowed slope value in the slope length-gradient factor.	Number	For all watershed in the state of Hawaii, the value should be 122 (Falinski, 2016).
Biophysical Table: A table mapping each LULC code to its cover-management factor (C) and support practice factor (P). One column should be named "lucode" and contain the LULC code from the land cover and land use raster. The other two columns should be named "usle_c" and "usle_p" and contain the associated C factor and P factor, respectively. The C factor indicates how much erosion is likely to occur at this land use/land cover type. The smaller the C factor value, the less erosion is expected to come from that type. To account for the terrain factor in the model run, the C factor in the biophysical table should be modified. The C factor for each LULC code should be the original C factor from Table 4 multiped by the terrain factor from Table 5 that is associated with the geologic origin under that LULC code. The P factor indicates whether erosion reduction practices are implemented in that area. A value of 1 means there are no erosion reduction practices implemented in that land cover/land use type and a smaller value indicates best management practices are implemented in that land cover/land use type.	.CSV file	Table 4 shows the C factors for land use/land covers in Hawaii, and Table 5 shows the terrain factor by geologic origin.
Workspace: The folder where outputs will be written.	Folder name	--

Table 3. Borselli k Parameter by Watershed Location (Falinski, 2016)

Watershed Location	Borselli k Parameter
Windward part of the island of Hawaii	4
Leeward part of the island of Hawaii	2.5
Oahu	2.5
Maui	2
Lanai	2
Molokai	1.25
Kahoolawe	2.4
Kauai	1.6
Niihau	1.5

Table 4. C Factor Values for Land Use/Land Cover (Falinski, 2016)

Land Use/Land Cover	C Factor	Land Use/Land Cover	C Factor
Evergreen	0.014[16]	Developed, Medium Intensity	0.01
Scrub Shrub	0.014[17]	Impervious Surface	0.001
Bare Land	0.7	Palustrine Scrub Shrub Wetland	0.003
Pasture/Hay	0.05	Palustrine Emergent Wetland	0.003
Grassland	0.05	Unconsolidated Shore	0.003
Open Water	0	Estuarine Forested Wetland	0.003
Cultivated Land	0.24[18]	Estuarine Scrub Shrub Wetland	0.003
Developed, Low Intensity	0.03	Estuarine Emergent Wetland	0.003
Palustrine Forested Wetland	0.003	Background	0
Open Space Developed	0.05	Palustrine Aquatic Bed	0

Table 5. Terrain Factor by Geologic Origin (Falinski, 2016)

Hawaii		**Oahu, Kauai and Niihau**	
Geologic origin	**Terrain factor**	**Geologic origin**	**Terrain factor**
Hamakua Volcanics	1	Honolulu Volcanics	1
Hawi Volcanics	1	Kolekole Volcanics	1
Hilina Basalt	0.001	Koolau Basalt	1
Hualalai Volcanics	0.001	Waianae Volcanics	1
Kahuku Basalt	0.001	Kiekie Volcanics	1
Kau Basalt	0.001	Koloa Volcanics	1
Laupahoehoe Volcanics	0.1	Paniau Basalt	0.1
Ninole Basalt	1	Waimea Canyon	0.1
Pololu Volcanics	1	--	--
Puna Basalt	0.001	--	--
Maui, Molokai, Lanai and Kahoolawe		**All Islands**	
Geologic Origin	**Terrain factor**	**Geologic origin**	**Terrain factor**
East Molokai Volcanics	1	Open water	1

[16] Evergreen forest: 0.035 for Hamakua and Kohala volcanoes
[17] Scrub/shrub: 0.05 for leeward volcanic units
[18] Cultivated land: 0.4 for pineapple (Lanai) or 0.51 for sugarcane crop (central Maui)

Hana Volcanics	0.001	Fill	1
Honolua Volcanics	1	Alluvium	1
Honomanu Basalt	1	Landslide Deposits	1
Kalaupapa Volcanics	1	Slope Deposits	0.001
Kanapou Volcanics	1	Tephra Deposits	0.1
Kaupo Mud Flow	1	Beach Deposits	0.1
Kula Volcanics	0.01	Lagoon Deposits	1
Lahaina Volcanics	1	Older Dune Deposits	1
Lanai Basalt	1	Younger Dune Deposits	0.1
Wailuku Volcanics	1	Talus and Colluvium	0.1
West Molokai Volcanics	1	Marine Conglomerate and Breccia	0.1
--	--	Caldera Wall Rocks	0.001

The most relevant output is the “sed_export.tif’, showing the sediment exported from every pixel. Because of the geology of Hawaii, data on the pixel level from this raster may be inaccurate. The model tends to predict higher sediment export from areas with steeper slopes. In Hawaii, high slopes occur in high elevation areas where the sediment supply may be naturally limited by the unique geology of Hawaii. Therefore, the model overestimates the amount of sediment export in the mountains because it assumes unlimited sediment supply in steep areas with thin or little soil. For this reason, the sediment export raster data should not be used as the sole or main method for determining where BMPs should be implemented within the watershed.

The sediment export raster can be combined with land use/land cover data to determine which land use classes are disproportionately contributing to sediment loading. The amount of sediment mass exported per acre for each land use can be calculated by adding up the value of every pixel in the sediment export raster in each land use and dividing that sum by the number of acres that the land use covers.

It is crucial that multiple lines of evidence are considered when determining where BMPs should be implemented. The normalized difference vegetation index (NDVI)[19] is a satellite-based measurement that could be useful in identifying areas with minimal vegetation which may be susceptible to increased erosion. The NDVI quantifies vegetative health and density. NDVI values closer to positive 1 indicate the presence of abundant and healthy vegetation, and a value closer to 0 indicates there is less vegetation (NASA, 2025). Looking at NDVI data in a raster format would allow a user to visualize areas within the watershed that have little vegetation or unhealthy vegetation, indicating that the area could benefit from BMP implementation. If the resolution of the NDVI data is a lower resolution, it may be difficult to pinpoint areas where BMP implementation would be the most valuable. Therefore, further evidence should be used when selecting areas for BMP implementation. A high resolution and recent satellite image can supplement older land use/land cover data and lower resolution NDVI raster data. A satellite image can be used to more accurately identify areas with minimal vegetative cover which could benefit most from BMP implementation. Further useful evidence can be collected on-site in the watershed. If possible, a person can walk along streams in the watershed and identify locations in the watershed where BMP implementation would be the most advantageous, such as locations with invasive plant species, minimal vegetation and/or the presence of feral ungulates. Each of the options listed above is important evidence that should be considered when the user is deciding on locations for BMP implementation.

[19] One potential source of NDVI data is NOAA’s Suomi National Polar-orbiting Partnership (Suomi NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) Vegetation Indices (VNP13A2) Version 2 data product which can be queried using the ‘modisfast’ R package.

After determining where BMPs will be implemented, the next step is to re-run the model with inputs that account for the BMPs that would be implemented to determine how they would affect sediment loading. The model inputs for the revised run should remain almost entirely the same. A different directory should be entered into the Workspace field or the results from the last model run will be overwritten. Additionally, either the support practice factors in the biophysical table or the land use/cover raster should be edited:

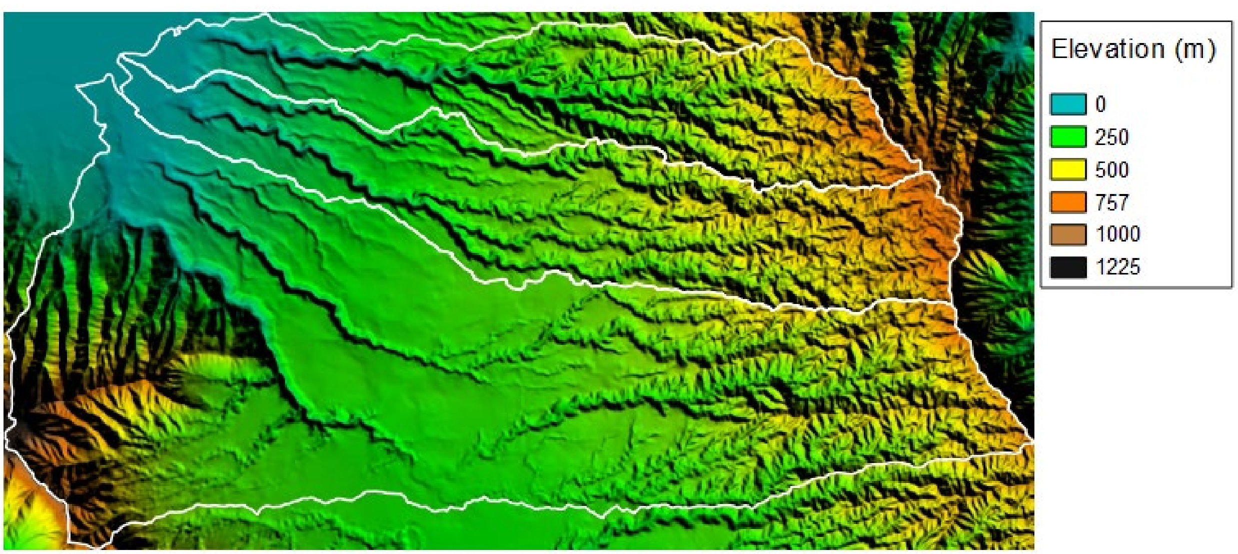
- The P factors in the biophysical table should be decreased for each land use/land cover type where an erosion reduction practice will be implemented.
- Alternatively, the land cover/land use raster should be edited to show how the land use/land cover would change with erosion reduction practices implemented. For example, bare land could be changed to a type of forest cover if a best management practice would be to plant native species on non-vegetated land.

To determine the effect that the implementation of best management practices would have on sediment exports, the outputs from both model runs can be compared. The sum across every pixel in "sed_export.tif" outputs illustrate how much sediment load reduction would occur with BMP implementation on the watershed level.

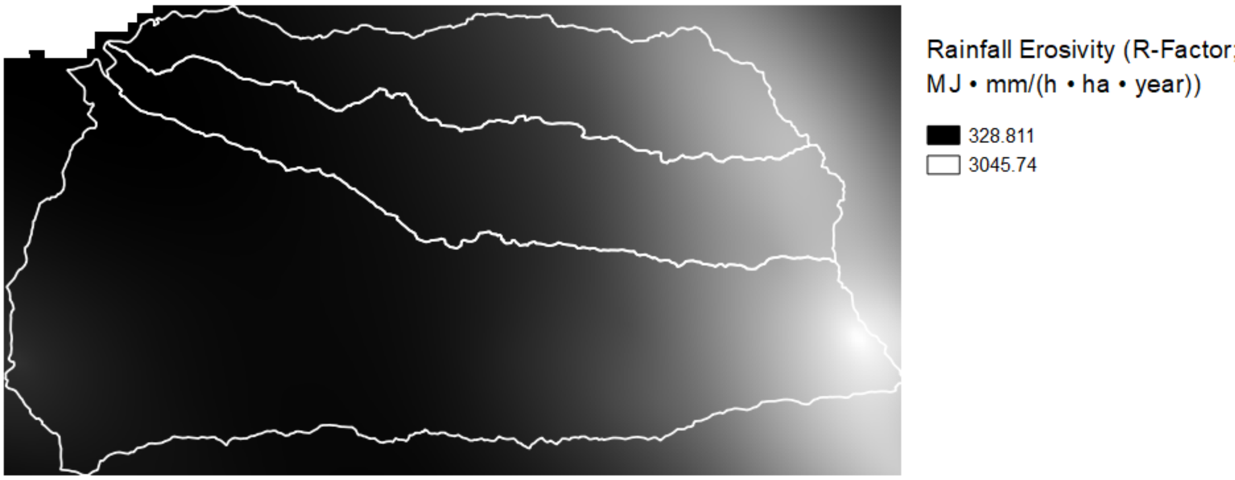
Example Use of the Procedure

To illustrate the Step-by-Step Procedure, this section looks at an example watershed: Kaiaka Bay. The Kaiaka Bay watershed is on the coast of the island of Oahu. The Kaiaka Bay and several streams that drain into the bay are listed as impaired. Both invasive plant species and feral ungulates are thought to cause high levels of erosion in this watershed, making the Kaiaka Bay watershed a good example watershed for the procedure (AECOM et al., 2018). The GIS data inputs for the InVEST model must all be in the same projected coordinate reference system, so every GIS data input is in the NAD83 coordinate reference system. The data inputs used for running the model with current conditions are below:

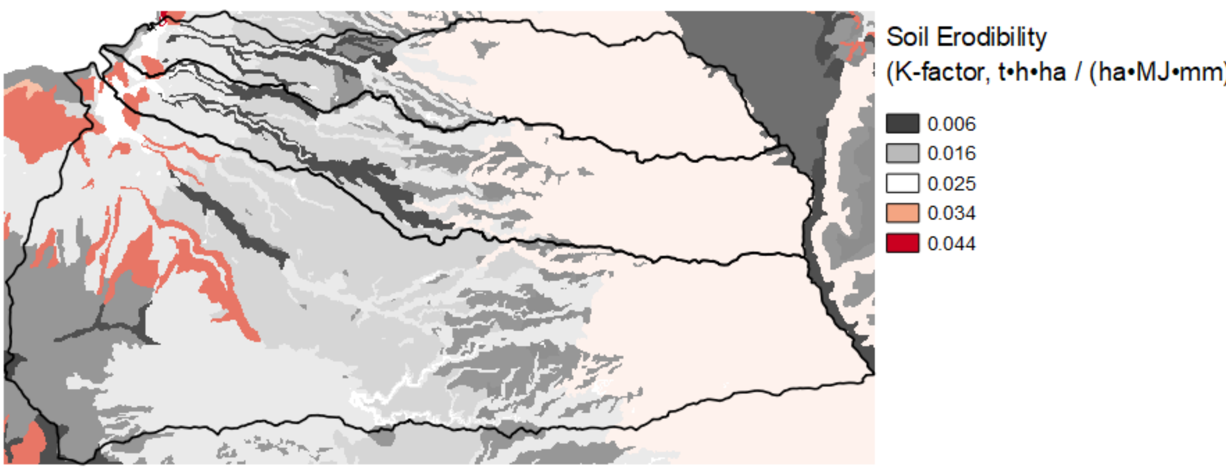
- Elevation Map: A DEM raster showing elevation in meters in the Kaiaka Bay and the surrounding area. This raster is a valid input for the InVEST model because the elevation is in meters and it extends beyond the Kaiaka Bay watershed boundary.



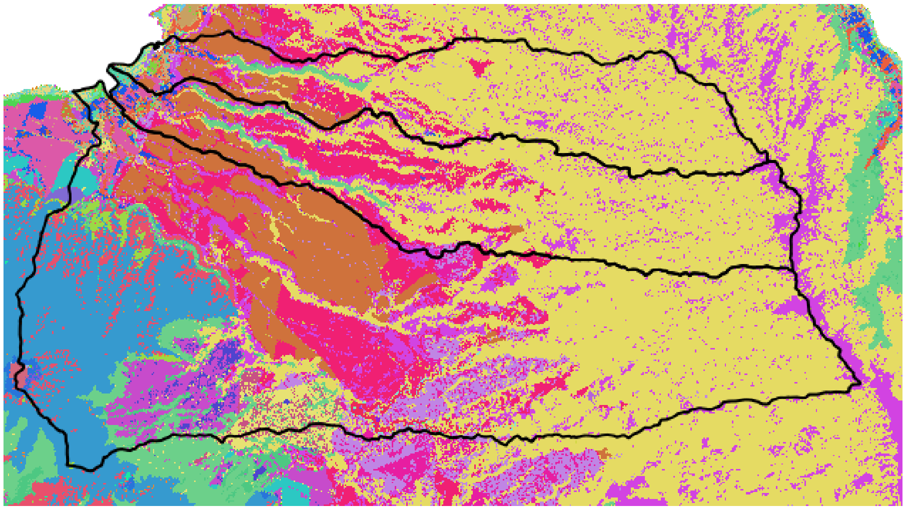
- Rainfall Erosivity: A rainfall erosivity map in raster format showing the rainfall erosivity throughout the Kaiaka Bay watershed in MJ • mm/(h • ha • year), the units required by the model.



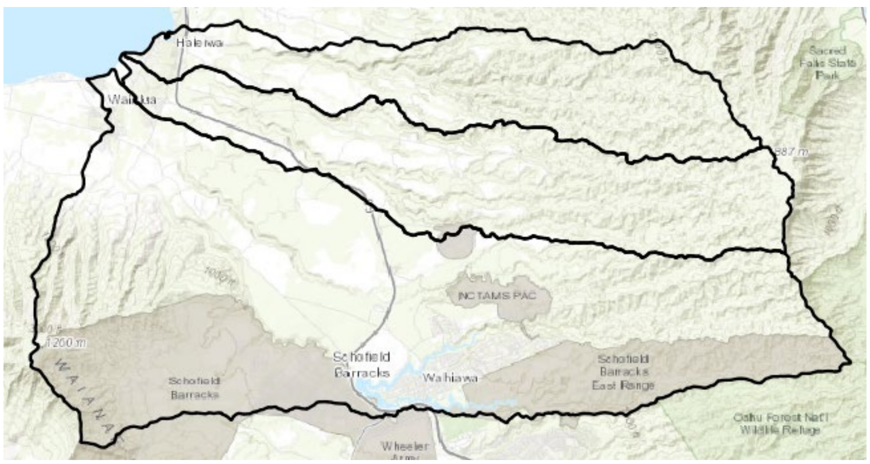
- Soil Erodibility: A map showing soil erodibility, or K factors, within the Kaiaka Bay watershed in raster format. The values in the raster format are in the proper units for the model, t • h • ha / (ha • MJ • mm).



- Land Use & Land Cover and Geologic Formation: A raster categorizing the land in Kaiaka Bay watershed by their land use/land cover and their geologic formation. This raster has over 1000 land cover/geologic formation categories, but not all categories have pixels that belong to them. Each land cover/geologic formation category has a unique LULC code so that this raster can be connected to the biophysical table.



- Watershed boundary: A vector outlining the Kaiaka Bay watershed.



- Threshold Flow Accumulation: 200. Value was derived through trial and error, and was identified when the delineated stream network approximately matched the "real" stream network for the watershed.

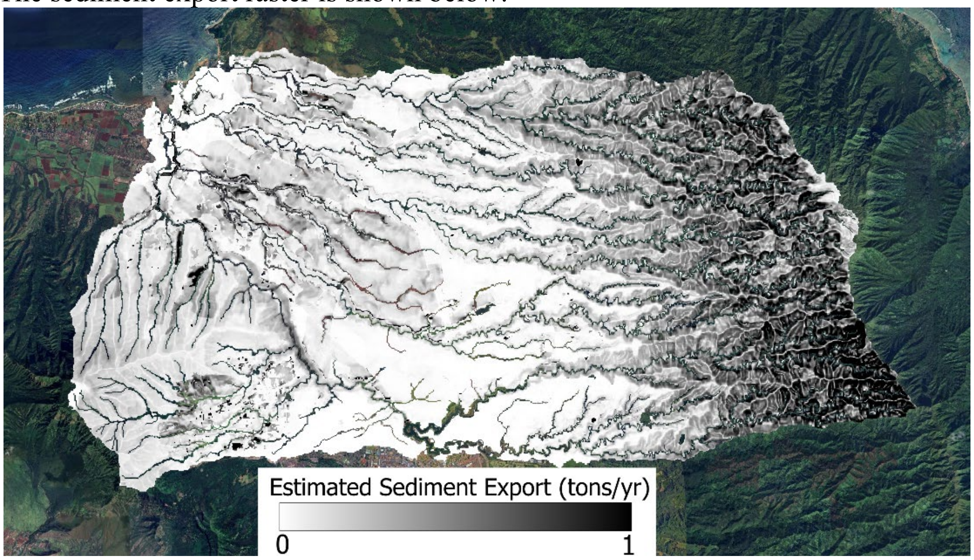
- Borselli k Parameter: The Borselli k parameter for this model run is 2.5, the value for all watersheds on Oahu.

- Maximum SDR Value: The maximum SDR value for this model run is 0.5, the value for all watersheds on the state of Hawaii.

- Maximum L Value: The maximum L value for this model run is 122, the value for all watersheds on the state of Hawaii.

- Biophysical Table: The biophysical table for this model run contains a column with each LULC code from the land use and land cover raster. Each LULC code is mapped to a modified C factor that is the original C factor from Table 4 multiplied by the terrain factor from Table 5 or the geologic origin associated with the LULC code. For example, a small piece of land in the Kaiaka Bay watershed is scrub shrub land (C factor = 0.014) with beach deposits as its geologic formation (terrain factor = 0.1), so the modified C factor in the biophysical table is 0.0014. The P factor for every LULC code is 1 because no support practices have been implemented in this watershed.

Once the inputs have been gathered, the baseline scenario is run. The model outputs suggest that a disproportionate amount of sediment export is occurring in the mountainous area of the Kaiaka Bay watershed. The sediment export raster is shown below:



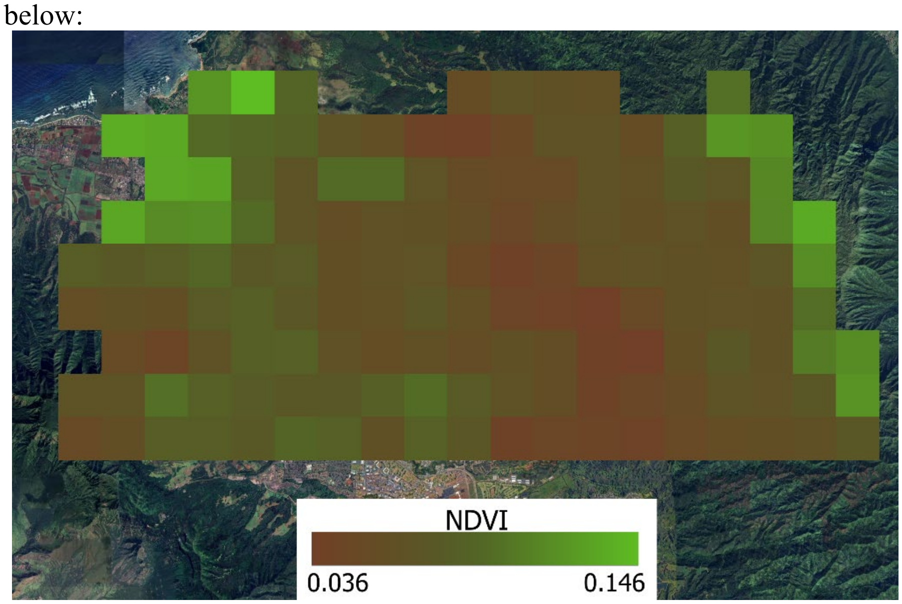
This raster indicates that the model expects the highest amount of sediment export to occur at the higher elevations of the watershed, but as discussed in the Step-by-Step Procedure section, the InVEST model tends to overestimate sediment export in high elevation areas. For this reason, multiple lines of evidence are considered when deciding on the locations for BMP implementation in this example. To determine the land class/land uses that contribute the most to sediment export relative to their area in the watershed, the pounds of sediment exported per acre is important evidence to evaluate as well. This value is calculated by adding the sediment export for every pixel in each land use/land cover and then dividing this sum by the acres each land use covers in the watershed. For example, bare land covers 405 acres of land in the Kaiaka Bay watershed and the model estimates that 1790.5 pounds of sediment are exported from bare land each year, so the pounds of sediment load per acre per year for bare land is 1790.5 divided by 405 which is 4.42. The sediment load per acre for each land use is shown in Table 6.

Table 6. Pounds of Sediment Load Per Acre Per Year by Land Use

Class	Edge of Stream Sediment Load (lbs/acre/year)
Developed, High Intensity	0.00
Developed, Med Intensity	0.00
Developed, Low Intensity	0.00
Developed, Open Space	0.11
Cultivated Crops	1.08
Pasture/Hay	0.26
Grassland/Herbaceous	0.44
Evergreen Forest	1.37
Scrub/Shrub	0.90

Class	Edge of Stream Sediment Load (lbs/acre/year)
Palustrine Emergent Wetland	0.01
Palustrine Forested Wetland	0.01
Palustrine Scrub/Shrub Wetland	0.01
Estuarine Forested Wetland	0.03
Estuarine Scrub/Shrub Wetland	0.23
Unconsolidated Shore	0.00
Bare Land	4.42
Open Water	0

This table indicates that bare land areas contribute the most sediment per acre in the Kaiaka Bay watershed, so bare land within the watershed may be a beneficial target for BMP implementation. Planting native plant species could minimize the sediment load coming from areas that are currently bare land by transforming it into vegetative cover (or evergreen forest in terms of land cover classes). Currently, bare land covers 405 acres of the watershed and the sediment export from this land is 1790.5 pounds. To calculate the amount of sediment load from this land after BMP implementation, assuming all the bare land becomes evergreen forest, the acres of bare land should be multiplied by the sediment load per acre for evergreen forest. This returns a value of 554.85 pounds of sediment load per year from this land, a 1235.65 pound decrease. These calculations should be considered when selecting locations for BMP implementation, but additional evidence should be evaluated as well. As discussed in the Step-by-Step Procedure section, NDVI data can be useful evidence as well. The NDVI data in raster format for the Kaiaka Bay is below:



The pixels with a lower NDVI index, which are shown in darker brown, are less vegetated areas. This image indicates that the middle section of the Kaiaka Bay watershed is less vegetated, so BMP implementation could be especially valuable in this area. However, the resolution of this raster data is low, so it is difficult to use it to precisely choose locations for BMP implementation. Therefore, other evidence such as high-resolution satellite images and drone footage can be used to pinpoint areas with minimal or invasive vegetation. As an additional line of evidence, people familiar with the Kaiaka Bay watershed can be interviewed to collect information on areas with minimal vegetation, invasive plants and/or feral ungulates. Furthermore, a person can walk along streams in the Kaiaka Bay watershed and document the most eroded areas. The information gathered from the InVEST model run, the NDVI index raster, satellite images, drone footage, interviews and documentation from someone on site should all be carefully considered when determining where BMPs should be implemented.

Useful Resources and Materials

To supplement the information included in this addendum, more information on the InVEST model and using this model in the state of Hawaii is linked below:

- More information on the InVEST sediment ratio delivery model including background information, required data inputs, and guidance on interpreting outputs is here: SDR: Sediment Delivery Ratio — InVEST® documentation
- More information on the InVEST DelineateIt tool discussed in the Step-by-Step Procedure to create watershed boundaries: DelineateIt — InVEST® documentation
- Further details on the Kaiaka Bay watershed: Kaiaka Bay Watersheds Characterization
- For more information on running the InVEST model for watersheds in Hawaii, including the rationale for many of the non-GIS inputs see Predicting Sediment Export into Tropical Coastal Ecosystems to Support Ridge to Reef Management [dissertation], available for download here: (PDF) PREDICTING SEDIMENT EXPORT INTO TROPICAL COASTAL ECOSYSTEMS TO SUPPORT RIDGE TO REEF MANAGEMENT

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United States Geological Survey (USGS). 2025. 1/3rd arc-second Digital Elevation Models (DEMs) - USGS National Map 3DEP Downloadable Data Collection. https://data.usgs.gov/datacatalog/data/USGS:3a81321b-c153-416f-98b7-cc8e5f0e17c3