DEPARTMENT OF TRANSPORTATION
STATE OF HAWAII

Prepared By

OCEANIC INSTITUTE

FINAL

ENVIRONMENTAL STATEMENT

ADMINISTRATIVE ACTION

for

IMPROVEMENTS AT ALA WAI BOAT HARBOR

PHASE I - JOB H. C. 2004

THIS STATEMENT FOR IMPROVEMENT WAS DEVELOPED IN CONSULTATION WITH THE STATE OFFICE OF ENVIRONMENTAL QUALITY CONTROL AND IS SUBMITTED PURSUANT TO:

SECTION 1(b)
EXECUTIVE ORDER
August 23, 1971

Dec 4, 1972 — Melvin E. Lepine

Date — MELVIN E. LEPINE
Chief, Harbors Division

CLEARED BY STATE DOT FOR CIRCULATION AND COMMENTS

12/4/72 — for E. Alvey Wright

Date — FUJIO MATSUDA, Director

THE ENVIRONMENTAL IMPACTS OF THE PROPOSED CONSTRUCTION (PHASE I) FOR THE ALA WAI BOAT HARBOR

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I. INTRODUCTION

1. Background information

The Ala Wai Boat Harbor is located on the south shore of Oahu between Waikiki Beach and the Ala Moana Park. It is partially surrounded on the mauka side by various resort and commercial establishments, the most prominent of which are the Ilikai Hotel and the Kaiser Hospital. A small man-made lagoon belonging to the State of Hawaii lies immediately to the east of the harbor (See Figure 1).

The Ala Wai Canal opens into the northwest corner of the harbor discharging waters collected from the Manoa and Palolo valleys. The canal was constructed in 1923 to protect Waikiki Beach from storm water originating in the Manoa and Palolo valleys as part of the Waikiki Reclamation Project. These collected storm waters were originally discharged at Kewalo Basin, but were diverted to their current location during the construction of the Ala Wai Boat Harbor. The origins of the water in the canal include two major streams, several storm sewers and tributary waters from both residential and industrial areas. The tributary drainage districts of the Manoa and Palolo Streams are primarily residential in character although some commercial and light manufacturing activities exist. It has been estimated that a volume of several million gallons is passed into the boat harbor daily (Cox and Gordon, 1970). The pollutional effects of the Ala Wai Canal on the Waikiki Beach area were recognized in the report "Honolulu Sewage Disposal Survey" (May 1940 to September 1941) by the Territory's Bureau of Sanitation.

The Ala Wai Boat Harbor was originally constructed from a barge channel built by the U.S. Armed Forces in the early 1900's, which provided Fort DeRussy with direct transport of goods from the sea. This channel was later filled in and connection made between the Canal and Harbor. The Harbor has expanded in increments since then, with constructional dredging providing fill for the Ala Moana Shopping Center and for the establishment of Magic Island. With the formation of Magic Island and the construction of a breakwater at the southernmost end of the harbor, current patterns were intensified and affected the "Ala Moana Bowl", a highly prized area for surfing.

2. Statement of the problem

In 1967, the U.S. Army Corps of Engineers recommended that the Ala Wai Boat Harbor again be expanded and improved to meet with the increasing demands for docking and mooring facilities by a growing population of boat owners. The original plans issued by the Corps included a seaward expansion

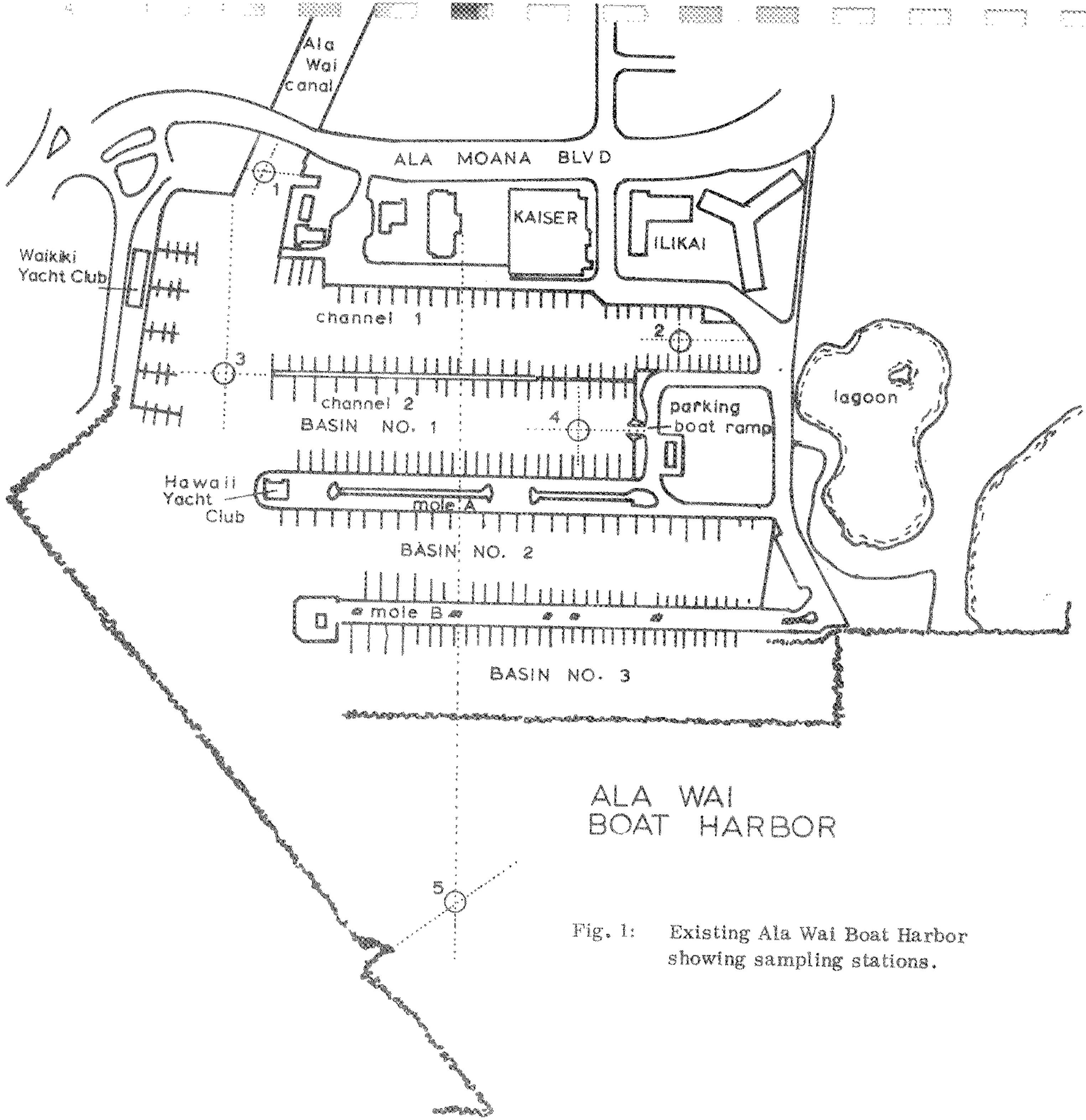


Fig. 1: Existing Ala Wai Boat Harbor showing sampling stations.

of the harbor which would have eliminated surfing from this area. In recognition of this, the Legislature of the State of Hawaii formulated and approved Act 217 authorizing the preparation of a master plan for improvements within the harbor which would not interfere with surfing activities. Such a plan was submitted to the Department of Transportation by Donald Wolbrink and Associates, Inc. in 1969.

Due to cost considerations, this plan has presently been highly modified and separated into individual construction phases. Phase One of these facility improvements involves the removal of the stationary T-pier and many of the fixed docking areas presently available within Basin One of the boat harbor. These are to be replaced by floating concrete docks supported by styrofoam cores and located to make better use of the existing water space within this basin. The present facilities are shown in Figure 1 with the proposed modifications displayed in Figure 2.

The Environmental Quality Act of 1970, Act 132, 1970 Legislature, State of Hawaii and the Governor's Executive Order, dated August 23, 1971, made necessary the formulation of environmental impact evaluation statements for any proposed projects which utilize state land or funds. It is believed that the State's contention is for the progress of economic development to be in accord with the protection, preservation, and enhancement of the intrinsic environmental qualities of the Islands by the preparation of these documents. The environmental impact statement presented here is intended to meet with these requirements and concerns in the construction of the new facilities at the Ala Wai Boat Harbor.

The studies conducted during the formulation of the statement attempt to assess the impact of the proposed action upon the biological, social and economic environments likely to be affected. It should be pointed out that a full environmental evaluation of this sort requires long term study, at least to a point where variations in biological parameters can be monitored and assessed with annual changes. Due to both budgetary and time restrictions imposed by the requirements of the Harbors Division, this study is based upon sampling and observations conducted during portions of July and August, 1972.

On the basis of this study and the information obtained, as well as through communications with authorities familiar with this environment, attempts are made to point out adverse consequences likely to occur if this construction is carried to completion. From this evaluation, various recommendations and schemes for alternatives which may better serve both environmental and economic concerns are presented. Also considered are differences between effects of short and long term consequences for both good and bad characteristics which may arise from this project, since all are of necessity in an overall evaluation.

Finally, we have listed those biological, physical, social and economic resources which will be, or have already been, permanently consumed by this operation.

3. Procedures and methods

In selecting both the sampling schedule and the station locations, consideration was given towards evaluation of the individual sources of potential environmental inputs which influence the ecological relationships within the harbor. Figure 1 shows the sampling site locations.

Station 1, located at the intersect of visual transects extending from the mid-point of the Ala Moana Bridge and from the mauka side of the channel boat launching ramp, provides for an evaluation of materials entering the harbor through the canal during outgoing tides and demonstrates the extent of tidal flushing.

Stations 2 and 4 are both within the backwaters of their respective channels and are separated by the T-pier. A preliminary study conducted by Donald Wolbrink and Associates, Inc. indicated these areas as debris collecting sites and probably experience minimal mixing with canal waters. Evaluation of these stations with the changing tides in conjunction with Station 3 near the end of T-pier allows for approximate judgments to be made concerning the contributions made by sources within Basin 1 which effect water quality.

Sampling times were chosen on the basis of tidal flow characteristics and are listed in Table 1. A study by Gonzales in 1971 has shown that tidal patterns within the Ala Wai Harbor do not differ from those for the Honolulu Harbor. During both incoming and outgoing tidal periods, sampling were collected while the rate of current flow was reasonably constant. This was done to avoid the collection of uncomparable data.

Table 1. Characteristics of Scheduled Sampling Periods in Ala Wai Boat Harbor

Sampling Period	Date	Time	Tidal Characteristics
1	7/10/72	1030-1430	Incoming tide, flow in linear phase
2	7/17/72	1500-1900	Tides at zero flux, very little movement in or out of harbor
3	7/24/72	1000-1400	Incoming tide. Flow on linear phase
4	8/02/72	1200-1600	Outgoing tide, rate of flow approximately equals that of previous incoming tide

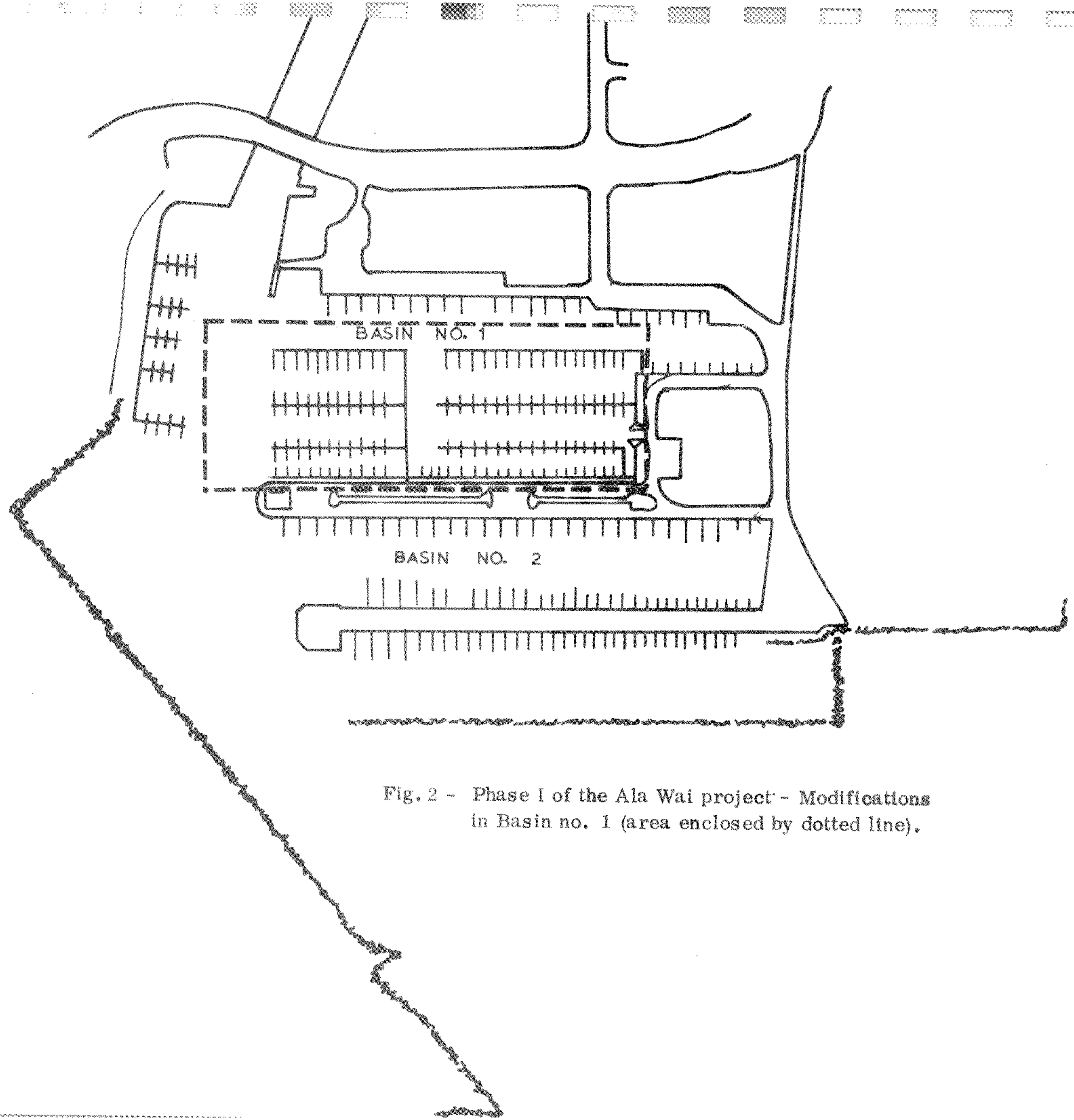


Fig. 2 - Phase I of the Ala Wai project - Modifications in Basin no. 1 (area enclosed by dotted line).

II. CAUSATIVE AGENTS AND SOURCES WITHIN THE ALA WAI BOAT HARBOR

There are four causative agents from which nutrients--particularly the elements nitrogen (N) and phosphorus (P)--can be derived to account for the extraordinarily high level of productivity which exists in Ala Wai Boat Harbor. These are fertilizers, sewage, detergents and rainfall.

Fertilizers applied to residential gardens or the Ala Wai Golf Course could be carried into the harbor via the canal. Domestic fertilizers usually have a N/P ratio between 6 and 10, depending upon the use for which they are intended.

Sewage in the harbor may arise from (a) septic tank leakage from the comfort station on the mole between the two basins; (b) direct discharges from vessels within the harbor; (c) discharges into the Ala Wai Canal which are carried into the harbor; and (d) an outfall which exists outside the harbor. Untreated sewage waters at an outfall can have a nitrite plus nitrate-N/Total P ratio of about 0.4.

Domestic detergents used for washing dishes, laundry, or the boats themselves are prime sources of phosphate (PO_4). The remaining source of nutrients is through storm drain run-offs which empty directly into the harbor. Although not anticipated to be a major source the extent to which this contributes to the problem cannot be realized without direct measurement following heavy rainfall.

All these agents entering the harbor are then dispensed and circulated by the movements of the tides and by the current patterns existing within the harbor itself.

1. Current movements

Water movements in the harbor have been analyzed from current meter readings and salinity and temperature data collected during portions of July and August 1972. This period was not characteristic of "normal" conditions. There was no rainfall and the days were typified by cloudless skies and gentle trade winds. The surf never exceeded 2-3 feet during the times of measurement.

As many measurements were made as time would allow. The final total is small, however, and the precision of the following generalized current patterns is minimal.

All generalized current patterns are supported by temperature and salinity data with the exception of the two- and three-meter depth determinations at Station 1. No explanation can be offered for this. Since the directions indicated by the current meter conflict with both temperature-salinity data and general physical laws at this station, more analytical emphasis has been placed upon the information received from the remaining stations.

The following current patterns are envisaged: during the rising tide, the incoming water (after passing Station 5) is apparently deflected by the Magic Island jetty wall along the west side of the harbor towards Station 4 in Basin 1. This deflected flow across the line of water discharged from the canal creates a counterclockwise vortex between the end of the T-pier and the mouth of the canal.

The effects of this vortex on water movement in the harbor are influenced by the strength of the tide and the volume of run-off from the canal. In general, the vortex should effect continuous circulation through Basin 1. Inflowing surface seawater builds up near the reaches of the mole adjacent to the boat launching ramp and breaks in two directions: the larger volume appears to be forced below the surface to 4 m depth and to again divide, moving out of the Basin or beneath the T-pier toward Station 2. The subsurface water leaving Basin 1 together with the water discharged by the canal meet and mix around Station 3 at depths greater than 2 meters and together move back out to sea beneath the incoming tide. At Station 5, the outflowing current was observed at depths of 5 m and more.

On a falling tide, the surface water from the canal flows apparently unhindered out past Station 5. However, the vortex circulating through Basin 1 draws some surface canal water towards the inner reaches at Station 4. Directional movement is then beneath the T-pier towards Station 2 as on a rising tide, but this time the water remains on the surface and is then pulled back into the main outflow or recirculates.

In summary, the data indicate that at times there could be an outflow of water regardless of the state of the tide. The particular records showed a subsurface outflow for a period on a rising tide and a surface outflow for a period on a falling tide. The pattern of this movement is not fully understood but is suggested to be result of the vortices present in the harbor. Salinity and temperature data for the water conditions at Station 1 are predominantly characteristic of water in the canal suggesting that most of the mixing occurs within the harbor itself. Surface water properties at each of the remaining four sampling stations show that the waters from the canal follow the main outflow pattern and discharge across the surface during a falling tide and give support to the observation of a subsurface movement for a period on the rising tide.

2. Data interpretation

The $\bar{N}/\bar{P}$ ratio, the average concentrations of nitrogen and phosphorus, expressed by weights, can be used to indicate the uniformity of nutrient sources between the various sampling stations, particularly if analyzed in conjunction with the N-P correlation coefficient. For example, if the same nutrient source were contributing to the nutrient concentrations at two different stations, both the correlation coefficients and the nutrient ratios would be similar. Obviously, differential rates of nutrient uptake by organisms (among other factors) influence this ratio. The proportion of organic to inorganic nitrogen can also influence this ratio, although the magnitude of this effect is considered negligible. Therefore, a strict analysis of this sort assumes all factors to be equal. Productivity measurements provide a basis upon which this assumption can be tested.

The correlation of N and P levels with bacterial concentrations can be used to establish sewage as a polluting agent. If the data can then be unidirectionally correlated with salinity, the proportionate contributions of the harbor and canal to the sewage inputs can be judged. High correlation coefficients of P to N at each sampling site are inferred to mean that there exists one primary input source of these nutrients within the vicinity; intermediate values that more than one source is contributing at such a location; and coefficients near zero that a totally independent discharge of each component exists. This correlation is subject to the assumption that nitrate-nitrogen constantly represents the only significant source of nitrogen within the waters.

The proximity of the source of nutrients to the sampling point is reflected in the $S_{\bar{x}}^2/\bar{x}$ ratio, with large ratios indicating a nearby source. Influences of localized mixing at the point of discharge followed by the diffusion and the dilution of effluent as it passes through the system tend to make the waters more homogeneous in composition as distance from the source increases.

Correlation of either or both nutrients with level of salinity is inferred as an indication of origins within the harbor as opposed to the canal. A negative correlation coefficient infers an inverse relationship between components being compared; for example, an increase in salinity having an associated decrease in the concentration of N and/or P.

3. Data

3.1 Station 1

The concentrations of Total phosphorus (P) and nitrate nitrogen (N) are higher than ther permitted limits for Class B waters. The criteria used for establishing the sources of these components have been explained above.

Nutrient data and analyses are as follows:

(a) Mean concentration of nutrients during tidal periods, and variance to mean ratios as related to depth:

	Total $\bar{N}/\bar{P}$	Total $S_x^2/\bar{x}_p$	Total $S_x^2/\bar{x}$	Outgoing $\mu g\ \bar{P}/l$	Outgoing $\mu g\ \bar{N}/l$	Incoming $\mu g\ \bar{P}/l$	Incoming $\mu g\ \bar{N}/l$
Surface	3.67	5.57	59.54	52.313	206.311	38.688	127.491
2 m	.775	2.48	4.28	15.113	12.698	15.965	11.481
Bottom	.278	2.49	1.609	22.088	7.322	32.380	7.609
N-Total P correlation (Falling Tide)	.738						

The data shows a high correlation of P with N, indicating that a single primary source of these nutrients is present. The source of nitrogen would appear to be closely associated with the proximity of the station since a high $S_x^2/\bar{x}$ ratio for nitrate-nitrogen exists. This relationship is not apparent for total phosphorus concentrations.

High negative correlations exist for nitrate nitrogen and total phosphorus with salinity (S), as shown below related to tidal rise and fall.

(b) Nutrient and bacterial correlations with salinity as related to tide:

	NO_3-S°/oo	P-S°/oo	Fecal-S°/oo	Total coliform-S°/oo
Falling tide	-.600	-.886	-.800	-.543
Rising tide	-1.00	+.500	-.875	-.875

Total P would appear to originate at this station from the canal waters as approximately 90% of its concentration can be explained on the basis of its association with lower salinity waters. Nitrate-nitrogen, however, may likely have some additional sources within the vicinity of Station 1. Only 60% of its concentration can be attributed to inputs from the canal. Possibly, some fertilizers used at the Ala Moana Park may enter the canal at this point, or some unknown agents may be deposited in the waters nearby from any of the buildings near the dry dock facilities.

The high $S_x^2/\bar{x}p$ ratio could be explained by a localized discharge of detergents. For example, the major source might be within Basin 1 and therefore the ratio would be expected to increase significantly with incoming tides. The data indicate that such an occurrence is likely.

There is a strong negative correlation of both fecal and total coliforms with salinity. The concentrations of the bacteria do not meet the standards for Class A waters in the State.

(c) Fecal and total coliform concentrations related to tide and depth (number/100 ml):

	Fecal Coliforms				Total Coliforms			
	x_m Rise	x_m Fall	$S_x^2/\bar{x}$	D max	$\bar{x}_m$ Rise	$\bar{x}_m$ Fall	$S_x^2/\bar{x}$	D max
Surface	223	365	182.08	446	1430	1820	973.81	2505
2 m	38	54	31.93	71	498	670	219.29	691
Bottom	50	30	30.25	63	280	365	63.92	411
Sediments	470	75	728.43*	614	985	1845	993.46	2287

* significant

Together with the correlation results for nitrate and total phosphate, the data analysis infers that the major causative agents at Station 1 for the high concentrations are untreated sewage and detergents and that sources are discharged into the canal and harbor.

3.2 Station 2

Located in the backwater of Channel 1 in Basin 1, Station 2 exhibits high concentrations of total phosphorus and moderate levels of coliform bacteria and nitrate. Although there exists a strong correlation of P with nitrate-N concentrations, it is not as pronounced as at Station 1.

The data also show that the ratios of nitrate-N to total P differ markedly from those at Station 1 and demonstrate a separate pattern. It may be deduced that this location recieves one or possibly two prime inputs from sources which differ in type from those affecting Station 1. The high concentrations of phosphates indicate that one of the causative agents is most probably detergents.

Nutrient data and analyses are as follows:

(a) Mean concentration of nutrients during tidal periods, and variance to mean ratios as related to depth:

	Total $\bar{N}/\bar{P}$	Total $S_x^2/\bar{x}_p$	Total $S_x^2/\bar{x}_n$	Outgoing $\mu g\ \bar{P}/l$	Outgoing $\mu g\ \bar{N}/l$	Incoming $\mu g\ \bar{P}/l$	Incoming $\mu g\ \bar{N}/l$
Surface	.645	65.67	9.637	54.638	29.253	82.925	59.465
2 m	.352	15.53	1.73	13.950	8.204	31.868	7.847
Bottom	.482	1.76	6.42	23.250	13.909	27.745	10.647
N-Total P correlation (Falling Tide)	.615						

An extremely high $S_x^2/\bar{x}$ ratio for phosphate concentrations in surface waters of Channel 1 further demonstrate the presence of nearby sources of phosphate; the low $S_x^2/\bar{x}$ ratio for nitrate infers a source removed from the immediate vicinity.

Both the concentrations of nitrate and phosphate are positively correlated with salinity, and indicate that both nutrients are either carried in by the flow of oceanic waters or discharged directly into the harbor itself.

(b) Nutrient and bacterial correlations with salinity as related to tide:

	NO_3-S°/oo	P-S°/oo	Fecal-S°/oo	Total coliform-S°/oo
Falling tide	+.486	+.314	+.086	+.429
Rising tide	-.500	+.500	-.875	-.750

It can be concluded from the data that the waters from the canal have little influence on conditions at Station 2.

It has already been demonstrated that the canal is not the major source of sewage material at Station 2. This is confirmed by high $S_x^2/\bar{x}$ ratios for both fecal and total coliform concentrations which indicate nearby origins. Furthermore, coliform concentrations are positively correlated with salinity during falling tides and indicate sources within the harbor.

(c) Fecal and total coliform concentrations related to tide and depth (number/100 ml):

	Fecal Coliform				Total Coliform			
	$\bar{x}_m$ Rise	$\bar{x}_m$ Fall	$S_x^2/\bar{x}$	D max	$\bar{x}_m$ Rise	$\bar{x}_m$ Fall	$S_x^2/\bar{x}$	D max
Surface	51	165	63.63	167	362	1455	973.81*	2505
2 m	24	46	22.76	56	355	460	219.29	691
Bottom	18	92	45.89*	128	306	470	63.92	411
Sediments	86	220	192.20	280	427	530	993.46	2287

* Significant

It is concluded that both nutrients and raw sewage are discharged in fairly large quantities from domestic sources, possibly from the boats or from surrounding buildings. The prime source of phosphate is probably domestic detergents. Because several drainage conduits enter the harbor within this area, delineation of specific sources can not be made from present data.

3.3. Station 3

No correlation can be found between the concentration of nitrate and phosphate at Station 3. This indicates that both originate from separate sources. Support for this indication is provided by the differences observed between the depth profiles of these two nutrients.

Nutrient data and analyses are as follows:

(a) Mean concentration of nutrients during tidal periods, and variance to mean ratios as related to depth:

	Total N/P	Total S_x^2/x_p	Total S_x^2/x_m	Outgoing µg P/l	Outgoing µg N/l	Incoming µg P/l	Incoming µg N/l
Surface	2.511	2.54	82.87	41.850	156.121	37.479	42.430
2 m	.495	8.61	10.36	13.950	10.031	33.992	13.643
Bottom	.162	43.06	4.107	22.088	5.684	70.107	9.261
N-Total P correlation (Falling Tide)	.089						

The concentration of nitrate is observed to decrease with depth, but phosphate levels reach their maximum in the bottom waters. A stratified water column effected by one source in the surface waters and another in the sub-surface layers is envisaged. This is further supported by current measurements and patterns (see Appendix I).

A certain amount of horizontal mixing occurs at depth. Current measurements indicate that little vertical mixing of the surface and sub-surface waters occurs, and that upper layers are almost entirely of canal origin. Although many lateral vortices undoubtly occur, none apparently has sufficient strength to draw up the basin waters below.

Additional indications from the data suggests that as tidal flows enter the Basin 1 area the surface water may fold under and sink so that surface nutrient concentrations at one station are similar to those in the bottom waters of the next. Current direction measurements show that such a movement can be expected during periods of incoming tides. For example, a flow pattern commencing at Station 4 and becoming increasingly more pronounced as the flow progresses from within the basin to Station 3 is indicated by the following data.

Station	Surface Concentration P, µg/l	Surface Concentration P, µg/l succeeding station	Bottom Water Concentration P, µg/l succeeding station
4	30.039	82.925	27.745
2	82.925	37.479	70.107
3	37.479	14.756	26.443

The increase in phosphates with depth is thus the result of the phosphate load within Channel 1. This load is responsible for the decrease in the correlation coefficient for phosphorus with salinity.

(b) Nutrient and bacterial correlations with salinity as related to tide:

	NO_3-S°/oo	P-S°/oo	Fecal-S°/oo	Total coliform-S°/oo
Falling tide	-1.000	-.600	-.257	-.543
Rising tide	-.500	.000	-.875	-.875

Approximately 40% of the total amount of phosphate observed at Station 3 is contributed by the waters from Basin 1.

Although large amounts of nitrate are discharged in the vacinity of Station 2 it is apparently an insignificiant load compared with those contributed by the canal. Nitrate concentrations decrease significantly with depth and show little of the relationships described for phosphorus. Virtually all the nitrate is attributable to its association with waters of reduced salinities. There is, however, a large $S_x^2/\bar{x}$ ratio for nitrates at Station 3. A subsurface conduit, draining the lagoon in the Ala Moana Park, enters the harbor near this Station and may be responsible for some of this load.

(c) Fecal and total coliform concentrations related to tide and depth (number/100ml):

	$\bar{x}_m$ Rise	$\bar{x}_m$ Fall	$S_x^2/\bar{x}$	D max	$\bar{x}_m$ Rise	$\bar{x}_m$ Fall	$S_x^2/\bar{x}$	D max
Surface	115	79	32.03	129	535	930	293.23	1086
2 m	64	62	29.52	90	448	245	105.40	505
Bottom	82	39	36.12	92	355	525	182.48*	468
Sediments	2500	108	3512.24*	2593	2500	2080	188.99*	3424

* Significant

The low correlation coefficient for bacteria with salinity indicate that there may be some local discharge of fecal and urinary wastes near to Station 3. This is not surprising as many of the boats near the end of T-pier are occupied by permanent residents who must travel approximately 400 yards to the nearest comfort station.

3.4. Station 4

Station 4 is apparently a most unique part of the harbor in terms of nutrient concentrations and effects.

Nutrient data and analyses are as follows:

(a) Mean concentration of nutrients during tidal periods, and variance to mean ratios as related to depth:

	Total $\bar{N}/\bar{P}$	Total $S_x^2/\bar{x}_p$	Total $S_x^2/\bar{x}_n$	Outgoing µg $\bar{P}$/l	Outgoing µg $\bar{N}$/l	Incoming µg $\bar{P}$/l	Incoming µg $\bar{N}$/l
Surface	.258	6.90	8.02	40.688	5.341	30.039	12.873
2 m	.485	6.40	6.75	12.788	8.225	28.195	11.669
Bottom	.418	14.08	11.06	8.138	5.852	41.711	14.770
N-Total P correlation (Falling Tide)	.292						

Although a large portion of the waters at Station 4 appear to flow directly towards Station 2, the concentration of nitrate nitrogen is five times less than that at Station 2. Furthermore the concentration is over three times less than that of the surface waters of Station 3 2hich precede and contribute to it. It appears that Channel 2 functions as a treatment pond for those nitrogenous components discharged or transported into it.

Phosphorus uptake is considerably less pronounced. On average a 21% decrease in the total amounts of phosphorus between the waters of Station 4 and Station 3 which precedes it is recorded. The range of 20-22% recorded at Station 4 for total phosphorus assimilation depends upon the depth at which the comparative data is recorded and assumes complete mixing of canal and harbor bottom waters at Station 3.

The overall effect of these low uptakes is to produce very uniform and extremely low $\bar{N}/\bar{P}$ and $S_x^2/\bar{x}$ ratios for both nutrients compared to all other stations.

The components themselves as recorded at Station 4 arise through inputs from Station 3. The influence of phosphate discharges within Channel 1 and with nitrate additions from the canal are still indicated by the correlations with salinity.

(b) Nutrient and bacterial correlations with salinity as related to tide:

	NO_3-S°/oo	P-S°/oo	Fecal-S°/oo	Total coliform-S°/oo
Falling tide	-.429	+.143	-.771	-.943
Rising tide	+.500	+.500	+.125	+.500

Bacterial discharges are strongly correlated with the salinities of the canal water.

(c) Fecal and total coliform concentrations related to tide and depth (number/100 ml):

	Fecal				Total Coliform			
	$\bar{x}_m$ Rise	$\bar{x}_m$ Fall	$S_x^2/\bar{x}$	D max	$\bar{x}_m$ Rise	$\bar{x}_m$ Fall	$S_x^2/\bar{x}$	D max
Surface	23	67	44.31	86	144	362	162.10	447
2 m	59	73	39.89*	109	500	850	587.40*	1180
Bottom	43	28	36.14	92	155	214	62.49	337
Sediments	120	10	211.90	155	975	1330	1280.35*	2006

* Significant

The levels of both fecal and total coliforms are slightly higher than Station 3, indicating that additional sewage material may be discharged in relatively small amounts near this sampling site. The high $S^2_{\bar{x}}/\bar{x}$ ratios for bacterial densities support this indication.

It is concluded that the majority of inputs into Channel 2 are contributed by agents and sources which effected Station 3 and which proceed it in directional flow. A small amount of sewage is discharged from the boats or possibly from the comfort station along the mole.

Channel 2 is considered to be a treatment pond for the nutrient discharges which enter Basin 1. The apparent decrease in uptake of phosphate may be due to several factors, but most probably to the proportionate difference of nutrient assimilation arising from the metabolic processes of resident autotrophs. The ratio of nitrate/phosphate uptake is about 11:1, which is very similar to that known to occur under the laboratory culture conditions (16:1).

3.5. Station 5

The site of Station 5 was selected to act as a control station indicating the influence of:

1) The combined effects of all discharges within the harbor upon seaward locations during falling tides,

and 2) the capacity of rising tides to flush the enriching components out of the harbor and to indicate any additions to the harbor waters which might be contributed by sources outside the harbor entrance.

Through the discovery of a continuously outflowing current below the 5 m depth at this location, it is apparent that harbor and canal influences will constantly effect external populations. These influences will increase and diversify during periods when heavy rainfall increases the discharge rate and the composition of materials within the canal.

The present study was over a limited period of time and little rainfall was recorded. The data therefore can not be representative of other times of the year but rather an evaluation of conditions during a period of almost ideal weather.

The bottom water concentrations of nutrients at Station 5 are typical of sources within the harbor during rising tides and that mainstream surface concentrations are typical of seaward surface levels during falling tides.

Nutrient data and analyses are as follows:

(a) Mean concentration of nutrients during tidal periods, and variance to mean ratios as related to depth:

	Total $\bar{N}/\bar{P}$	Total $S_x^2/\bar{x}_p$	Total $S_x^2/\bar{x}_n$	Outgoing $\mu g\ \bar{P}/l$	Outgoing $\mu g\ \bar{N}/l$	Incoming $\mu g\ \bar{P}/l$	Incoming $\mu g\ \bar{N}/l$
Surface	3.140	3.46	90.53	10.463	9.527	14.756	66.808
2 m	2.439	11.03	25.48	2.325	9.366	13.098	28.252
Bottom	1.011	7.20	38.76	6.975	3.514	26.443	30.282
N-Total P correlation (Falling Tide)	.231						

During falling tides the concentration of phosphorus is reduced (x 4) at the surface of Station 5 relative to the corresponding value at Station 3. Nitrate concentrations also decrease (x 16.4). The ratio of the uptake of N/P is only 4.1:1, significantly lower than that in Channel 2. This indicates an additional downstream source of either nitrogen or phosphate; a highly significant reduction in production resulting in nutrient limitation, or other physiological stresses.

(b) Nutrient and bacterial correlations with salinity as related to tide:

	NO_3-S°/oo	P-S°/oo	Fecal-S°/oo	Total coliform-S°/oo
Falling tide	-1.000	+.086	-.371	+.429
Rising tide	- .500	+.625	-.750	+.125

The low $S_x^2/\bar{x}$ ratios found for phosphate concentrations tend to eliminate a phosphorus enriched discharge as the explanation. High $S_x^2/\bar{x}$ ratios occur at all depths for nitrogen concentrations, most pronounced at the surface indicating a localized input effecting all depths. However, correlation coefficients for nutrients with salinity demonstrate that all of the nitrate wastes arise from canal and harbor waters during falling tides. On rising tides only half of the total amount can be attributed to a low salinity source. The high $S_x^2/\bar{x}$ ratios for nitrogen together with a decrease in the correlation coefficients between tidal periods indicate a nearby source of nitrate wastes.

The N/P ratios at Station 5 are high and significantly different from preceding stations. This infers that there exists not only a nearby causative source, but one which differs in type from those from within the canal and harbor. During rising tides there is a significant increase in the concentration of nitrate at all depths. Although not as pronounced, a similar increase is found for phosphates. Concurrently there is a doubling of turbidity (see Appendix X). A secchi disc extinction coefficient of .335 was recorded at Station 5 during falling tides increasing to .620 on rising tides.

There are a significant number of coliform bacteria throughout the water column at all times.

(c) Fecal and total coliform concentrations related to tide and depth (number/100 ml):

	Fecal				Total Coliform			
	$\bar{x}_m$ Rise	$\bar{x}_m$ Fall	$S_x^2/\bar{x}$	D max	$\bar{x}_m$ Rise	$\bar{x}_m$ Fall	$S_x^2/\bar{x}$	D max
Surface	29	5	26.71	33	322	204	70.03	405
2 m	17	2	11.75	18	199	960	1351.15*	1277
Bottom	29	38	37.21	63	320	151	80.28	371
Sediments	564	50	929.26*	715	1645	865	892.14	1819

* Significant

Correlation coefficients of bacterial densities to salinities indicate that total coliform concentrations are more closely associated with sea water salinities than those of the canal regardless of the state of the tide. The opposite is suggested for fecal coliforms. The latter may or may not have the capacity to survive at length within waters of high salinity. Current research indicates that coliforms other than E. coli may have a better capacity for survival under such conditions.

The opposite correlations of both classes of bacteria to salinity are therefore indicative of their relative existence in surrounding coastal waters. Coliform bacteria might be deposited in the sediments during falling tides and resuspended on rising tides.

One conclusion is apparent from this data. During a rising tide a considerable amount of sediment resuspension must occur near the outer edge of the reef near Station 5. The sediments deposited during falling tides or periods of inactivity on the seaward side of the reef are carried up to the surface by the action of the rising tide. The source of the coliforms, nutrients, and particular matter at Station 5 appears to be the sediments deposited in this area and originating from within the canal and harbor or from Magic Island.

III. INFLUENCE OF CAUSATIVE AGENTS UPON PRODUCTIVITY

Productivity measurements provide indications of base food and energy levels available for all non photosynthetic organisms within the affected vicinity of the Harbor. Thus, any effects upon this base will have a direct effect upon the organismic trophic structure dependent upon the base for support. The general consideration for an entire food and energy level pre-empts specific organismic analyses. In highly enriched waters the complexity of the food web is reduced supporting the use of this approach. Through an understanding of the factors which affect the rates of production within the harbor, statements regarding the general conditions of the harbor environment at any time can be made.

Among the environmental factors which influence basic productivity are light, concentrations of nutrients and dissolved gasses, temperature, and salinity. These factors have been analysed separately in order to establish the components which limited production at the time.

Productivity measurements were made at surface and 3 meter depths during regular sampling periods. Table 2 shows the various productivities measured during the first four sampling periods. During rising tides the general trend is toward greater basal production with the mainstream of flow through the harbor. The rates at Station 3 are slightly higher than those of Station 1, more than twice those for Station 5, and about 3 times those of Stations 2 and 4 in the back of Channel 1.

Table 2: Average Productivies During Tidal Periods

Station	Depth	mg $C/m^3/hr$ Productivity Rising Tide	mg $C/m^3/hr$ Productivity Falling Tide
1	Surface	207.25	163.15
	3 m	14.18	9.95
2	Surface	69.06	522.87
	3 m	8.71	23.66
3	Surface	225.26	95.09
	3 m	17.55	5.31
4	Surface	79.38	255.09
	3 m	27.08	23.57
5	Surface	101.88	76.34
	3 m	52.14	38.996

During falling tides the order is reversed. Back channel stations have greater productivities than those in the mainstream and Station 2 shows values comparable to the highest found by Harris (1972) for the most eutrophic regions of the canal. The mainstream stations (1, 3, and 5) have surface values ranging from 3.2 to 5.6 times lower than Station 2. The ranked order of the mainstream levels is similar to that during the rising tide.

1. Temperature and Salinity

Variations in temperature and salinity, the vertical profiles of which are shown in Figures 3 through 5, do not account for the observed differences in production. Further, the ranked station sequence for productivities bears little resemblance of these two parameters. Salinities range from 28.06 to 34.89, depending upon depth and distance from the canal, and temperature varies only by 1.5°C vertically and by 1.0°C between stations. In order for temperature to be responsible for the productivity rate variations, a 15-25 °C difference between surface stations would have to exist. The salinity data used for the figures were obtained from laboratory determinations by a Bissett-Berman precision salinometer.

2. Dissolved Oxygen

Levels of dissolved oxygen were frequently above saturation values during equilibrium periods and falling tides, reaching a maximum value of 146% saturation on the equilibrium tide of July 17 at Station 3 (Appendix X). Natural diffusion of oxygen from the atmosphere at the air/water interface cannot account for these high values, but high productivities which exist in the harbor undoubtedly result in these supersaturated conditions. The median saturation values for incoming and outgoing tides are shown in Table 3.

High natural productivity in the day can result in high oxygen demands during the night. Continuous oxygen profiles were therefore measured over a single day-night period for a full tidal cycle. The results are shown in Figure 6.

Oxygen concentration in surface, 2 meter, and bottom waters were found to mimic the tidal patterns at Stations 1, 2, 3, and 5. Although decreases in oxygen concentration were evident during rising tides, these losses were replenished during falling tides. The exchange of canal waters and their almost equivalent concentrations of oxygen are possibly responsible for this effect. However, it must be mentioned that the observed decreases in oxygen concentration were less than anticipated. It is also possible that a lower population density was present during this period of measurement. More data is necessary to fully evaluate this potential disturbance.

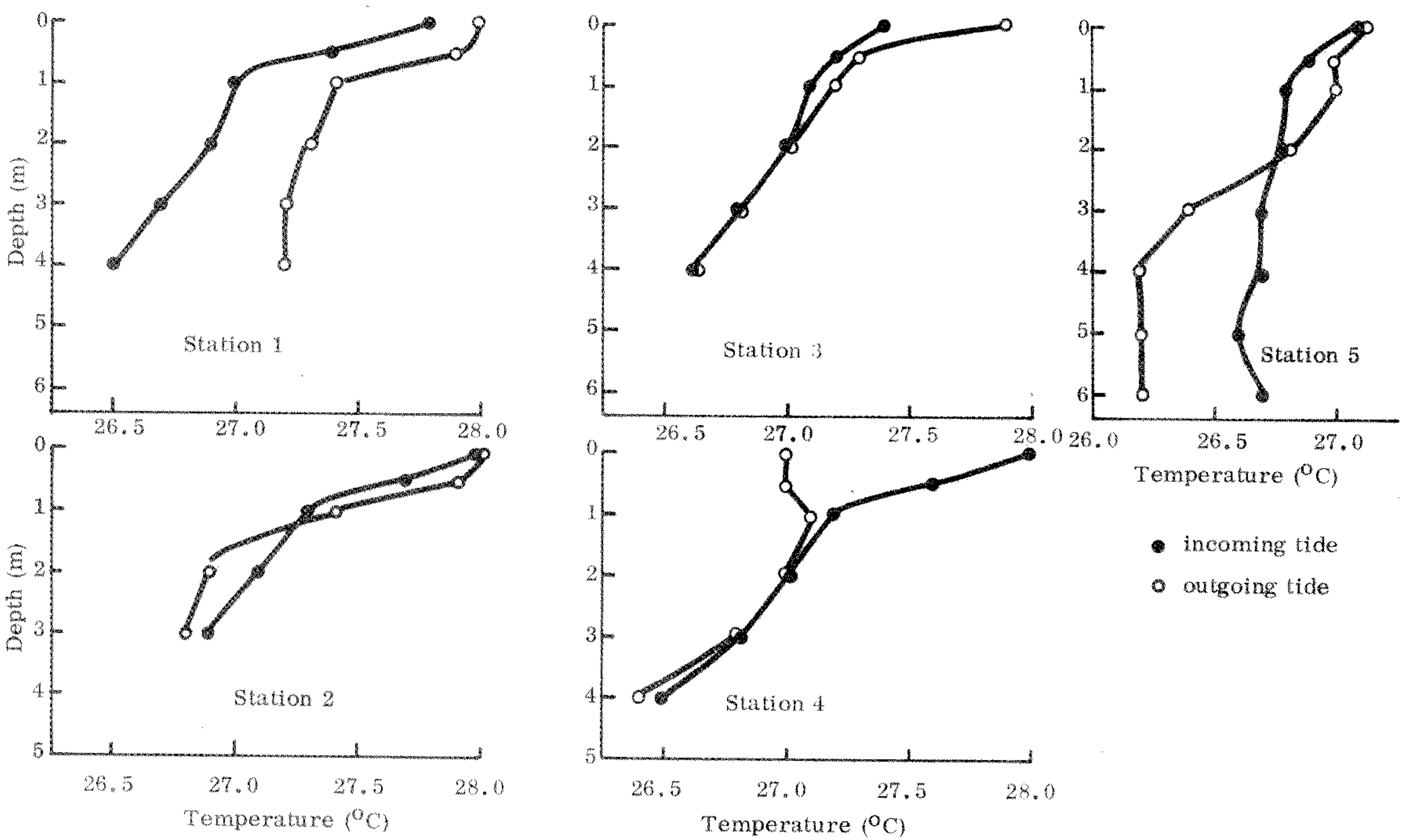


Figure 3 Temperature profiles at sampling stations in Ala Wai Boat Harbor, for incoming and outgoing tides.

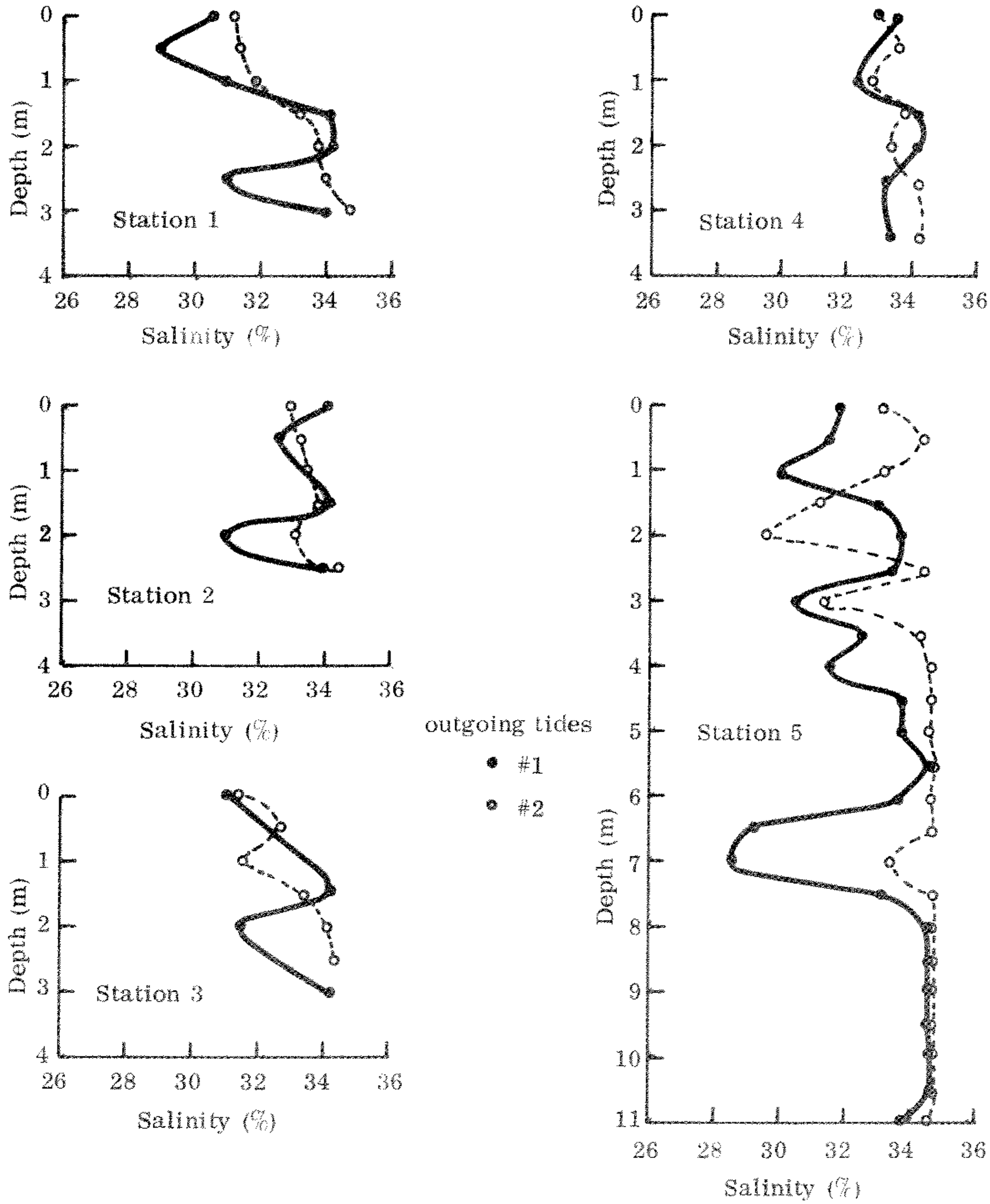


Figure 4 - Salinity Profiles within Ala Wai Boat Harbor with outgoing tides

Table 4: Concentrations of Dissolved CO_2 and its Relationships to Depth and Tides

Station	Depth	Dissolved CO_2 (m moles/l) Rising Tide Range	Rising Tide Median	Falling Tide Range	Falling Tide Median
1	Surface	1.834-2.162	1.998	.665-.422	.544
	2 m	1.814-2.153	1.984	.555-.328	.444
	Bottom	2.097-2.153	2.125	.820-.332	.576
2	Surface	1.942-2.149	2.046	.574-1.270	.922
	2 m	1.329-2.095	1.712	.835-1.070	.953
	Bottom	1.977-2.097	1.977	.396-.485	.441
3	Surface	1.876-2.098	1.987	.625-.378	.502
	2 m	1.959-2.149	2.054	.320-1.180	.750
	Bottom	1.959-2.149	2.054	.468-1.010	.739
4	Surface	1.882-2.098	1.990	.630-.683	.657
	2 m	1.371-2.097	1.734	.448-.645	.547
	Bottom	1.969-2.153	2.061	.636-1.050	.843
5	Surface	1.889-2.095	1.992	.388-.590	.489
	2 m	1.787-2.091	1.939	.485-.583	.534
	Bottom	1.499-2.091	1.795	.575-.696	.636

The total CO_2 concentration is directly dependent on the tidal cycle, decreasing 75% during falling tides. It is possible that the concentrations in the harbor during rising tides are very near normal because the source of CO_2 is the coastal water itself, unexposed as yet to the heavy demands present in the harbor. During falling tides, the source of CO_2 is either from the waters of the canal or the harbor itself and both have very high productivities; thus the decrease of CO_2 concentration is observed. The length of time which coastal waters take entering Basin 1 appears to be long enough for almost complete depletion of available carbon sources for photosynthesis to occur. At such times, CO_2 will affect production.

The data indicate more precisely that high natural productions are responsible for the low concentration of carbon dioxide; not the reverse. Production within the harbor during falling tides increases by 150% over that measured during rising tides, together with an associated decrease in CO_2 concentration by 75%. The observed difference can be explained partially by the fact that some depletion of CO_2 occurred within the waters before they entered the harbor.

It must be concluded that CO_2 concentrations are not initially limiting to production within the harbor, but that high demand for carbon by photosynthetic organisms within both the canal and harbor can reduce the concentrations and temporarily effect the total amount of production. The magnitude is not sufficient to indicate carbon as a prime factor limiting natural production.

4. Hydrogen Sulfide

Hydrogen sulfide (H_2S) concentrations are extremely variable ranging from less than detectable amounts to significant levels at certain stations. Maximum levels were recorded at Station 1 during falling tides comparable at all depths. Bottom waters at Station 2 and 4 also show similar high levels (Table 5). During rising tides, uniformly low concentrations appear throughout the harbor, having little dependence on depths.

Table 5: Concentrations of H_2S and its Relationship to Depth and Tides

Station	Depth	Sulfide Concentrations (µg at/l) Rising Tide Range	Median	Falling Tide Range	Median
1	2 m	0.00-0.00	0.000	0.000-3.738	1.869
	Bottom	0.00-0.26	0.13	0.000-3.738	1.869
2	2 m	0.00-0.33	0.17	0.000-0.000	0.000
	Bottom	0.00-0.56	0.28	0.000-1.829	0.915
3	2 m	0.00-0.59	0.29	0.000-0.000	0.000
	Bottom	0.00-0.59	0.29	0.000-0.000	0.000
4	2 m	0.00-0.59	0.29	0.000-0.000	0.000
	Bottom	0.00-0.62	0.31	0.000-1.829	0.915
5	2 m	0.00-0.59	0.29	0.000-0.000	0.000
	Bottom	0.00-0.62	0.31	0.000-0.000	0.000

Localized concentrations of H_2S are normally anticipated to show in bottom rather than in upper level waters. Sufficient organic matter exists in the sediments (see Table 6) for use by bacteria for the production of H_2S. Presently H_2S produced quickly decreases in concentration as it diffuses up through the water column, transforming rapidly to the sulfate ion in the presence of oxygen. Because such changes are not observed relative to depth (except at Stations 2 and 4), it must be concluded that the source originates within the canal or outside the harbor.

Table 6: Organic Carbon Concentrations in Sediments and Relationship to Tides

Station	Tide	Organic C in Sediment (%)	Mean Concentrations $\bar{x}$	$\bar{X}$
1	Incoming	4.494	3.306	2.960
	Incoming	2.118		
	Falling	2.583	3.045	
	Falling	3.507		
	Mixed	2.530	2.530	
2	Incoming	1.725	1.214	1.219
	Incoming	0.7036		
	Falling	0.678	1.294	
	Falling	1.910		
	Mixed	1.150	1.150	
3	Incoming	4.626	2.888	3.672
	Incoming	1.150		
	Falling	3.473	2.428	
	Falling	1.382		
	Mixed	5.700	5.700	
4	Incoming	5.772	3.627	2.923
	Incoming	1.482		
	Falling	1.865	1.771	
	Falling	1.677		
	Mixed	3.370	3.370	
5	Incoming	1.600	1.437	1.070
	Incoming	1.274		
	Falling	0.913	.862	
	Falling	0.811		
	Mixed	0.910	.910	

Some H_2S is however produced in the vicinity of the two backwater Stations 2 and 4. Significant concentrations were noted periodically and only in the bottom water.

The concentrations of H_2S are not yet high enough to produce noticeable environmental effects and consequences. Ekman (1953) demonstrated that levels of 22.32 μg at/l were required before plankton organisms would avoid the effected waters. The highest observed levels within the harbor are about one seventh of this value.

5. Phosphorus

One factor which was possibly limiting to production during the period of this investigation was phosphorus. Figure 7 shows the observed concentrations of total phosphorus which influenced the productivities. A correlation coefficient of .451 was calculated for the relationship of phosphorus concentrations at the surface with productivity rates, and was found to be significant (95% t=2.404; 19 D. F.). This relationship is fully independent of tidal influences. That these data can be described by a straight line further demonstrates that this limitation was in effect at all measured concentrations.

The equation

$$Y = .70334 + .00435x$$

where Y = Total phosphorus concentration in μg at/l
x = Productivity rate in mg C/m^3/hour

shows that production by the present population should approach zero when total phosphorus is reduced to a concentration of 21.8 μg l. This value is very close to the maximum permitted levels for Class AA waters.

In this analysis, it must be recognized that a portion of the total measured phosphorus concentration is ascribable to the phosphate levels within the phytoplankton cells themselves. If phosphate is limiting, it will, of course, effect the density of cells within the water in direct proportion to its concentration. However, phosphates are a component of these cells, and, as such, when cell number increases, the measured total phosphate concentration will also increase. These data do not allow for a judgement to be made regarding the severity of this interference. and further studies studies must be conducted to conclusively demonstrate phosphate limitations.

At present more than one half of the total determinations for surface waters in the harbor have values which do not meet with the allowable levels for a Class B water (.030 mg/l), resulting in an average concentration of .0414 mg/l. In order to reach the value suggested by this data, a reduction of 90% would be required and would involve control of both the harbor and the canal. A 40% reduction can be achieved simply by the total elimination of phosphorus materials originating within Basin 1, assuming physical characteristics identical to those for the period of this study.

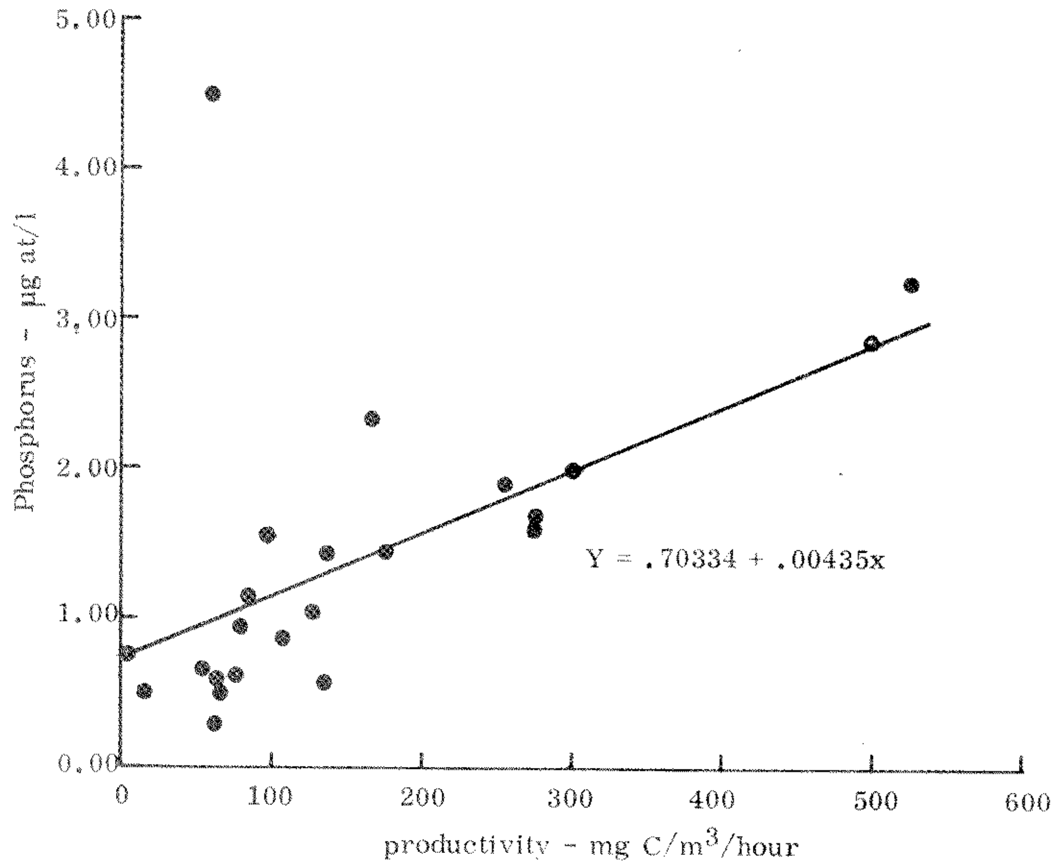


Figure 7: Measured concentrations of total P yielding observed productivities during the months of July and August, 1972.

6. Nitrates

Nitrate concentrations showed no relationship at all with observed productivities. Even though the ratiosof nitrate to phosphate are very low, there is no indication that it might become limiting.

Surface concentrations of nitrate-nitrogen were periodically observed to be high and beyond what would be allowable for the total nitrogen levels for Class B waters. For example, at Station 1 the levels of nitrate averaged .206 mg/l; the total nitrogen limitation is 0.200 mg/l. It must be realized that the limits prescribed by the State are based upon total nitrogen concentration at any time and not upon average values over a period. Nitrate is only a portion of the total load, so that it is highly probable that nitrogen levels must also occur in concentrations above those required. Although ammonia and amino-nitrogen determinations would have been beneficial, budgetary restrictions imposed by the State did not permit such analyses.

Even though nitrate is not a limiting factor within the harbor, it can have a large influence upon population composition on the basis of its proportionate association with phosphate. Nitrate/phosphate ratios are traditionally used as an indicator of eutrophication in fresh water lakes, with lowered ratios correlated to a greater degree of environmental aging.

7. Light

Light is attenuated in inverse proportion to the square of the distance from its source as it is transmitted through a medium. Two constants, one attributable to light scattering and the other to absorption, modify this relationship to the particular characteristics of a given medium.

Photosynthesis proceeds with rates linearly proportional to the amounts of light avaliable until the system becomes saturated and can go no faster. As light intensity increases beyond the proportionate phase, a limit is reached at which the system becomes overloaded and declines.

Only at times when light intensity is less than the saturation value will productivity rates change with depth in proportion to the amount of light available. Under these conditions the decline with depth will fit the pattern of a negative exponential curve.

The extinction coefficient, or more correctly, the coefficient of attenuation, is a measure of the rate at which the amount of light is removed with depth. The numbers arrived at are negative exponents of the base of the natural logarithm, *e*, and thus are characterized by a negative exponential curve. Transformed by a logarithmic scale, they yield a linear curve which expresses the relative amount of light attenuated between the surface and any given depth. When compared with the percent difference in productivities between the surface and a constant depth, a straight line will result only if the light intensity at the surface is equal to, or less than, the saturation intensity. It is then that light can be considered a factor whichlimits production throughout the water column.

Such an analysis is presented by Figure 8 . Linearity exists when the coefficient of attenuation exceeds a value of approximately .700, but the relationship is obscured at values less than this. This shows that for just less than half of the time, light was present at less than saturation values near the surface and thus limiting to production.

A theoretical analysis of this sort carries with it certain assumptions. The first is that photo-inhibition does not occur at the .2 meter depth where surface productivities are determined. Consequently this would tend to decrease the observed difference between production at the two depths and result in an underestimation of the crucial coefficient levels. The second is that organismic density distribution and composition do not vary significantly between the depths. This is a risky assumption since the effects upon the relationship are unpredictable.

Taking these assumptions into consideration, the following conclusion is reached respective to light. It is likely that the concentrations of other components of the system are approaching levels at which they can no longer be considered limiting. At such a time, the most abundant of all factors in tropical regions, namely light, must take control. The interaction of all these factors will be considered in the following statement of environmental condition.

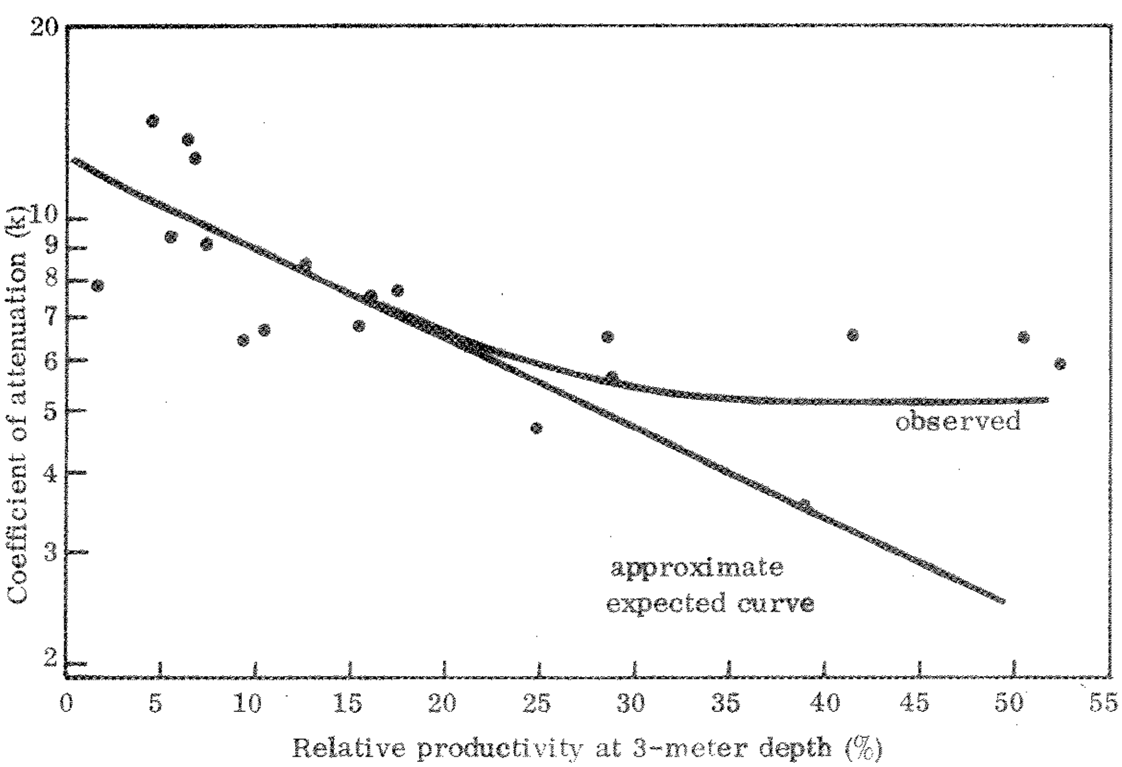


Figure 8

Relationship of productivity at depth to relative amount of light available.

IV. GENERAL CONDITION OF THE PRESENT ENVIRONMENT

The waters of the Ala Wai Boat Harbor have high productivities, reaching a maximum surface fixation rate of 6.26 g C/m^3/day within Basin 1. This rate is very nearly equivalent to the maxima attained in the most eutrophic regions of the canal.

The rate is possibly limited by the present phosphate concentrations. However, because light has been demonstrated to limit productivity rates near or at the surface (if the coefficient of attenuation is ≥ 0.700), phosphate concentrations are approaching the maximum levels where they still might produce these limitations. Furthermore, it is expected that during periods of increased discharge from the canal, increases in water turbidity and phosphate concentration will result and the critical levels will be surpassed. During these times the light, not the phosphate concentration, will be the limiting factor.

As a result of the combined effects of light and phosphate concentration upon the rates of productivity, the concentrations of available CO_2 drop significantly. Although the initial concentrations of CO_2 are sufficient for high productivity, the levels decrease continuously through the day. Incoming tidal water will counter losses to some degree but falling tides will not. If falling tides coincide with periods of high productivity, the concentrations of CO_2 may increase sufficiently to cause a reduction in the rate of productivity.

Thus there exist three factors which can potentially limit the high productivity in the harbor, namely light, phosphate and CO_2. Both light and CO_2 effects are, however, dependent upon the presence of phosphate.

The high productivities and the complex patterns of circulation within the harbor have resulted in periodic supersaturated oxygen concentrations throughout the water column. This effect influences the environment immediately outside the harbor. Fluctuations between saturated and supersaturated conditions normally can result in the destruction of organisms confined to the affected areas. That such consequences exist is perhaps shown by the lobster kills observed at sampling Station 5 (see Appendix XII), although other explanations are certainly possible.

The present of supersaturated waters does have the advantage of keeping the levels of hydrogen sulfide (H_2S) below critical levels. The fact that H_2S can be detected at all, however, is an indication that more than sufficient amounts of carbon are available in the sediments for the growth of a large population of Desulfovibrio bacteria.

High productivity is obviously occurring in the presence of three limiting factors and is probably approaching a maximum. This suggests that marked eutrophication of the harbor is occurring and is accompanied by decreases in species diversity and population stability. Because the tolerance limits for certain of the existent populations are being reached and in some cases surpassed, a relatively short time remains before the next stage of eutrophication is gained.

At present, any sudden and marked change in either light intensity or phosphate concentration might result in a sudden decline of the primary producers. Because of the present density and instability of the population, the sudden discharge of any toxic materials (herbicides, heavy metals, oil) will more certainly produce this result.

There are three probable consequences of a rapid decline in the present population of primary producers. In order of increasing likelihood, these are

(1) the re-establishment of a new population dominated by a desirable organism,
(2) the rapid depletion of oxygen in conjunction with an increased generation of H_2S and a fish kill, and
(3) the re-establishment of a new population dominated by an undesirable organism.

If the second alternative occurs, it will be followed by the establishment of a new population with characteristics of either (1), or more likely (3).

Over the longer term, however, it is certain that the two latter alternatives will occur unless action is taken to avoid it. For example, during the study period a bloom of a dinoflagellate (tentatively identified as a strain of Gymnodium breve) occurred. Because the harbor waters have high nutrient concentrations, a generally low N/P ratio, and large quantities of dissolved organic materials, conditions are favorable for recurrent blooms of this sort.

The existing current movements are presently contributing some stability to the system through the continuous exchange and circulation of water. Any interference with the existing current pattern other than the one specifically designed to improve circulation radically must be avoided since this control would be lost.

How long, therefore, can the present population exist before radical changes are felt? Analyses of nutrient concentrations near the end of the T-pier were conducted by Gonzales (1971) and by Harris (1972). Comparison of their data with present findings provides approximate rates of increase since 1969 as follows: nitrate-N has increased an average threefold annually at approximately a linear rate; between 1969 and 1970 a fourfold increase in phosphate was recorded and is assumed to have continued increasing to some degree, but the present analyses for Total-P and not soluable phosphate prevent direct comparison. As the present environment in the harbor is already very near the maximum a limited time remains before radical changes occur, even if the assumption is made that a twofold increase of the concentrations is required to produce this effect. It is a matter only of probability as to which of the last alternatives will be felt first.

Additional factors, such as the presence of pesticides and heavy metals, were found not to be of immediate concern. Data received from Allen Eshelmann, through the courtesy of Dr. Doak Cox of the University of Hawaii, showed that zinc, copper, mercury, and cadmium occur in higher than expected concentrations and appear to arise in part from sources within the harbor (See Appendix XII). This demonstrates a need for caution and suggests future monitoring of these components would be advisable. Presently, however, no objection is offered against the proposed construction in the harbor on the basis of these components. Schultz (1971) demonstrated that the concentrations of DDE, Dieldrin, DDT and DDD were also present in low concentrations. The sources of these pesticides were thought not to exist in the harbor.

V. SOCIO-ECONOMIC ENVIRONMENTAL ANALYSIS

A study of the socio-economic environment of Ala Wai Boat Harbor was conducted. This describes the socio-economic dimensions of the proposed expansion and evaluates them individually.

Specifically: (1) An optimal boat size distribution policy for the Ala Wai Boat Harbor has been formulated using information collected on the size distribution of boats presently moored in the harbor; (2) Individual demand and aesthetic relationships for recreational boating have been derived. This information was obtained first hand from interviewing a stratified random sample of boat owners; (3) Current recreational boating expenditures are computed and the recreational boating expenditures for 1975 are projected; and finally (4) The attitudes of the different segments of population towards the proposed Boat Harbor expansion are discussed and some of the associated use conflicts are indicated.

The analysis that follows is based on the assumption that 289 new mooring slips will be created, bringing the total capacity of the Ala Wai Boat Harbor to 723 boats. A further assumption is that the project will be completed and fully operating by 1975.

1. Boat size distribution

Complete records of 261 boats moored at the Ala Wai Boat Harbor were analyzed for type and size of boat (Dept. of Trans., Harbors Divis. files). The results showed that 32 percent of the existing boats are cabin cruisers, 49 percent are sail boats, and the remaining 19 percent are of miscellaneous descriptions. The average overall boat length is 36.3 feet. The distribution of size for different boat types is shown in Figure 9 .

An estimate for the total population of boats moored at the Ala Wai Boat Harbor was derived on the basis of information obtained from Harbor files. It shows that 29 percent of the boats are $\leq$ 30' in length, 43 percent are 31' - 40', and 28 percent are $\geq$ 41' in length.

Boat length will be an important consideration in designing the expansion of the marina and as a result boat size distribution of potential boat owners is an indicator of the demand for additional mooring slips. The waiting list for mooring spaces at the Ala Wai Boat Harbor is, thus, a useful criterion for deriving a boat size distribution policy.

As of May 1972 there were 700 valid applications on file for mooring spaces at the Ala Wai Boat Harbor (Dept. of Trans., Harbors Divis. files). The waiting list is not a true 'proxy' for estimating aggregate demand since there are many potential boat owners who are discouraged from filing an application for a mooring

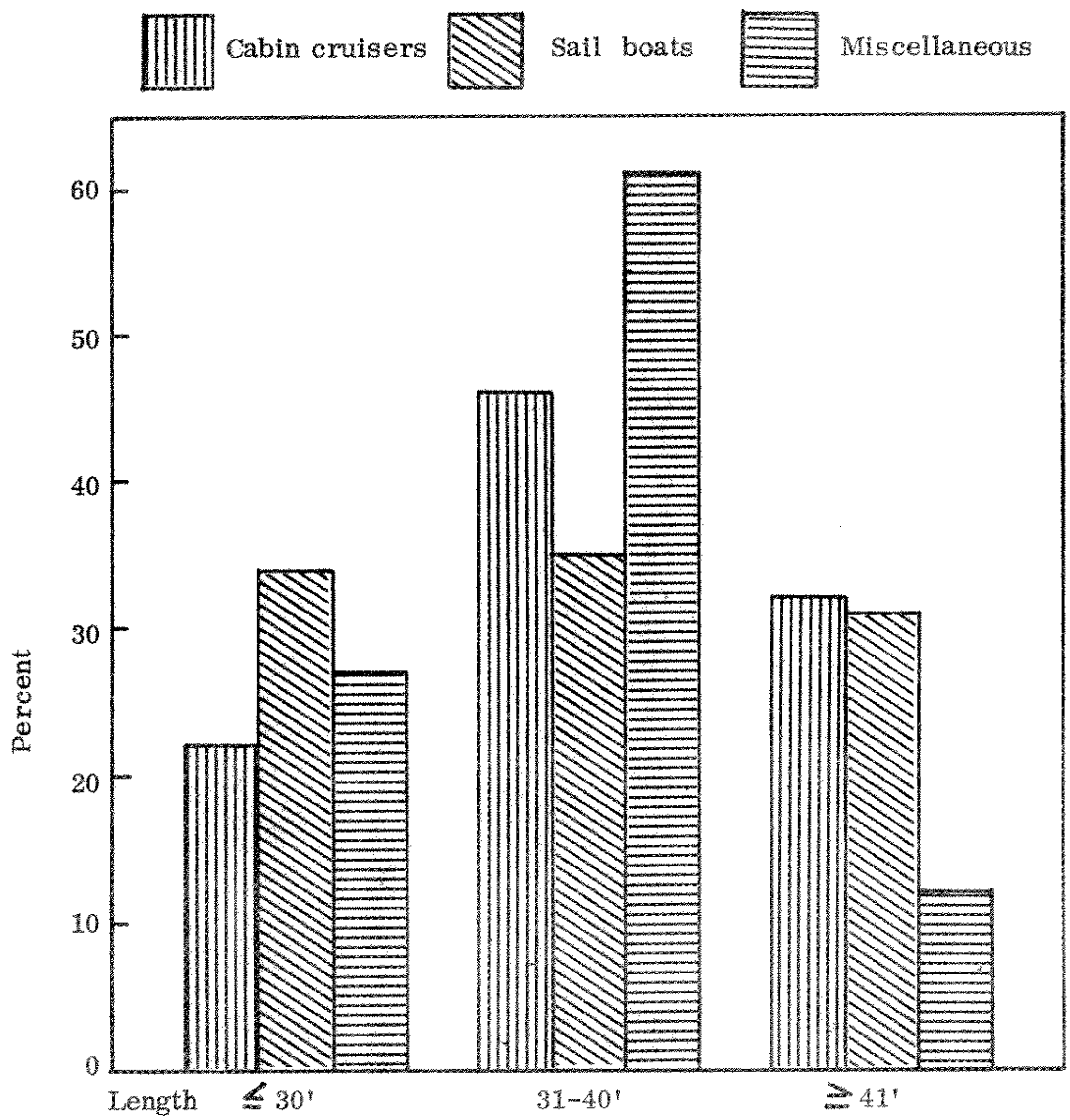


Fig. 9 Percent distribution of size for different boat types at Ala Wai Boat Harbor, July 1972.

slip, since they know that such a lengthy waiting list exists. The important implication to note is that the proposed expansion of the harbor will accommodate only about 40 percent of the present number of applicants.

Table 7 shows the waiting list distribution of boats on the basis of data for 1969 (Dept. of Trans., Harbors Divis. files) and a distribution policy for allocating boats of different sizes. Although no time series data is available for predicting trends in boat size, the waiting list distribution indicates an increasing demand for the ≦ 30' and ≧ 41' boat length categories.

Table 7: Boat size distribution for Ala Wai Boat Harbor: Existing and Proposed.

Item	Size of boat						
	≦30'		31'-40'		≧ 41'		Total boats
	No.	%	No.	%	No.	%	No.
Existing	126	29.0	187	43.0	121	28.0	434
Waiting list	134	46.6	81	28.0	74	25.6	289
Proposed	260	36.0	268	37.0	195	27.0	723

The analysis assumes that boats displaced during reconstruction will be replaced by boats of similar length.

The optimal boat size distribution policy recommended is where 39 percent of the boats are ≦30' in length, 37 percent are 31' - 40' and 27 percent are ≧ 41' in length.

2. Survey of boat owners

A stratified random sample of 20 boat owners was designed on the basis of boat type and size. The boat owners were interviewed using a prepared questionnaire. The stratified random sampling technique was justified under the assumptions that boat type and size would influence ownership and operating costs as well as boating activities and level of participation.

The recreationists selected in the sample were asked particulars regarding expenses incurred for various pleasure boating activities, certain socio-economic characteristics, as well as information on recreational habits. Individual responses from the survey were very encouraging, indicating a concern on the part of boat owners regarding public expenditure for harbor facilities.

3. Individual demand for recreational boating

The estimation of demand for pleasure boating is a difficult undertaking in the general absence of market prices for most recreational activities. Thus, expenditure incurred by recreationists engaged in the experience was adopted in determining a 'proxy' of price and demand for pleasure boating.

The relevant expenditures considered were fixed investments, annual costs, and daily costs (McNeely, 1968). These were obtained from the questionnaire responses and converted to aggregate costs per participant day.

The demand conditions were analysed by plotting the cost of participation against the number of participant days involved in recreational boating (Fig. 10). The validity of the method is demonstrated in Appendix V.

Results of the survey indicate the average boat is used for recreational purposes 56.3 days each year (approximately once a week) and the average number of participants is 5.4 on each occasion, or an average of 304 participant days per boat each year. The total for the 434 boats moored at the Ala Wai Boat Harbor (excluding Waikiki Yacht Club) is therefore 131,936 participant days per year.

It was found that 65 percent of total participant days were involved in pleasure sailing and 35 percent in sport fishing activities. Other activities such as water skiing, scuba and skin diving accounted for less than 1 percent of total participant days. Frequency of boat use and average number of participants per boat were identical for pleasure sailing and sport fishing activities.

4. Recreational boating expenditures

The average total cost for each participant in recreational boating was estimated from equation (i) to be \$22.60 per day. The empirical findings are presented in Table 8 .

Table 8: Recreational boating expenditures by major cost categories, 1972.

Cost category	Daily participant cost	Annual cost/boat	Total for harbor/yr	Percent of total
Fixed investment	\$9.20	\$2,796	\$1,213,741	40.7%
Annual costs	7.72	2,348	1,018,487	34.2
Daily costs	5.68	1,726	749,352	25.1
	22.60	6,870	2,981,580	100.0

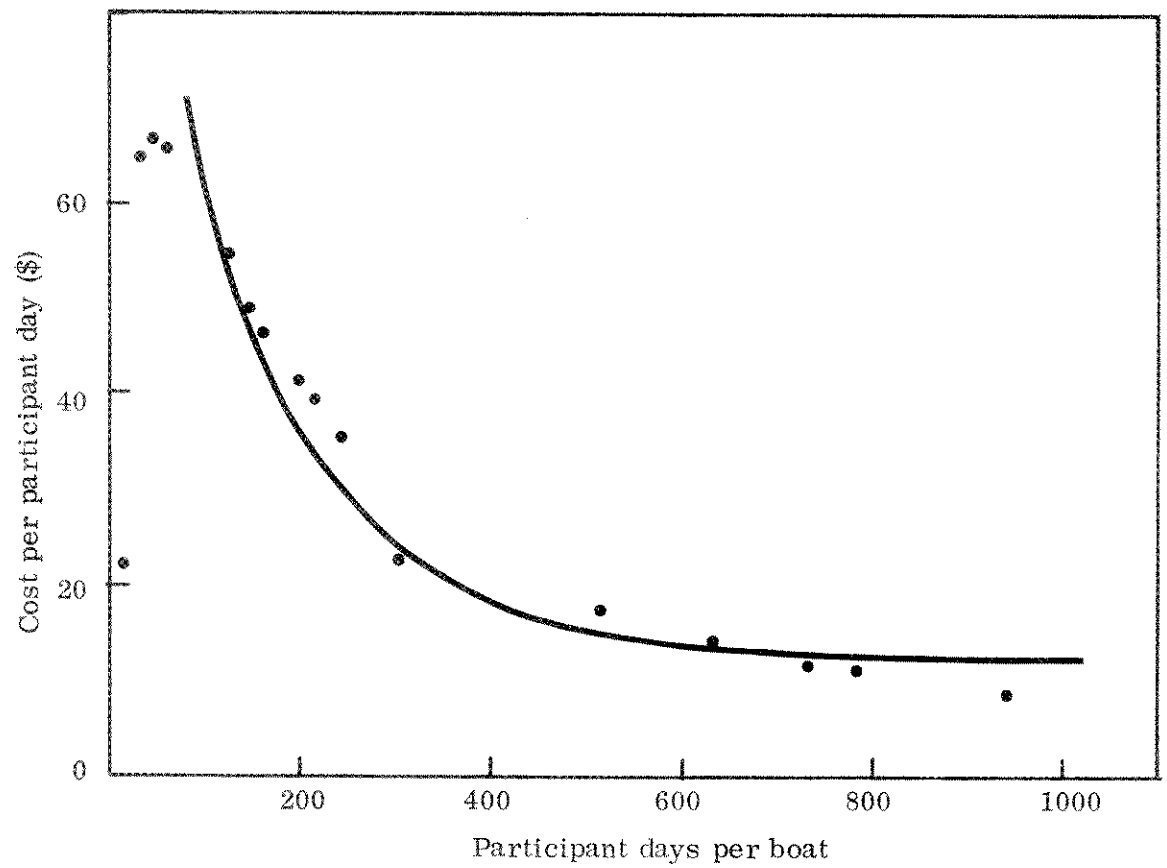


Fig. 10 Average individual demand curve for pleasure boating.

Since there is an average number of 304 participant days for each boat, the total annual costs of owning and operating a boat amount to $6,870. The total expenditure for the 434 boats moored at the Ala Wai Boat Harbor is then $2,981,580 per year. The major cost category is fixed investment (depreciation), 40.7 percent, followed by annual costs, 34.2 percent, and daily costs, 25.1 percent.

The average initial capital expenditure per boat and associated equipment was found to be $27,965, and assuming a 10% salvage value at the end of its useful life, the average investment per boat is $15,381. Thus, the average value of investment at any point in time for the 434 boats moored at the Ala Wai Boat Harbor is $6.7 million.

5. Aesthetic value of recreational boating

The socio-economic characteristics of the 20 respondents were analyzed in an attempt to quantify the aesthetic values associated with recreational boating.

The average days of recreational participation per boat (Y) was hypothesized to be a function of certain explanatory variables such as annual cost (X_1), household size (X_2), household income (X_3), boat owner's age (X_4), distance travelled to boat (X_5), boat owner's weeks of vacation (X_6), years of residence (X_7), and years of experience (X_8).

A linear algebraic equation was fitted to the cross-section data using stepwise multiple regression analysis. The empirical findings are summarized in Table 9 .

Table 9: Regression coefficients of the estimated equation (ii).

Intercept	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	R^2
517.541	0.012	-58.214	0.004	-7.090	20.517	-2.528	-4.902	4.566	0.69
	(0.60)	(-0.70)	(1.30)	(-0.62)	(1.50)	(-0.39)	(-0.72)	(0.75)	

Substituting the mean values of the explanatory variables results in a predicted average of 304 participant days per boat each year.

The regression equation shows that variables X_1, X_3, X_5, and X_8 are positively related to recreational participation, whereas the remaining variables show a negative relationship. Sixty-nine percent of the variation in participant days per boat was explained by the socio-economic variables considered in the analysis.

The mean values of the explanatory variables also reflect the socio strata that boat owners represent. These are compared with the County and State estimates (D. P. E. D., State of Hawaii, 1971).

Average annual household income was found to be $30,450, which implies that 22.6 percent of annual household income is required for owning and operating a boat. Average household size was 3.8 persons which is the same as the average for the State in 1970. As a result, per capita personal income is $8,013. Although this is considerably higher than the per capita personal income from Honolulu County ($4,356 in 1969), this is largely explained by the age of the boat owner (average age was 48 years).

The ethnic composition of the boat owners was 80 percent Caucasian, 10 percent Japanese, and 10 percent Hawaiian. The proportion of Caucasian boat owners is considerably higher than the compositon of Caucasians in the Oahu ethnic stock (28 percent in 1964-67).

Boat owners travelled an average distance of 8.55 miles to the harbor, implying that the location of the Ala Wai Boat Harbor in the heart of the Honolulu metropolitan area does not impose any serious traveling constraints on boat owners.

The average boat owner has 4.6 weeks of annual vacation from his regular employment (10 percent of owners are retired), has been a resident of the State for 29.2 years, and has 24.6 years of experience affiliated with recreational boating.

The average boat owner has occupied a slip at the Ala Wai Boat Harbor for 8 years. Seventy-five percent of the boat owners have a level of education equivalent to a university degree, and over 90 percent of the registered owners are male.

Another finding was that 15 percent of the boats in the sample were also used as permanent residence. Information provided by the Department of Transportation showed 35% of the boats within Basin 1 had people living on board, with a permanent resident population of 139, (Woolsey, personal communication, 1972).

6. Projected recreational boating expenditures for 1975

Regression equation (ii) can be used directly for projecting recreational boating expenditures for 1975. Also, assuming that phase I will be completed by 1975, expenditures resulting from additions to mooring capacity can also be separated. This will be useful for determining benefits associated with additional public investment at the Ala Wai Boat Harbor.

An assumption underlying the use of regression equation (ii) is that the participants in recreational boating in 1975 will possess the same socio-economic characteristics as their 1972 counterparts. That is, the coefficients of the estimated parameters will remain unchanged.

First, if income and consumer recreation prices for Honolulu County from 1969 to 1975 are similar to trends from 1965 to 1969 (D. P. E. D., State of Hawaii, 1971), income can be expected to increase by 39.5 percent and consumer recreation prices by 17.5 percent. Adjusting the mean values for income and consumer recreation prices accordingly, and substituting these into equation (ii) gives the projected participant days per boat for 1975. The result is an increase of 67 participant days (22 percent) to 371 participant days per boat in 1975. Similarly, an estimate of the average total cost per day for each participant can also be derived. Substituting the projected number of participant days for 1975 into equation (i) and adjusting expenditures upward by 17.5 percent shows that the average total cost per participant day will decrease by $0.39 (1.7 percent) to $22.21 in 1975. Thus, the total annual cost of owning and operating a boat in 1975 will be $8,240.

Table 10 shows the projected expenditures by boat owners in 1972 and 1975, including the effects of additonal mooring capacity.

The analysis shows that expansion of the Ala Wai Boat Harbor to a total mooring capacity of 723 boats will result in 268,233 participant days in 1975 and an expenditure of $5,957,520 by participants in recreational boating. Of this, 107,219 participant days and $2,381,360 of participant expenditure accures to net additional mooring capacity proposed for the harbor.

Table 10: Projected recreational boating expenditures for 1975.

Item	1972	1975	1975	1975
No. of boats	434	434[1]	723[2]	289[3]
Participant days/boat	304	371	371	371
Total participant days	131,936	161,014	268,233	107,219
Cost/participant day ($)	22.60	22.21	22.21	22.21
Cost/boat ($)	6,870	8,240	8,240	8,240
Total expenditure ($)	2,981,580	3,576,160	5,957,520	2,381,360

[1] Existing boats [2] Total boats proposed [3] Additional boats

The average investment per boat is estimated to be $16,439 in 1975, and the total investment for the 723 boats proposed for the harbor is $ 11.9 million.

7. Attitudes towards boat harbor expansion

All of the boat owners surveyed were in favor of expanding the Ala Wai Boat Harbor to further develop the marine-based recreational resources of Hawaii. However, there was some dissatisfaction expressed towards present facilities which should be given due consideration in future plans for the harbor. Insufficient parking facilities were cited as a major problem. Space considerations require a multi-story structure operated as a revenue-producing facility primarily for boat owners. Whether it would obstruct the view of guests at the Ilikai Hotel would have to be a consideration. Toilet and shower facilities are totally inadequate and poorly located to serve the existing harbor layout. This applies particularly to persons living aboard boats, an issue that received mixed feelings among boat owners interviewed. Additional locker space per boat is also required.

All of the boat owners interviewed expressed interest in seeing a State-wide harbor plan proposed for implementation. Boat owners were concerned that insufficient provision was made for berthing visiting boats. This becomes particularly apparent when boat owners travel to a neighbor island.

VI. ENVIRONMENTAL IMPACT OF THE PROPOSED CONSTRUCTION WITHIN THE ALA WAI BOAT HARBOR

1. Impact

The present environment in the Ala Wai Boat Harbor is characterized by:

- o Nutrient concentrations significantly above the permitted limits prescribed by the State;
- o Productivity levels among the highest ever recorded for tropical waters; at times increasing at rates which result in significant reduction in carbon dioxide concentrations;
- o High turbidity, which periodically causes light intensity to become a limiting factor throughout the water column;
- o Supersaturated oxygen concentrations;
- o Organismic population instability.

Therefore, it can be anticipated that significant deleterious changes will occur sometime in the future, even if no additional construction is made. The proposed construction within the boat harbor is thus, with certain conditions, of little short term consequence to the biological environment.

However, if certain controls are not implemented, the construction will accelerate the rate of eutrophication within the harbor by the combination of the following:

(a) If the boating public is contributing significant amounts of phosphorus-based waste materials to the nutrient load within the harbor, the concentration of phosphate will increase at a rate greater than is currently being observed. It has been shown that the boat harbor presently contributes approximately 40% of the total phosphate which reaches the end of the T-pier. The annual rate increase is presently about fourfold by the combined additions from the canal and harbor, but almost half is from the harbor alone. Observations made during the course of this study indicate that boaters discharge and dump washwaters into the harbor. From the existing data it is impossible to determine the relative impact from this source relative to the additional inputs from storm drains, hotels and other commercial establishments, and recreational facilities which contribute to the nutrient load of the harbor. Further study would be required to make this determination. Increasing the number of boats within Basin 1 by 65% may increase the rate proportionately. Since at least five additional sources exist within Basin 1, it is impossible to be more specific without further study.

(b) The water circulation within Basin 1 will be adversely affected. During incoming tides, the surface flow into the basin is presently responsible for simultaneous outflow of subsurface water. All support piers which are proposed for Mole A will interfere with this surface movement. The counterclockwise vortex which is established during falling tides will also be affected. The extent to which this will result in a reduction in the present flushing rates within Basin 1 and in the removal of one of the major stabilizing influences of the present environment is unknown at present but is possibly of significant consequence.

c) The amount of available light will be decreased. The addition of mooring spaces will bring about a 2.4 fold increase in the shading of surface waters over that which presently occurs from the effects of boats along the T-pier. A total of 30.2% of the interchannel surface waters will not recieve direct sunlight when the sun is directly overhead. A reduction in the general light intensity withinthe Basin will decrease the critical concentrations of nutrients required for light to become the major limiting factor.

All of these modifications, separately or in combination, will decrease the time interval between now and the moment of population collapse. This is true for the present and all succeeding populations to follow.

The consequences offshore in the event of a collapse will depend very much upon the states of the tides at the time during the immediately following event. At worst, the immediate removal of the affected water to the reef would cause consequences similar to those experienced in the harbor, but of reduced magnitude. At best, the majority of the effected waters might be retained within the canal and harbor, and the effects outside the harbor would be minimal.

The offshore reef areas affected would depend in part upon the strength and direction of the surface winds. Under normal trade conditions, the effects would be concentrated on the reef areas between the harbor and Kewalo Basin. During kona conditions, some of the affected water would be transported to the Waikiki Beach area and cause some disturbance of this environment.

The proposed construction appears to have advantageous effects upon the socio-economic environments. The results showthat income generatedfor the state economy for recreational boating at the Ala Wai Boat Harbor is presently $2,446,458. In 1975, with the completion of the expanded mooring capacity, the amount is estimated to be $4,996,653; an increased income from public investment of $1,997,279 annually.

The economic impact of recreational boating expenditures on the local economy was ascertained by using a local multiplier concept (see Appendix V). The results of the analysis are shown in Table 11 .

Table 11- Impact of recreational boating expenditures on the economy of Hawaii.

Item	1972	1975	1975	1975
No. of boats	434	434[1]	723[2]	289[3]
Additional income/boat ($)	5,537	6,911	6,911	6,911
Total additional income ($)	2,446,458	2,999,374	4,996,653	1,997,279

[1]Existing boats [2]Total boats proposed [3]Additional boats

Some conflicts were uncovered however. A few recreational fishermen felt that the additional fishing effort would deplete the resources, conflict with commercial interests (particularly sport fishing activities), and result in a lower catch per unit of expenditure in the fishing effort. If such is the case, the area is already being over-fished, and a study on the population dynamics of the most valued specied should be made. Additionally, the increased requirements for parking must be taken into consideration.

2. Alternatives

There appear to be no useful alternative sites for the implementation of this project on the leeward side of the island. Existing resort, industrial and recreational developments are extensive for some distance along the shore on both sides of the Ala Wai Boat Harbor. The nearby Kewalo Basin is a commercial facility and would not serve the needs of recreational boating.

The establishment of an additional facility on the windward side of Oahu would not meet the needs which exist in the Honolulu area. It does appear, however, the expansion of the facilities at Heeia Lagoon in Kaneohe Bay merits some consideration. Such a facility would meet some of the needs of the residents of Kailua, Kaneohe, Heeia, and Punaluu communities. The need for expansion in this area has not been established by this present study.

If no construction were to be done within the Ala Wai Boat Harbor, a projected annual sum of approximately $2 million to the State's economy from this source would be lost. It is likely, however, that much of the loss would be recovered by consumer investments in other markets.

The majority of the environmental short term consequences of this construction will not be avoided by the relocation of this project since much of the present instability results from the inputs from the Ala Wai Canal. Further, if proper action is taken, the environmental condition will improve.

The evaluation of the environmental impact of this proposed facility has demonstrated the need for action to be taken in order to retain this resource.

3. Unavoidable adverse environmental effects

It has been shown that the present environment is in jeopardy and that the proposed construction will not, in itself, alter the short term results. Radical changes within this system are imminent and unavoidable.

On a long term basis, however, the additional moorings will decrease the amount of light available for the surface waters. The adversity of this effect will depend upon the implementation of controls, to be discussed in the following section.

4. Relationship between long and short term uses of the environment and the maintenance and enhancement of long term productivity

The proposed construction will not have major short term consequences. The long term consequences depend entirely upon man's ability to conscientiously protect and enhance his environment. This protection can be afforded by full and rigid control of the concentrations of the limiting nutrient and of circulation within the harbor. Enrichment experiments on the harbor waters must be conducted to demonstrate conclusively the limiting nutrient.

If the concentration of this nutrient is made sufficiently low to limit growth within this environment, the reduction in the amount of available light will be of little consequence. If phosphorus is, in fact, limiting, this can be accomplished by reducing concentrations to a level not to exceed .021 mg/l; the amount determined by this study to bring the productivity to the present phytoplankton population to almost zero. In practice, this level should not exceed .025 mg/l as this appears to be the maximum safe level which will ensure constant phosphate limitations to growth.

By reducing discharges of the limiting nutrient directly within the harbor, it is possible that the level in the water will be significantly lowered. Because of further inputs via the canal, it will be necessary to locate and eliminate these additional sources. Nutrient source elimination must occur if the environment is to be preserved.

It is necessary to instigate the process of source reduction progressively because of the close inter-relationships of the various environmental parameters. To ensure that critical limits are not surpassed after this program, the waters within the harbor should be monitored continually.

The proposed construction of a pump-out station at the Texaco fueling dock and connection of all sewage facilities to City and County lines prior to modifications of Basin 1 will have favorable influences. Further benefits will be realized when shipboard treatment facilities become mandatory.

Circulation is one of the major stabilizing influences upon the present environment. Major consideration must be given to constructions which will maintain circulation through the harbor, particularly beneath any of the proposed main piers. This would reduce interference with inflowing surface waters. It is not known if such designs will be sufficient to main circulation at the required level for control of productivity. This could be determined through either hydraulic modeling before construction or by the monitoring of current patterns after construction is complete. In either case, sufficient contingency funds should be available to correct adverse effects.

If these recommendations are implemented the environmental quality of the harbor and offshore areas will be significantly improved by the construction of the proposed harbor extension.

5. Irretrievable and irreversible commitments of resources

With the exception of labor and materials involved in the construction of this facility, light will be the only resource which will be permanently lost as a result of this construction. The consequences of this have already been thoroughly explained.

APPENDIX I

ANALYSIS OF CURRENT PATTERNS

A. Materials and Methods

Measurements of current direction and velocity were made at five selected stations inside the harbor (Figure 1) using an Ekman-Merz current meter operated at various depths. In addition, a continuous film recording current meter (by General Oceanics Inc., Florida) was kept at selected depths at regular intervals during the study. Surface drift was observed and recorded using the tracer Rhodamin B16 dye.

The data was obtained during the experimental period between July 31 and August 11, 1972.

B. Results

Current velocity and direction were determined for each of the sampling stations in the harbor between 0.0 and 6.2 m in depth. Illustrations of the changes in current velocity with depth are given in Figure 2, in which flow towards the canal or the basins in the harbor is represented by a negative velocity.

Hourly data obtained by the film recording current meter are illustrated in Figure 3 . The state of the tide and the time and duration of recording are included.

Figures 4(a) and 4(b) represent the magnitude and direction of surface currents for incoming and outgoing tides repsectively. Figures 4(c) and 4 (d) show current patterns at depths of 2 m and 3 m respectively for incoming tides.

Figure 5 provides photographic evidence of the surface current drift at Station 1 using the Rhodamin B16 dye. The northeasterly wind blowing at the time was between 10-15 knots. The first picture was taken at 1400 hours and the second and third at intervals of 0.5 and 4.0 minutes respectively. The drift current was calculated to be 18.9 cm/sec at the time.

C. Discussion

Figure 4 illustrates that there is a surface flow into the harbor and into the canal during the flood tide. This surface flow is compensated by an outward subsurface movement. The depth of reversal of the currents in the harbor gradually decreases from 5.75 m at Station 5, to 1.1 m at Station 1. At Station 2 the reversal probably occurs 1 m below the surface and at Station 4 at 1.5 m depth.

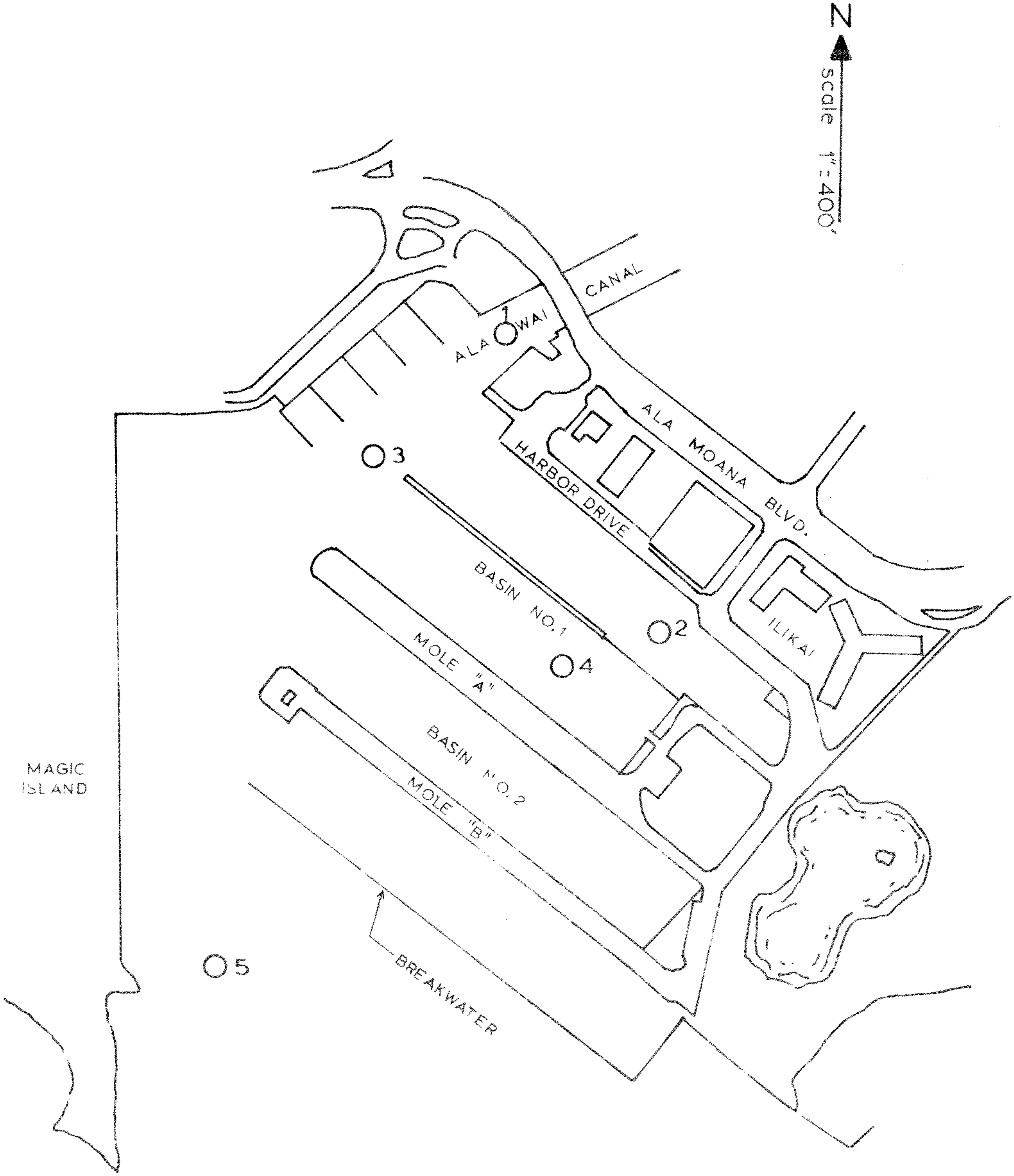


Fig. 1 Current measurement stations, Ala Wai Boat Harbor

Gonzalez (1971) recorded a freshwater run-off from the Manoa and Palolo streams into the Ala Wai Canal and thence into the harbor as surface water in the approximate area of Station 1. However, this fact depends upon the volume of run-off, the level and state of the tide besides other parameters. During a period of little run-off and high tidal range the surface flow could reverse on an incoming tide and flow back into the canal. This was probably the case on 8-8-72 at Station 1 (Figure 2) when a surface flow in this direction was recorded.

The compensating subsurface flow is directed towards the entrance of the harbor in opposition to the surface flow. The vertical thickness in depth of the subsurface flow gradually increases between Stations 1 and 5. Current distributions in Figure 2 further illustrate this two-tiered motion in the harbor.

The distanct changes in the current distributions at the surface layer indicate the extent of the mixing in the harbor. The direction and velocity of the wind influences the mixing as well. Wind velocities were moderate during the experimental period, namely between 0-15 knots.

The possibility of a surface counter-clockwise movement is indicated near Station 3 (Figure 4) during the incoming tide. This may be due to the confluence of the incoming surface water due to the tide and the discharge of runoff through the canal. But the whole surface water from the Basin 1 and from Station 3 seems to flow out of the harbor during the outgoing tide (Figure 2).

The maximum current velocity recorded was 10.35 cm/sec at a depth of 2 m at Station 1 on 8-8-72, and a minimum of 1.17 cm/sec at a depth of 3 m at Station 2 on 8-11-72.

The film recording current meter recorded maximum velocity as a depth of 2.5 m at Station 3 on 8-4-72. The time was 1405 hr while high tide occurred at 1300 hr on that day (Figure 3). At Station 2 and at the same depth the maximum velocity recorded on 8-11-72 lagged the high tide by 145 min. For both these cases the current velocity minima occurred between 7-8 hr after high tide. Current reversals recorded at Station 4 at 3 m depth on 7-31-72 (Figure 3) both coincide with the tide reversal at 1200 hr on the respective days.

D. Conclusions

1. The current circulation in the Ala Wai Boat Harbor describes a two-layered flow pattern with a surface inward flow compensated by a deeper returning outward movement.

2. The minor variations from this general pattern which do and can occur are dependent on the tidal range, velocity and direction of wind, and the volume of run-off passing through the Ala Wai Canal into the harbor.

3. A similar flow pattern exists within Basin 1 which contained Stations 2 and 4 and where maximum current velocities of 3.39 and 7.25 cm/sec respectively were recorded at the surface during incoming tides.

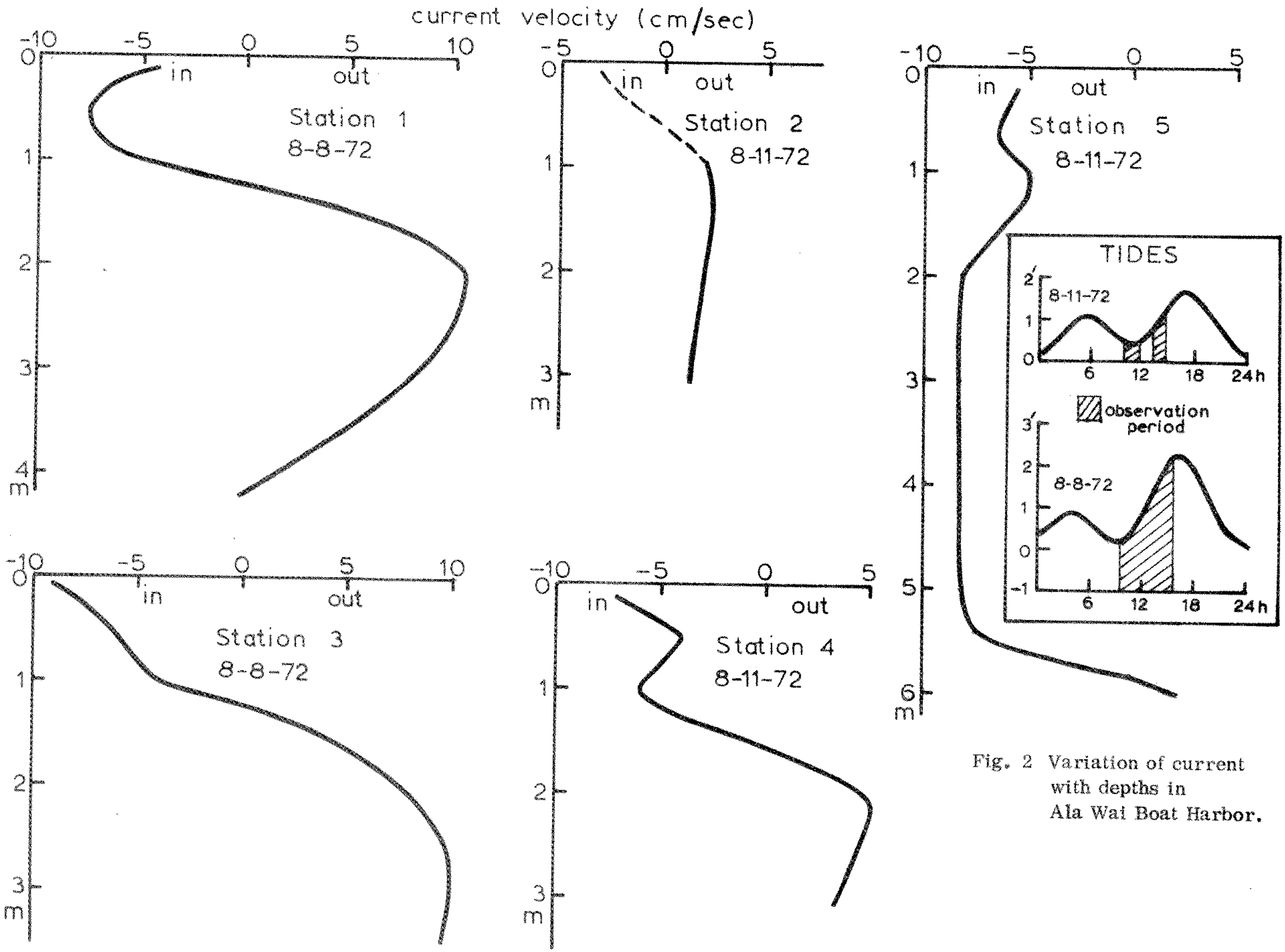


Fig. 2 Variation of current with depths in Ala Wai Boat Harbor.

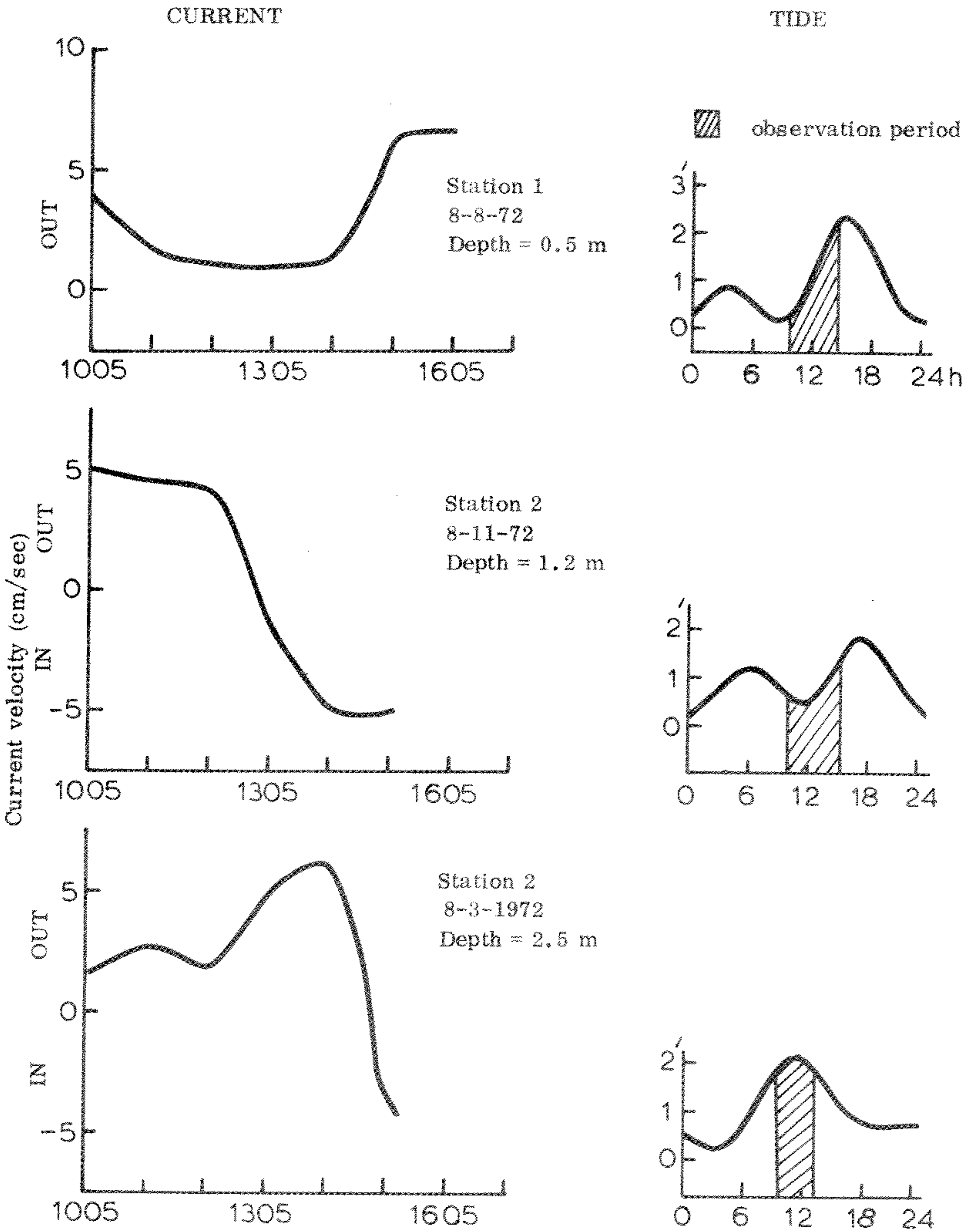
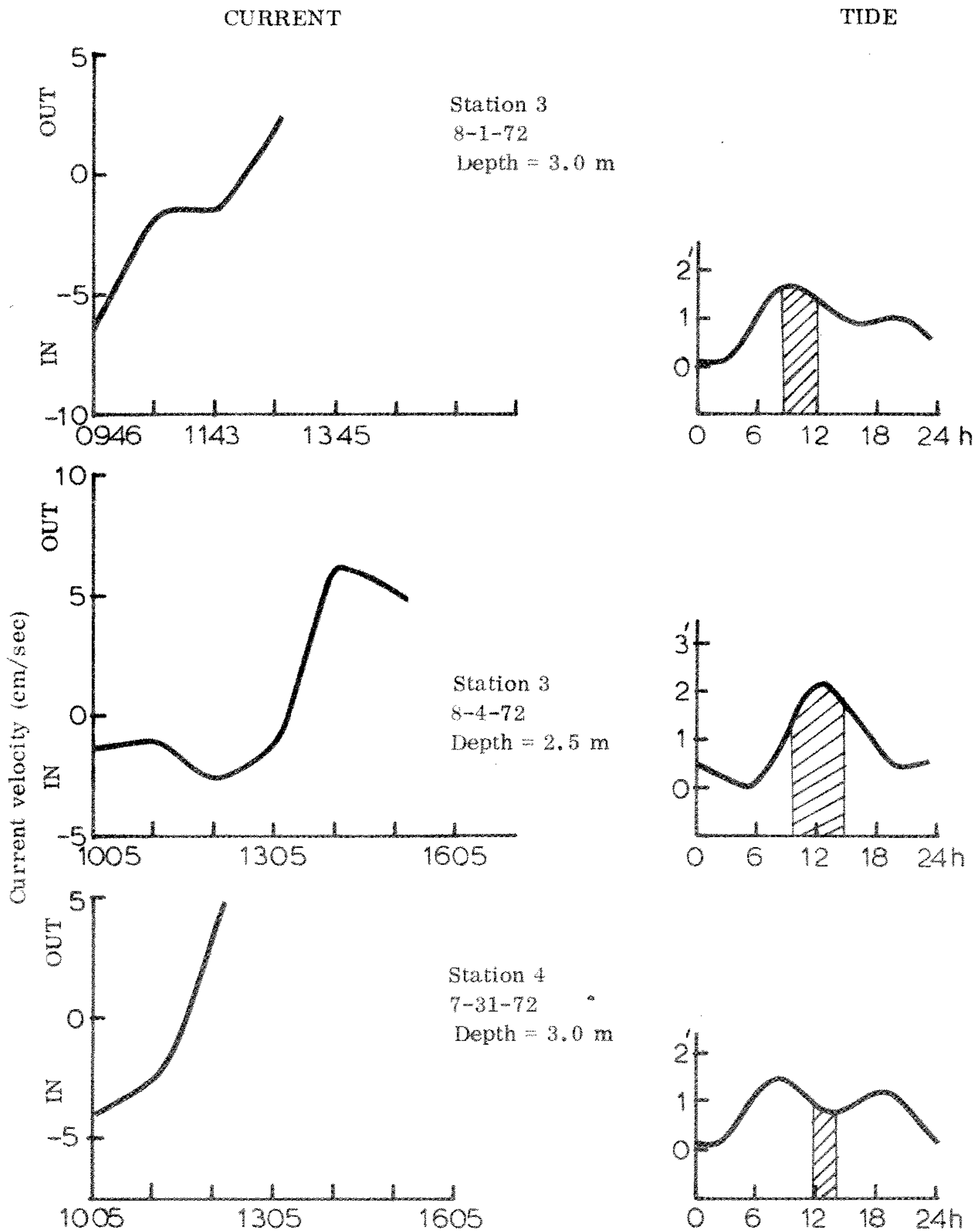


Fig. 3 Hourly variation of current velocities in Ala Wai Boat Harbor.



(Fig. 3 continued)

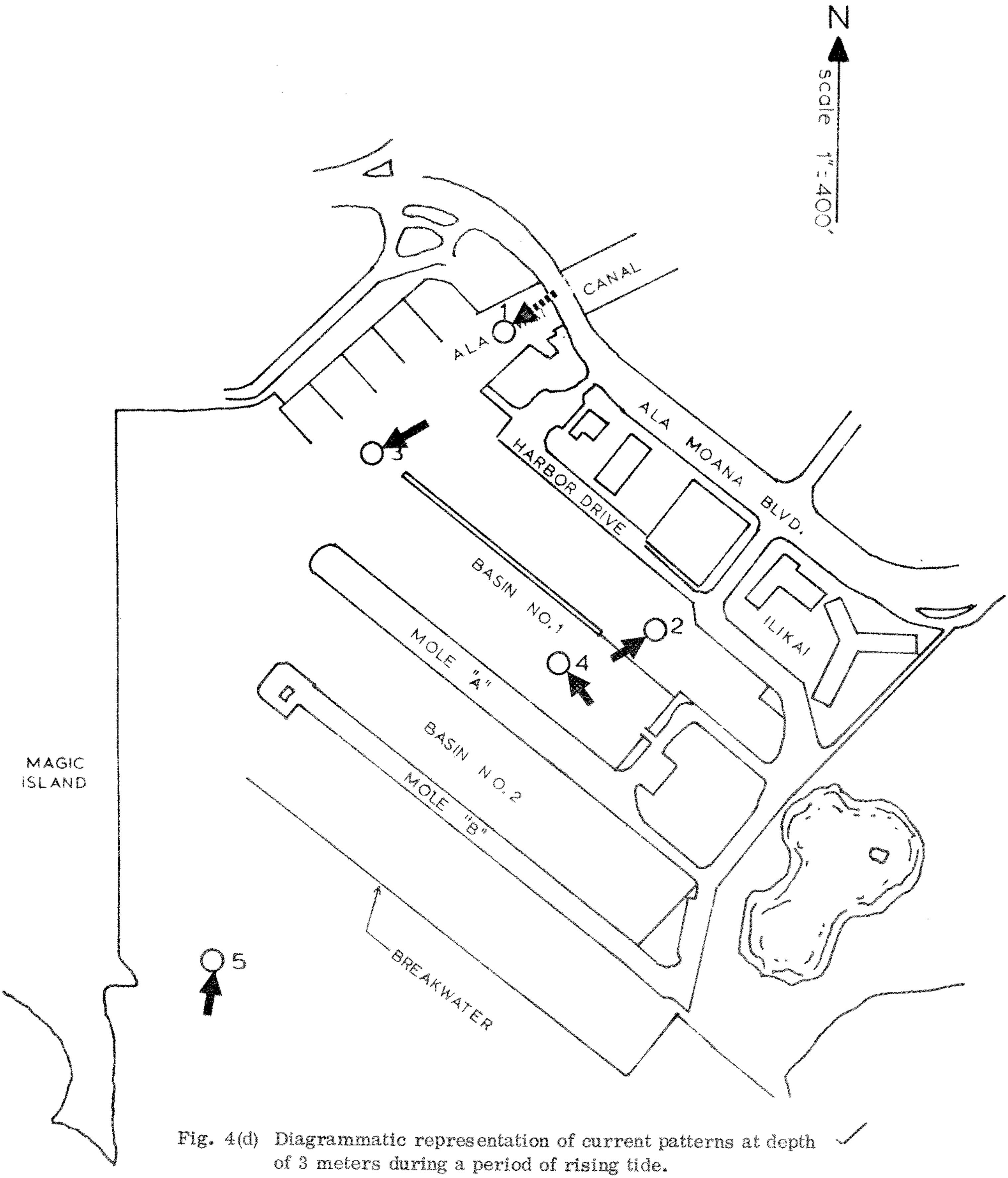
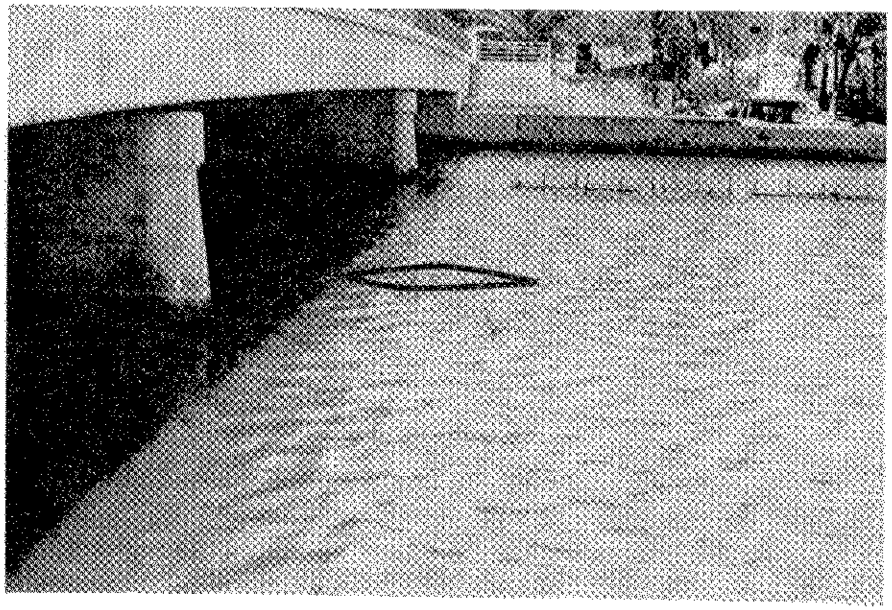
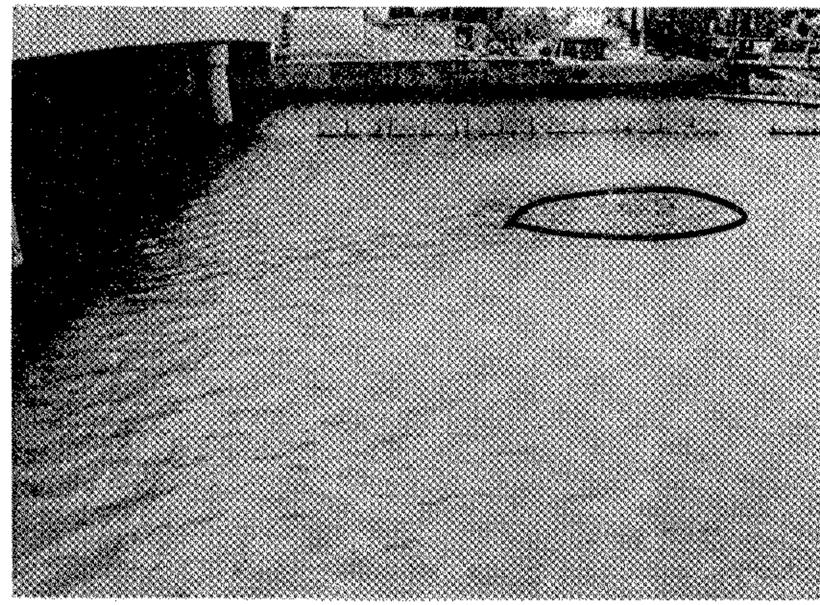


Fig. 4(d) Diagrammatic representation of current patterns at depth of 3 meters during a period of rising tide.





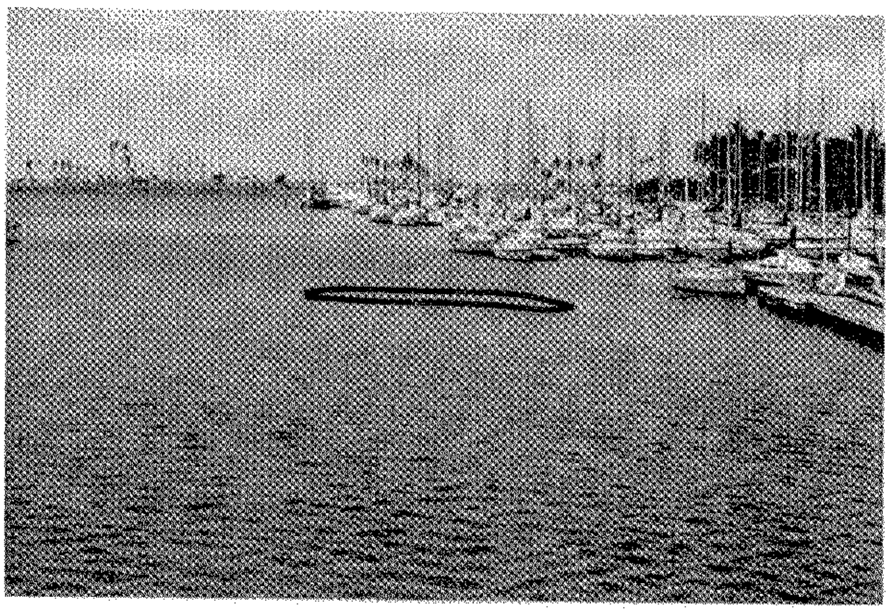


Fig. 5 Surface drift at Station 1 - August 14, 1972. Top left: position of dye marker at 1402 hours is immediately seaward of Ala Wai Canal bridge. Top right: after 30 seconds dye marker has moved seaward as indicated. Bottom left: after 4 minutes dye position is near Waikiki Yacht Club moorings. (For reference, see Station 1 on p. 2)
Drift = 18.9 cm/sec.

APPENDIX II

PROCEDURES FOR COLLECTION OF SAMPLES AND FIELD DATA

A. Sample Collection

Water samples from the surface, 2m and bottom were collected by a diver for laboratory analyses of nitrate, total phosphate, carbonate concentrations and for estimations of total and fecal coliforms. Additional 2 m and bottom samples were collected for analyses of hydrogen sulfide levels.

All samples for chemical analysis were collected at marked depths on sampling lines using normal procedures for minimizing turbulence and entry of air. For the collection of bottom water samples disturbance of the sediments was also minimized. Water samples for bacterial analysis were collected in sterile containers using similar precautions.

Core samples of the sediments (2.5 x 25 cm) were collected from each station for laboratory determination of total organic carbon concentrations and bacterial levels. The sediments at all five stations were found to be very soft and manageable so that no special impacting device was necessary. The core samples for bacterial determinations were placed in sterilized containers.

Immediately following collection all samples were covered with ice and stored in darkness. In the laboratory, all samples were either analysed immediately or stored in a freezer at -20^{o}C.

B. Collection of Field Data

At each station vertical profiles of temperature, salinity, and dissolved oxygen were determined from field measurements made at half meter intervals. Correct depths and intervals were determined by the use of a measured plumb line.

Water samples for salinity determination were collected at each designated point by a diver and brought to the surface for immediate analysis. Measurements were made with an AO Optical Salinometer. The samples were then sealed, stored on ice, and transported to the laboratory for more accurate determinations with a Bissett-Berman model 6230 inductive salinometer having a repeatable accuract of $\pm$ 0.003 o/oo.

Temperature and oxygen measurements were recorded simultaneously using a YSI Model 51A oxygen monitor equipped with a pressure compensating probe. Oxygen concentrations were measured at each half meter interval following calibration for salinity, temperature, and pressure.

Turbidity was determined at each station using a weighted 20 cm Secchi Disk. Three successive readings were made and the average recorded as the Secchi Depth. Extinction coefficients were calculated using the approximation of Poole and Atkins (1929), namely $k = 1.7/D$, where k is the extinction coefficient and D the Secchi Depth in meters.

APPENDIX III

METHODS OF LABORATORY ANALYSIS

A. Chemical Analysis of Water Samples

Nitrate concentration was determined according to the method of Strickland and Parson (1968), using N-(1-napthyl)-ethylenediamine to produce a measurable colored azo compound. A Unicam Sp 800 spectrophotometer at 543 nm was used.

Total Phosphorus was determined by the recommended procedure of Strickland and Parson (1968) using perchloric acid digestion of the unfiltered sample. Spectrophotometric analyses were conducted at 690 nm.

Sulphide concentration was measured spectrophotometrically at 600 nm after allowing the sample to react with p-phenylene-diamine hydrochloride and ferric chloride. Standardization was made with minimum aeration prior to each sulphide determination (Strickland and Parson, 1968).

Total carbon dioxide was calculated from the initial temperatures determined with the YSI oxygen monitor and the laborator r pH of the seawater sample measured by a Corning Model 10 pH meter after standardization. Calculations were made according to the formulations of Strickland and Parson, (1968).

Organic carbon concentration in the sediments was determined using peroxide digestion techniques, followed by evaporation to dryness at 120^{o}C (Harvey, 1970).

B. Bacteriological Analysis

The technique recommended by the Millipore Filter Corporation (1963) was used with some minor modifications for the analysis of bacterial concentrations for all samples.

One, ten, and fifty ml aliquots were used made up to 100 ml volume by the addition of appropriate volumes of sterile water. The entire volume was filtered through gas sterilized Gs 0.45 micron type Millipore filters and appropriate apparatus.

The filters were transfered to petri dishes containing Endo Agar, prepared according to the Difco Manual (9th Edition). The media permits the simultaneous growth of both fecal and non-fecal coliforms, distinguishable by colony shape and color.

Confirmatory tests using EMB agar were conducted for each sample. Incubation of inoculated Endo Agar and EMB plates were carried out at 35^{o}C for 18-24 hours.

APPENDIX IV

METHOD FOR PRODUCTIVITY ANALYSIS

APPENDIX V

METHODS FOR SPECIFIC SOCIO-ECONOMIC ANALYSES

A. Individual Demand for Recreational Boating

Demand conditions were analyzed using cost of participation as the dependent variable. The number of participant days involved in recreational boating was used as the independent variable. The influence of level of participation on average fixed costs was the a priori reason for selecting quantity as the independent variable, in addition to the proposition that fixed investment costs in the boat would encourage the recreationist to participate in pleasure boating more than he would other wise.

An exponential equation was fitted to the data using asymptotic regression analysis to derive the demand curve. The estimated equation for the demand schedule with daily participant costs (Y) as the dependent variable and the annual participant days per boat as the independent variable was:

$$Y = 30.7016 - 33.8408\ (0.8988^{X})$$
$$(5.19) \qquad (2.29) \qquad (11.57) \qquad\qquad \text{(i)}$$

where numbers in parentheses () are the t-ratios.

The coefficient of determination for equation (i) was 0.76. The means were $\bar{Y}$ = $22.60 per participant day and $\bar{X}$ = 304 participant days per year. The equation is presented graphically in Figure 10 (text, p. 38).

The results indicate that the use of total expenditures to estimate a proxy for the price recreationists pay for pleasure boating is a valid and useful method for deriving demand estimates. In addition, the fixed investment in the boat and equipment encourages the recreationist to participate more in pleasure boating than he would otherwise.

B. Impact of Recreational Boating Expenditures on the Economy of Hawaii

The economic impact of recreational boating expenditures on the local economy can be ascertained by using a local multiplier concept, adjusted to make allowance for "leakages" from the economy (Af. F., 1970).

The expression used is:

$$\text{Total income increase} = A/(1-BC) \qquad \text{(iii)}$$

where A = initial expenditure remaining in local area
B = propensity to spend disposable income locally
C = proportion of local income expenditure that accrues as local income.

Assuming that Hawaii's consumption and savings habits have remained similar over time, estimates of B = 0.85 and C = 0.50 are used in the expresion (1).

The magnitudes of the parameters for A are estimated to be:

$$A = 0.399f + 0.500a + 0.551d$$

where f = fixed investment costs
a = annual costs
d = daily costs

Values for A are estimated to be 3,241 for 1972 amd 3,974 for 1975.

APPENDIX VI

METHODS OF STATISTICAL ANALYSIS

The following methods were used for data analysis during the preparation of this Environmental Impact Statement.

1. Correlation Analyses

Correlation coefficients of either or both nutrients with level of salinity were computed using a rank correlation technique (non-parametric) if N was less than 15. When the sample size to be compared exceeded 15, the standard parametric procedure for calculation of correlation coefficients was employed.

Since nitrate, total phosphate, salinity, and bacterial analyses were conducted upon samples which were simultaneously collected, each could be considered to yield matched pairs of data for each specific depth at a particular station and time. Three samplings were made at each station during each sampling period. For the purpose of statistical analysis, each station was considered separately with comparisons made upon matched pairs. Sample pairs from periods of rising and falling tides were analysed separately.

Correlations of N to P and bacterial concentrations with salinity were conducted using the same criteria and precautions.

2. $S_x^2/\bar{x}$ was calculated using the equation for variance determinations appropriate for a small sample size. The subscript , x, is meant to indicate individual point values whose sum divided by N provides the mean and whose dispersion about the mean is estimated by the variance. This technique was used to analyse both nutrient and bacterial distributions related to tidal periods.

APPENDIX VII

DATA - CHEMICAL ANALYSES

Chemical Analyses: Ala Wai Harbor Study

Station	Date Collected	Total P (μg-at/l)	*Nitrate (μg-at/l)	Sulfide (μg-at/l)	Total CO_2 (m mole/l)	Organic C in Sediment (%)
1 Surface	7/10/72	1.412	14.002		1.834	
1 m	"	0.565	0.324	0.00	1.814	
1 Bottom	"	0.928	0.297	0.26	2.097	4.494
2 Surface	"	4.731	4.810		1.942	
2 m	"	0.353	0.595	0.33	1.329	
2 Bottom	"	0.706	0.729	0.56	1.857	1.725
3 Surface	"	1.412	0.270		1.876	
3 m	"	1.341	0.108	0.59	1.959	
3 Bottom	"	3.671	0.270	0.59	1.939	4.626
4 Surface	"	0.777	0.270		1.882	
4 m	"	1.200	0.351	0.59	1.371	
4 Bottom	"	0.988	0.270	0.62	1.969	5.772
5 Surface	"	0.565	0.595		1.889	
5 m	"	0.071	0.351	0.59	1.787	
5 Bottom	"	0.777	0.378	0.62	1.499	1.600
1 Surface	7/17/72	1.084	4.211		1.118	
1 m	"	0.465	1.316	0.00	1.415	
1 Bottom	"	1.161	0.790	0.17	1.333	2.530
2 Surface	"	0.619	3.685		1.550	
2 m	"	1.703	0.526	0.17	1.568	
2 Bottom	"	1.084	0.792	0.17	1.610	1.150
3 Surface	"	1.006	5.700		1.439	
3 m	"	0.852	1.841	0.17	1.458	
3 Bottom	"	0.852	1.053	0.17	1.155	5.700
4 Surface	"	1.161	1.569		1.426	
4 m	"	0.619	1.316	0.17	1.575	
4 Bottom	"	1.703	1.841	0.17	1.550	3.370
5 Surface	"	0.387	8.949		1.290	
5 m	"	0.774	3.685	0.17	1.568	
5 Bottom	"	0.929	3.948	0.17	1.554	0.910

* Nitrate plus nitrite

Chemical Analyses: Ala Wai Harbor Study - Incoming Tide

Station	Date Collected	Total PO_4 (μg-at^P/l)	*Nitrate (μg-at^N/l)	Sulfide (μg-at^S/l)	Total CO_2 (m mole/l)	Organic C in Sediment (%)
1 Surface	7/24/72	1.600	1.835	0.00	2.162	
1 m	"	0.945	0.223	0.00	2.153	
1 Bottom	"	1.018	0.223	0.00	2.153	2.118
2 Surface	"	0.509	1.414	0.00	2.149	
2 m	"	0.509	0.275	0.00	2.095	
2 Bottom	"	1.091	0.198	0.00	2.097	0.7036
3 Surface	"	0.800	1.663	0.00	2.098	
3 m	"	1.455	0.075	0.00	2.149	
3 Bottom	"	0.582	0.099	0.00	2.149	1.150
4 Surface	"	0.582	0.275	0.00	2.098	
4 m	"	0.800	0.050	0.00	2.097	
4 Bottom	"	1.091	0.124	0.00	2.153	1.482
5 Surface	"	0.582	0.124	0.00	2.095	
5 m	"	0.436	0.298	0.00	2.091	
5 Bottom	"	0.582	0.124	0.00	2.091	1.274

*Nitrate + nitrite

Chemical Analyses: Ala Wai Harbor Study

Station	Date Collected	Total PO_4 (μg-at^{P}/l)	*Nitrate (μg-at^{N}/l)	Sulfide (μg-at^{S}/l)	Total CO_2 (m mol/l)	Organic C in Sediment (%)
1 Surface	8/2/72	2.325	16.670		0.665	
1 m	"	0.600	1.095	3.738	0.555	
1 Bottom	"	0.975	0.429	3.738	0.820	
2 Surface	"	3.225	2.143		0.574	
2 m	"	0.675	0.286	0.000	0.835	
2 Bottom	"	0.900	0.310	1.829	0.396	0.678
3 Surface	"	1.575	15.477		0.625	
3 m	"	0.675	0.762	0.000	0.320	
3 Bottom	"	0.050	0.381	0.000	0.468	3.473
4 Surface	"	1.800	0.571		0.630	
4 m	"	0.675	0.214	0.000	0.448	
4 Bottom	"	0.450	0.429	1.829	0.636	1.865
5 Surface	"	0.600	0.714		0.388	
5 m	"	0.150	0.619	0.000	0.485	
5 Bottom	"	0.450	0.286	0.000	0.575	0.913
1 Surface	8/4/72	1.050	12.803		0.422	
1 m	"	0.375	0.719	0.000	0.328	
1 Bottom	"	0.450	0.671	0.000	0.332	3.507
2 Surface	"	0.300	2.036		1.270	
2 m	"	0.225	0.886	0.000	1.070	
2 Bottom	"	0.600	1.677	0.000	0.485	1.910
3 Surface	"	1.125	6.826		0.378	
3 m	"	0.225	0.671	0.000	1.180	
3 Bottom	"	0.375	0.431	0.000	1.010	1.382
4 Surface	"	0.825	0.192		0.683	
4 m	"	0.150	0.934	0.000	0.645	
4 Bottom	"	0.075	0.407	0.000	1.050	1.677
5 Surface	"	0.075	0.647		0.590	
5 m	"	0.000	0.719	0.000	0.583	
5 Bottom	"	0.000	0.216	0.000	0.696	0.811

* Nitrate + Nitrite

APPENDIX VIII

PRODUCTIVITY DATA

Productivity - Ala Wai Yacht Harbor

Date	Station	Depth (m)	pH	Productivity mg C/m^3/hr	% Productivity at 3 meter depth
a. Incoming Tides					
7/10/72	1	0	8.245	137.13	6.93
	1	3	8.235	9.5	
7/24/72	1	0	8.065	277.36	6.82
	1	3	8.149	18.85	
7/10/72	2	0	8.165	61.45	15.4
	2	3	8.180	9.43	
7/24/72	2	0	8.101	76.67	10.4
	2	3	8.151	7.98	
7/10/72	3	0	8.250	175.02	17.5
	3	3	8.245	30.68	
7/24/72	3	0	8.185	275.50	1.608
	3	3	8.185	4.42	
7/10/72	4	0	8.250	92.27	28.4
	4	3	8.230	26.62	
7/24/72	4	0	8.170	66.49	41.5
	4	3	8.170	27.53	
7/10/72	5	0	8.305	72.05	52.5
	5	3	8.290	37.81	
7/24/72	5	0	8.170	131.72	50.5
	5	3	8.170	66.47	

Productivity - Ala Wai Yacht Harbor

Date	Station	Depth(m)	pH	Productivity mg C/m³/hr	% Productivity at 3 meter depth
b. Equilibrium Tides					
7/17/72	1	0	8.370	128.58	7.44
	1	3	8.280	9.56	
7/17/72	2	0	8.251	65.78	12.7
	2	3	8.265	8.33	
7/17/72	3	0	8.345	83.34	16.0
	3	3	8.335	13.31	
7/17/72	4	0	8.305	109.35	20.8
	4	3	8.335	22.63	
7/17/72	5	0	8.365	48.09	24.9
	5	3	8.321	11.49	

Productivity - Ala Wai Yacht Harbor

Date	Station	Depth(m)	pH	Productivity mg C/m^3/hr	%Productivity at 3 meter depth
c. Outgoing Tides					
8/2/72	1	0	8.381	163.15	6.10
	1	3	8.261	9.95	
8/2/72	2	0	8.525	522.87	4.525
	2	3	8.265	23.66	
8/3/72	3	0	8.349	95.09	5.584
	3	3	8.290	5.31	
8/3/72	4	0	8.441	255.09	9.239
	4	3	8.271	23.57	
8/3/72	5	0	8.430	76.34	38.996
	5	3	8.400	29.77	

APPENDIX IX

BACTERIOLOGICAL DATA

Bacteriological Data (Number/100 ml)
Ala Wai Yacht Harbor

Date	Station	Surface		2-meter		Bottom Water		Sediments	
		Fecal	Total	Fecal	Total	Fecal	Total	Fecal	Total
a. Incoming Tide									
7/10/72	1	84	650	58	340	28	196	0	10
	median	116	760	64	360	36	210	10	200
		136	820	70	620	42	440	12	250
	$\bar{x}$	112	743	64	440	35	282	7	153
7/10/72	2	12	38	4	144	2	48	0	0
	median	26	94	8	150	4	62	0	4
		30	180	22	156	8	72	0	6
	$\bar{x}$	22	104	11	150	5	61	0	3
7/10/72	3	60	600	56	470	4	46	0	6
	median	140	690	82	620	74	170	8	24
		164	720	86	740	82	360	10	62
	$\bar{x}$	121	670	75	610	53	192	6	31
7/10/72	4	20	130	50	290	6	40	0	0
	median	24	168	62	650	6	60	0	2
		42	230	66	720	8	72	0	12
	$\bar{x}$	29	176	59	553	7	57	0	3
7/10/72	5	10	118	18	40	32	220	10	96
	median	48	400	24	42	54	250	28	640
		142	524	28	50	56	296	32	720
	$\bar{x}$	67	347	23	44	47	255	23	485

Bacteriological Data (Number/100 ml) Ala Wai Yacht Harbor (Con't)

Date	Station	Surface Fecal	Surface Total	2-meter Fecal	2-meter Total	Bottom Water Fecal	Bottom Water Total	Sediments Fecal	Sediments Total
a. Incoming Tides									
7/24/72	1	190	1850	6	220	58	330	760	1790
	median	330	2100	12	236	64	350	930	1770
		390	3400	16	380	70	474	970	1810
	$\bar{x}$	300	2450	12	278	64	384	890	1790
7/24/72	2	70	590	22	420	28	500	80	830
	median	76	630	40	560	32	550	110	850
		78	700	42	580	76	560	170	1020
	$\bar{x}$	74	640	34	520	44	536	120	900
7/24/72	3	80	370	36	264	84	440	4000	4000
	median	90	380	46	276	90	540	4000	4000
		130	450	50	310	120	700	4000	4000
	$\bar{x}$	100	400	44	216	98	560	4000	4000
7/24/72	4	22	114	54	330	40	244	160	1800
	median	22	120	56	350	80	250	240	1950
		48	132	62	416	92	304	430	3500
	$\bar{x}$	28	122	56	366	70	266	280	2420
7/24/72	5	6	220	8	250	2	300	830	2100
	median	10	244	10	356	4	390	1100	2250
		10	270	12	370	4	570	1250	2500
	$\bar{x}$	8	244	10	326	3	420	1060	2280

Bacteriological Data (Number/100 ml)- Ala Wai Yacht Harbor (Con't)

Date	Station	Surface		2-meter		Bottom Water		Sediments	
		Fecal	Total	Fecal	Total	Fecal	Total	Fecal	Total
b. Equilibrium Tide									
7/17/72	1	10	240	0	30	0	40	10	358
	median	16	280	2	42	0	100	14	400
		30	360	4	56	10	160	16	408
	$\bar{x}$	18	294	2	42	3	110	11	388
7/17/72	2	22	280	0	260	180	600	-	-
	median	28	296	8	304	140	600	22	52
		42	320	18	360	142	600	28	60
	$\bar{x}$	30	298	9	314	130	600	28	56
7/17/72	3	8	302	6	208	0	80	6	200
	median	12	328	6	236	8	160	8	210
		14	360	28	248	6	162	16	240
	$\bar{x}$	11	330	13	230	7	134	10	216
7/17/72	4	20	236	36	284	100	360	2	48
	median	36	240	40	296	106	372	2	60
		40	400	42	360	108	400	12	68
	$\bar{x}$	32	292	40	314	104	376	5	58
7/17/72	5	0	284	0	96	12	208	0	14
	median	2	296	2	102	16	240	0	16
		8	320	10	120	22	242	2	28
	$\bar{x}$	3	300	4	106	17	230	1	19

Bacteriological Data (Number/100 ml) - Ala Wai Yacht Harbor

Date	Station	Surface		2-meter		Bottom Water		Sediments	
		Fecal	Total	Fecal	Total	Fecal	Total	Fecal	Total
c. Outgoing Tide									
8/2/72	1	530	2100	16	440	40	160	130	2800
	median	550	3000	26	520	60	280	150	2850
		600	4000	38	600	70	380	180	3000
	$\bar{x}$	560	3033	27	520	57	273	153	2883
	2	80	600	22	292	44	248	40	380
	median	120	600	22	300	64	330	40	420
		124	600	28	324	108	360	50	450
	$\bar{x}$	108	600	24	305	72	313	43	417
	3	80	680	96	120	72	400	80	400
	median	110	1400	100	130	78	410	350	3100
		130	1450	104	160	84	520	550	3400
	$\bar{x}$	107	1177	100	137	78	443	327	2300
	4	10	96	0	84	24	150	0	30
	median	14	124	6	100	40	160	10	380
		20	136	10	120	44	190	50	780
	$\bar{x}$	15	119	5	101	36	167	20	397
	5	6	46	0	4	0	2	0	200
	median	8	48	4	10	0	14	40	300
		22	60	6	10	2	14	50	700
	$\bar{x}$	12	51	3	8	1	10	30	400

Bacteriological Data (Number/100 ml) Ala Wai Yacht Harbor

Date	Station	Surface		2-meter		Bottom Water		Sediments	
		Fecal	Total	Fecal	Total	Fecal	Total	Fecal	Total
c. Outgoing Tide									
8/4/72	1	150	600	46	800	0	410	0	800
	median	180	640	82	820	0	450	0	840
		310	850	96	1500	20	460	30	860
	x̄	213	700	75	1040	7	440	10	833
	2	150	2200	52	600	56	600	280	600
	median	210	2310	70	620	120	610	400	640
		220	2380	82	660	162	660	400	680
	x̄	193	2297	68	627	113	623	360	640
	3	20	400	20	292	0	620	0	940
	median	48	480	24	360	0	640	10	1060
		60	600	30	380	0	810	80	1220
	x̄	43	493	25	344	0	690	30	1073
	4	80	600	108	1200	2	240	0	2000
	median	120	600	140	1600	16	268	10	2280
		136	600	188	1600	22	304	40	2400
	x̄	112	600	145	1466	13	271	17	2227
	5	2	240	0	1840	48	376	30	1100
	median	2	360	0	1910	76	288	60	1430
		6	440	0	2000	102	502	80	1600
	x̄	3	347	0	1917	75	389	57	1377

APPENDIX X

FIELD DATA

Salinity, temperature, and dissolved oxygen profiles for incoming tides[1].

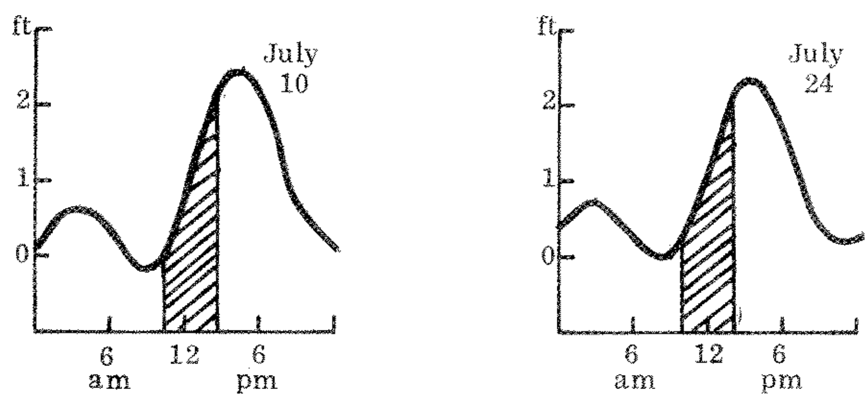
Station	Depth	Salinity* (°/oo) 7/10/72	Salinity* (°/oo) 7/24/72	Temperature (°C) 7/10/72	Temperature (°C) 7/24/72	Dissolved O_2 (mg/l) 7/10/72	Dissolved O_2 (mg/l) 7/24/72
1	0	29.0	35.0	26.0	26.5	6.70	6.20
	0.5	34.0	35.0	27.0	26.5	6.45	6.20
	1.0	34.0	34.0	26.5	26.5	6.29	6.25
	1.5	34.0	34.0	26.5	26.5	6.30	6.40
	2.0	34.0	34.0	26.0	26.5	6.00	6.40
	2.5	34.0	34.0	26.0	26.0	5.60	6.80
	3.0	34.0	34.0	26.0	26.0	4.29	7.00
	3.5	34.0	34.0	26.0	26.0	4.41	7.00
2	0	32.0	35.0	27.5	27.0	6.50	6.40
	0.5	33.0	35.0	27.0	27.0	6.40	6.60
	1.0	34.0	35.0	27.0	27.0	6.60	6.60
	1.5	34.0	35.0	26.9	27.0	6.25	6.80
	2.0	34.5	35.0	26.5	27.0	6.20	6.60
	2.5	34.0	35.0	26.5	27.0	6.00	6.60
	3.0	34.0	35.0	26.5	27.0	5.75	--
3	0	34.0	35.0	28.0	27.5	6.60	5.4
	0.5	34.0	35.0	27.0	27.5	6.45	6.0
	1.0	34.0	35.0	27.5	27.0	6.60	5.4
	1.5	34.0	35.0	27.0	27.0	6.60	6.5
	2.0	34.0	35.0	26.5	27.0	5.50	6.6
	2.5	34.0	35.0	26.2	27.0	5.70	6.5
	3.0	34.0	35.0	26.0	27.0	5.50	6.5
	3.5	34.0	35.0	26.0	27.0	5.60	6.4
	4.0	34.0	35.0	26.0	27.0	5.60	--
	4.5	34.0	35.0	25.9	27.0	5.40	--

* using optical salinometer

(continued - next page)

Station	Depth	Salinity (°/oo) 7/10/72	Salinity (°/oo) 7/24/72	Temperature (°C) 7/10/72	Temperature (°C) 7/24/72	Dissolved O_2 (mg/l) 7/10/72	Dissolved O_2 (mg/l) 7/24/72
4	0	33.0	35.0	27.0	27.0	6.40	5.0
	0.5	34.0	35.0	27.5	27.0	6.40	5.4
	1.0	34.0	34.0	27.0	27.0	6.20	5.4
	1.5	34.5	35.0	27.0	27.0	5.70	5.6
	2.0	34.0	35.0	26.5	27.0	4.80	5.6
	2.5	34.0	35.0	26.0	27.0	4.20	5.4
	3.0	34.0	35.0	26.0	27.0	4.20	5.25
	3.5	34.0	35.0	26.0	27.0	4.05	5.3
	4.0	34.0	35.0	26.0	27.0	4.60	5.3
	4.5	34.0	35.0	26.0	27.0	4.60	--
	5.0	34.0	35.0	26.0	27.0	4.60	--
5	0	34.0	35.0	27.5	27.0	5.65	6.4
	0.5	34.0	35.0	27.5	27.0	5.65	6.4
	1.0	34.0	35.0	27.2	27.0	5.65	6.3
	1.5	34.0	35.0	27.0	27.0	5.60	6.4
	2.0	34.0	35.0	26.9	27.0	5.20	6.5
	2.5	34.0	35.0	26.5	27.0	5.00	--
	3.0	34.0	35.0	26.5	27.0	5.00	--
	3.5	34.0	35.0	26.0	27.0	5.00	--
	4.0	34.0	35.0	26.0	27.0	5.00	--

[1] Shaded areas indicate periods of observation on rising tides of July 10 and 24, 1972.



Salinity, temperature, and dissolved oxygen profiles for equilibrium tide[1].

Station	Depth	Salinity (‰)	Temperature (°C)	Dissolved O_2 (mg/l)
		(all measurements made July 17, 1972)		
1	0	34.0	27.5	6.2
	0.5	34.0	27.5	6.1
	1.0	35.0	27.0	6.9
	1.5	35.0	27.0	7.0
	2.0	34.0	26.5	7.2
	2.5	34.0	27.0	7.6
	3.0	35.0	26.0	7.8
	3.5	35.0	26.0	7.8
	4.0	35.0	26.0	7.0
2	0	35.0	27.5	6.1
	0.5	35.0	27.0	7.0
	1.0	35.0	27.0	7.0
	1.5	34.0	27.0	7.4
	2.0	34.0	26.5	7.2
	2.5	35.0	27.0	6.6
	3.0	34.0	27.0	7.0
3	0	33.0	27.0	7.4
	0.5	33.0	27.0	7.0
	1.0	33.0	27.0	6.8
	1.5	33.0	26.5	8.0
	2.0	34.0	27.0	8.8
	2.5	34.0	26.5	9.1
	3.0	34.0	26.5	9.8
	3.5	34.0	26.0	9.8
	4.0	34.0	26.0	9.2
4	0	34.0	27.5	5.2
	0.5	35.0	27.5	7.4
	1.0	33.0	27.2	8.0
	1.5	34.0	27.0	5.4
	2.0	34.0	27.0	7.9

(continued - next page)

Station	Depth	Salinity ($^{o}/_{oo}$)	Temperature (^{o}C)	Dissolved O_2 (mg/l)
5	0	34.0	27.0	8.2
	0.5	33.0	27.0	7.2
	1.0	33.0	27.0	6.8
	1.5	34.0	26.5	5.4
	2.0	34.0	26.5	7.2
	2.5	34.0	26.2	6.4

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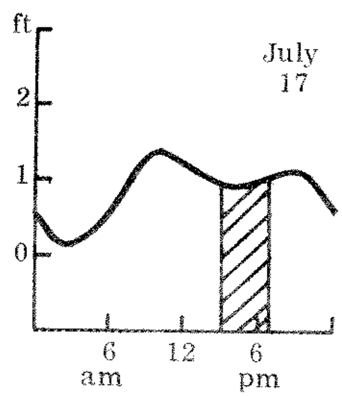
[1] Shaded area indicates period of observation on equilibrium tide of July 17, 1972.



Salinity, temperature, and dissolved oxygen profiles for outgoing tides[1].

		Salinity (°/oo)		Temperature (°C)		Dissolved O_2 (mg/l)	
Station	Depth	8/2/72	8/4/72	8/2/72	8/4/72	8/2/72	8/4/72
1	0	34.0	34.0	29.0	28.0	7.0	6.4
	0.5	34.0	34.0	29.0	28.0	7.0	6.2
	1.0	34.0	34.0	29.0	28.0	6.8	6.2
	1.5	34.0	34.0	28.5	28.0	6.8	6.1
	2.0	34.0	34.0	28.0	28.0	6.8	6.2
	2.5	34.0	34.0	27.0	28.0	6.8	6.2
	3.0	34.0	34.0	27.0	27.5	6.8	6.3
2	0	34.0	34.0	28.1	27.9	6.4	6.6
	0.5	33.5	34.0	28.1	27.5	6.4	6.5
	1.0	34.0	34.0	28.0	27.5	6.6	6.7
	1.5	34.0	34.0	28.0	27.0	6.4	6.5
	2.0	34.0	34.0	28.0	26.0	6.4	6.5
	2.5	34.5	34.0	27.0	26.0	6.4	6.2
	3.0	34.0	34.0	27.0	--	6.4	6.3
3	0	34.1	34.0	28.5	28.0	6.40	6.80
	0.5	34.1	34.0	28.5	28.0	6.8	6.45
	1.0	34.0	34.0	28.5	27.5	6.6	6.40
	2.0	33.5	34.0	27.0	27.5	6.6	6.39
	2.5	34.0	34.0	27.0	27.0	6.6	6.35
	3.0	34.0	34.0	27.0	27.0	6.7	6.35
4	0	34.0	33.5	28.0	28.0	6.85	6.90
	0.5	34.0	33.0	28.0	28.0	6.82	6.80
	1.0	34.0	33.5	28.0	28.0	6.80	6.75
	1.5	34.0	33.5	28.0	27.5	6.85	6.70
	2.0	34.0	34.0	28.0	27.5	6.85	6.60
	2.5	34.0	34.0	27.0	27.5	6.25	6.20
	3.0	34.0	34.0	27.1	27.5	6.65	6.40
	3.5	34.0	--	26.9	27.5	6.30	--

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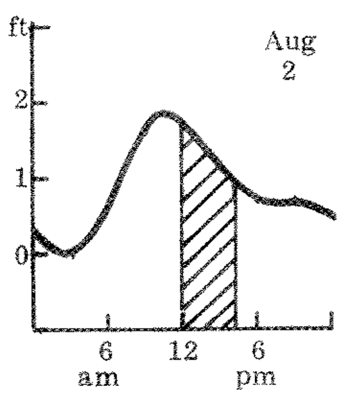
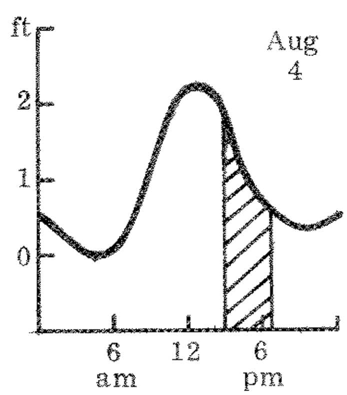
Station	Depth	Salinity ($^o/_{oo}$) 8/2/72	Salinity ($^o/_{oo}$) 8/4/72	Temperature (^oC) 8/2/72	Temperature (^oC) 8/4/72	Dissolved O_2 (mg/l) 8/2/72	Dissolved O_2 (mg/l) 8/4/72
5	0	34.0	34.0	28.0	27.0	6.60	6.80
	0.5	34.0	34.0	28.0	27.0	6.60	6.80
	1.0	34.0	33.0	28.0	27.0	6.45	6.75
	1.5	33.5	34.0	27.0	26.5	6.60	6.70
	2.0	34.0	34.0	26.5	26.0	6.45	6.70
	2.5	34.0	34.0	26.5	26.0	6.80	6.80
	3.0	34.0	34.0	26.0	26.5	6.80	6.80
	3.5	34.0	34.0	25.9	26.0	7.00	6.70
	4.0	34.0	34.0	25.9	26.0	7.00	6.60
	4.5	34.0	34.0	25.5	25.9	7.10	6.50
	5.0	34.0	34.0	25.5	25.5	7.00	6.50
	5.5	34.0	34.0	25.4	25.9	7.00	6.40
	6.0	34.0	33.5	25.5	25.9	7.10	6.40
	6.5	34.0	34.0	25.5	26.0	7.10	6.20
	7.0	34.0	34.0	25.0	25.5	7.00	6.20
	7.5	34.0	33.0	25.0	25.5	7.00	6.25
	8.0	34.0	33.0	25.0	25.5	7.00	6.20
	8.5	33.5	33.0	25.0	25.5	7.00	6.20
	9.0	34.0	34.0	25.2	25.5	7.10	6.40
	9.5	34.0	33.5	25.0	25.0	7.20	6.40
	10.0	34.0	34.0	25.1	25.0	7.20	6.40
	10.5	34.0	34.0	25.0	25.0	7.1	6.40
	11.0	34.0	34.0	25.1	25.0	7.1	6.40

[1] Shaded areas indicate periods of observation on falling tides of August 2 and 4, 1972.





Twenty-four hour temperature and dissolved oxygen profiles.

Station	Depth	T (°C)	DO (mg/l)	T (°C)	DO (mg/l)	T (°C)	DO (mg/l)	T (°C)	DO (mg/l)	T (°C)	DO (mg/l)	T (°C)	DO (mg/l)	T (°C)	DO (mg/l)
Time		1200		1430		1730		2010		2245		0145		0505	
1	0.0	27.6	6.60	27.8	6.45	28.1	6.39	28.0	6.38	27.2	6.50	27.0	6.44	26.4	6.42
	0.5	27.1	6.59	27.4	6.48	28.0	6.38	27.9	6.38	27.7	6.40	27.0	6.42	26.8	6.42
	1.0	26.9	6.60	27.0	6.55	27.3	6.41	27.4	6.40	27.1	6.42	27.0	6.48	26.9	6.44
	2.0	26.7	6.65	26.9	6.60	26.9	6.56	26.9	6.42	27.0	6.50	27.0	6.44	26.7	6.44
	3.0	26.2	6.70	26.7	6.60	26.7	6.58	26.8	6.44	26.8	6.35	26.8	6.50	26.3	6.44
	4.0	26.2	6.70	26.5	6.60	26.7	6.58	26.8	6.45	26.8	6.58	26.8	6.46	26.3	6.40
	4.5					26.7	6.58								
Time		1210		1445		1745		2030		2310		0210		0525	
2	0.0	28.1	6.58	28.0	6.40	27.8	6.39	28.0	6.38	26.3	6.55	26.1	6.44	26.2	6.45
	0.5	27.2	6.60	27.7	6.42	27.3	6.42	27.9	6.38	26.8	6.50	26.4	6.48	26.2	6.42
	1.0	27.1	6.60	27.3	6.49	27.2	6.41	27.4	6.40	26.9	6.59	26.8	6.44	26.6	6.42
	2.0	27.0	6.60	27.1	6.52	26.9	6.42	26.9	6.42	27.0	6.60	26.8	6.44	26.9	6.21
	3.0	26.9	6.65	26.9	6.58	26.7	6.56	26.8	6.44	26.7	6.59	26.7	6.58	26.8	6.40
	3.5					26.6	6.40	26.8	6.45						
Time		1130		1415		1710		2000		2330		0125		0450	
3	0.0	27.3	6.55	27.4	6.58	28.0	6.40	27.9	6.58	27.3	6.42	27.0	6.36	26.8	6.44
	0.5	27.1	6.50	27.2	6.50	27.6	6.42	27.3	6.40	27.2	6.44	27.0	6.40	27.0	6.40
	1.0	27.0	6.45	27.1	6.48	27.1	6.50	27.2	6.40	27.1	6.40	27.0	6.42	27.0	6.40
	2.0	26.9	6.40	27.0	6.60	27.0	6.48	27.0	6.40	27.0	6.40	27.0	6.40	26.8	6.43
	3.0	26.2	6.62	26.8	6.60	26.7	6.59	26.8	6.48	26.9	6.50	26.8	6.50	26.2	6.44
	3.5	26.1	6.80							26.8	6.58				
	4.0			26.6	6.60	26.6	6.57	26.6	6.60			26.7	6.40	26.1	6.42
	4.5					26.6	6.46								

(continued - next page)

Twenty-four hour temperature and dissolved oxygen profiles (con't)

Station	Depth	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
Time		1230		1500		1800		2055		2330		0230		0545	
4	0.0	27.9	6.50	28.0	6.42	27.7	6.54	27.0	6.42	26.4	6.52	26.2	6.50	26.1	6.43
	0.5	27.4	6.50	27.6	6.42	27.4	6.40	27.0	6.40	27.0	6.44	26.8	6.42	26.8	6.40
	1.0	27.2	6.48	27.2	6.50	27.1	6.44	27.1	6.44	27.0	6.40	26.9	6.44	27.0	6.42
	2.0	27.0	6.60	27.0	6.60	27.0	6.40	27.0	6.52	27.1	6.35	27.0	6.42	26.9	6.40
	3.0	26.8	6.59	26.8	6.60	26.7	6.50	26.8	6.46	26.8	6.55	26.8	6.44	26.8	6.42
	4.0	26.5	6.60	26.5	6.60	26.5	6.58	26.4	6.35	26.4	6.60	26.4	6.42	26.4	6.40
Time		1115		1400		1700		1945		2215		0100		0430	
5	0.0	26.6	6.61	27.1	6.70	27.1	6.45	27.1	6.42	26.9	6.56	26.2	6.58	26.1	6.44
	0.5	26.3	6.80	26.9	6.65	26.9	6.59	27.0	6.40	26.5	6.60	26.1	6.60	26.2	6.55
	1.0	26.3	6.70	26.8	6.63	26.8	6.60	27.0	6.42	26.4	6.52	26.1	6.60	26.1	6.50
	2.0	26.2	6.83	26.8	6.61	26.5	6.60	26.8	6.46	26.4	6.59	26.2	6.58	26.0	6.58
	3.0	26.2	6.80	26.7	6.61			26.4	6.48	26.2	6.60	26.1	6.60	26.0	6.54
	4.0	26.2	6.80	26.7	6.62			26.2	6.54	26.3	6.60	26.1	6.58	26.0	6.50
	5.0	26.2	6.90	26.6	6.65			26.2	6.58	26.2	6.60	26.1	6.60	26.0	6.48
	6.0	26.2	6.80	26.7	6.60			26.2	6.60	26.2	6.60	26.0	6.60	26.0	6.56

Extinction Coefficients as Index of Turbidity

Date	Station 1	Station 2	Station 3	Station 4	Station 5
(a) Rising Tide					
7/24/72	1.289	.698	.778	.659	.620
	1.252	.684	.778	.663	.598
	1.289	.681	.798	.667	.655
(b) Equilibrium Tide					
7/11/72	.893	.838	.758	.568	.468
	.932	.848	.740	.572	.465
	.913	.865	.758	.573	.470
(c) Falling Tide					
8/2/72	1.339	1.453	.929	.656	.343
	1.260	1.393	.904	.656	.343
	1.312	1.339	.915	.625	.339
8/4/72	1.491	.806	.871	.746	.407
	1.452	.818	.859	.754	.387
	1.428	.806	.871	.754	.385

APPENDIX XI

DIVER OBSERVATIONS

The following is a summary of the recorded observations made during diving operations.

A. Bottom Visabilities (in feet)

TIDE	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5
Rising	1.5-2	1.5-2	2-3	0	7
Rising	.25	2	3-4	1.5	15
Equilibrium	1.5-2	1.5-2	2-3	0	3
Falling	.5	0	2	.5	6
Falling	1.5	1.5-2	1	1.5	1.5-2

B. Observed Marine Life on Bottom

TIDE	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5
Rising	Sea Anemones	NONE	NONE	NONE	NONE
Rising	Sea Anemones	NONE	NONE	NONE	NONE
Equilibrium	Sea Anemones	NONE	NONE	NONE	5 dead lobsters
Falling	Sea Anemones	NONE	NONE	NONE	1 dead lobster
Falling	Sea Anemones	NONE	NONE	NONE	1 dead lobster

NOTE: All dead lobsters were still intact with meaty portions remaining

APPENDIX XII

HEAVY METALS AND PESTICIDES

A. Heavy metals in Ala Wai Boat Harbor Sediments and Water (Information and analysis courtesy of Mr. Allen Eshleman and Dr. Doak C. Cox)

On three occasions, July 7, 1971, July 14, 1971, and March 6, 1972, sediments and waters from the Ala Wai Canal and Yacht Harbor were sampled for heavy metals. The July samplings were assumed to represent the condition of the waterway during a period of low rainfall; the March sample series was obtained during a period of heavy rainfall. Sample sites are shown in Figure 1. All analyses are performed using standard atomic absorption spectrophotometric techniques.

B. Results

Sediments

Lead (Pb)-Using data from all three sampling dates, the mean Pb content of sediments sampled was 65.7 ± 39.9 ppm[1] (19-193; n=30). The highest values for the July samples were recorded at the extreme landward end of canal near Kapahulu Boulevard (193, 141 ppm respectively). The highest value encountered in the March sampling was 92 ppm at the juncture of the Ala Wai and the Manoa-Palolo Drainage Canal. Lead in harbor sediments (taken here as all samplings from the Ala Moana Bridge seaward) never exceeded 67 ppm (July 7). Samples taken by the Texaco Fuel Dock were uniformly low (20-29 ppm).

Zinc (Zn)- Zn was determined at 12 sampling stations on March 6 only. The mean Zn content was 181.0 ± 49.5 ppm. Values were generally higher in the Harbor area. The highest value, 252 ppm, was recorded at the Ala Moana Bridge station.

Copper (Cu) - Cu analyses was performed on March 6 samples. The mean copper content of sediments was 48.7 ± 16.7 ppm (30-76; n=12).

Cadmium (Cd) - For samples from all three dates, $\bar{X} = 1.8 \pm 1.1$ ppm (0.8-5.6; n=30). The highest and lowest values were recorded at the same general location, midchannel off the Texaco dock (0.8 ppm July 7; 5.6 ppm March 6).

Mercury (Hg) - The mean Hg content of sediments obtained on July 7 and 14 was 0.26 ppm; the mean Hg content of the March samples was 0.56 (0.09-1.34). On all sampling dates the highest values for Hg were obtained in the harbor area.

[1] Dry weight.

Waters

On all sampling dates water samples from the Texaco Dock, Ala Moana Bridge and Manoa-Palolo Drainage Canal Stations were analyzed for Pb, Cd and Hg. No detectable Pb or Cd was present in any samples (limit of detection: Pb 0.01 ug. ml^{-1}; Cd 0.005; Hg 0.0001). Detectable mercury was present in the March 6 samples (0.0007 ug ml^{-1} at the Texaco Dock).

C. Discussion

Pb: Lead in Ala Wai sediments may not originate from a source in the harbor. Dredging has probably distorted the distribution pattern in the Canal and Harbor. Substrate differences may also be important. For example, the bottom off the Texaco Dock is largely crushed coral whereas other stations are largely a high organic anaerobic sludge. The fact that the highest levels of lead in the March sampling run were recorded for the Manoa-Palolo Drainage Canal station suggests that some of the lead in the Ala Wai may originate externally to the Canal-Harbor area. Terrestrial soils on Oahu in regions of high motor vehicle traffic denisty may contain amounts of lead one or two magnitudes higher than the highest values reported for the Ala Wai sediments.

Zn and Cu: These two metals correlate well (r-0.78, p 0.01, 10 d.f.) and occur at highest levels in the harbor area, suggesting that they may have been leached from antifouling paints. The highest recorded Zn and Cu levels on Oahu are 480 and 165 ppm respectively in the Kapalama Canal[2].

Cd: Cadmium does not correlate well with any of the other metals. Levels of this metal are higher than "natural" but no source has been identified.

Hg: Mercury is probably released as a contaminant in the Harbor area. This is supported by the observations that high values were always associated with proximity to the harbor and that on one occasion, when relatively high amounts of Hg was present in harbor waters, the sediments showed a corresponding high level of Hg.

---

[2] Report on Keehi Lagoon and Waikiki Beach Water Quality. Keehi Lagoon Task Force, Office of Environmental Quality Control, January 1971, Appendix J-Z.

D. Pesticides

Shultz (1971) conducted a survey of chlorinated pesticide residues for the waters of the Ala Wai Canal. Table 1 exerpted from this report, generalizes the results of this survey.

COMPARISON OF PESTICIDE LEVELS OF WATER, SEDIMENT, ALGAE AND FISH FROM THE ALA WAI CANAL AND MANOA AND PALOLO STREAMS

	Pesticides (parts per trillion)				
Sample	DDE	Dieldrin	DDT	DDD	RATIO: DDD+DDE/DDT
Water*	0.2	11.1	1.8	2.2	1.22
Sediment*	40,000	40,000	70,000	120,000	2.39
Algae*	10,000	40,000	40,000	30,000	1.00
Mollies*	60,000	240,000	130,000	120,000	1.38
Guppies*	70,000	220,000	170,000	160,000	1.35
Elops (muscle)	140,000	110,000	90,000	400,000	6.00
Chanos (muscle)	250,000	410,000	120,000	130,000	3.17

* Combined for all locations.

Although some individual samples of fish yielded significant amounts of these pesticides, the average values were found to be within the limits of acceptibility.

It must be assumed that pesticide concentrations within canal waters and sediments are equal to or higher than those for harbor waters. No samples were taken within the harbor by Shultz, and funds were not sufficient to allow for sample collection by the Oceanic Institute.

APPENDIX XIII

FINAL PLAN FOR PROPOSED HARBOR IMPROVEMENTS

This plan differs from that described in the text by

(1) permanently fixing stationary docks to Mole A in lieu of the previously proposed floating pier;

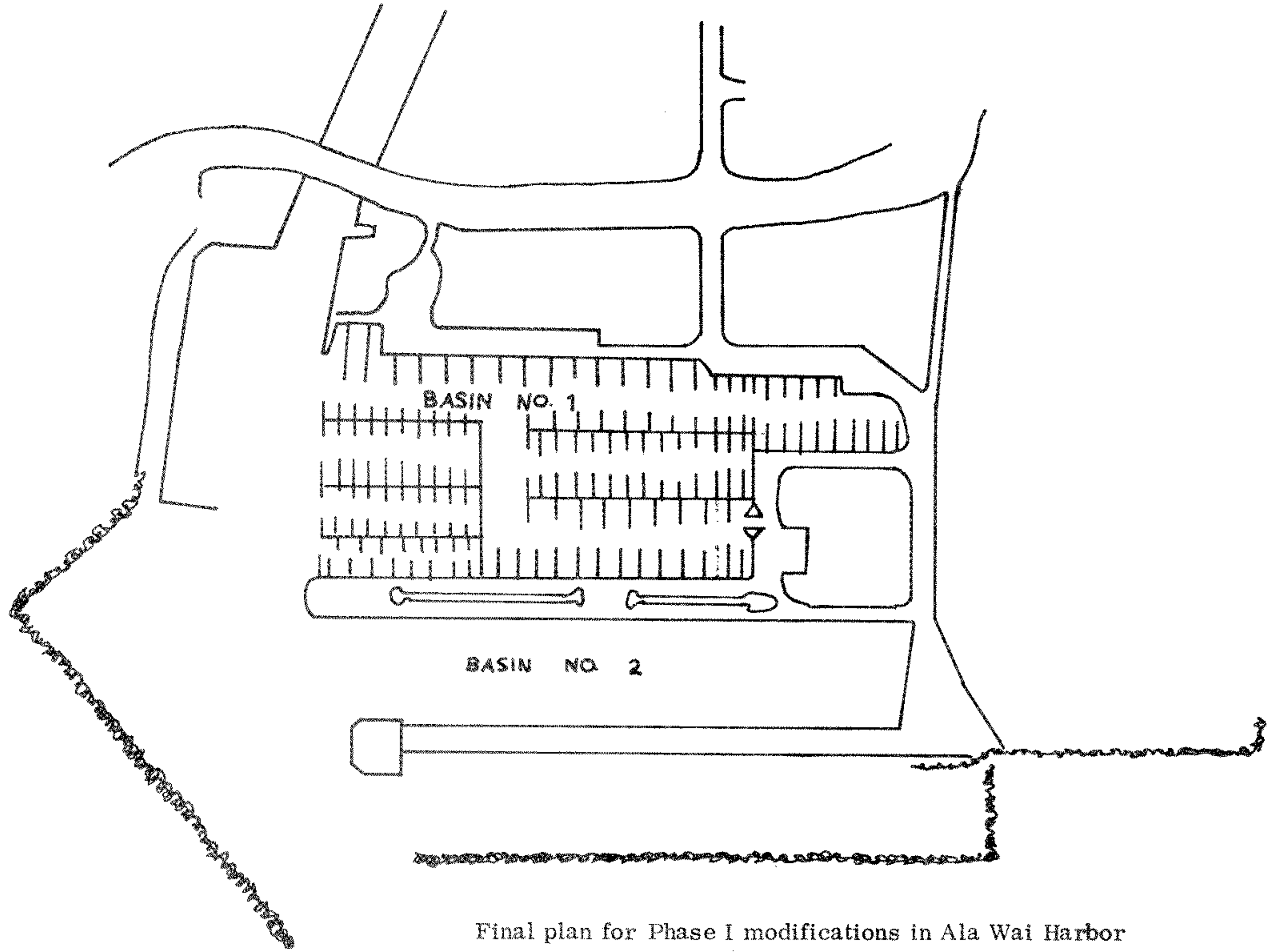
(2) elimination of the proposed floating pier extending from the ocean side of the existing launching ramp and approximately two-thirds of the total length of Mole A;

(3) repositioning of the remaining proposed floating piers extending from the Harbor master's area to a point nearer to the leeward side of the launching ramp;

(4) placement of new moorings on the channel side of the floating pier nearest to the Ilikai Hotel;

(5) replacement of the floating pier extending perpendicular to Mole A with a raised pier supported on fixed pilings. This modification may decrease the impact of this proposed construction upon circulation within the harbor. It is not known how significant this improvement will be.

These modifications to the original design are shown in the accompanying figure and may be compared with Figure 2 of the text.



Final plan for Phase I modifications in Ala Wai Harbor

As far as this Office is concerned, it appears that there is a considerable amount of confusion with respect to the types of diverse comments received. Perhaps a meeting with all of the agencies offering significant comments, the Harbors Division, and the Oceanic Institute will help to clarify the comments and enhance the final impact statement.

Thank you again for allowing this Office to review and process this draft statement. Should you have any comments concerning this letter, please call us at 548-6915.

Sincerely,

RICHARD E. MARLAND
Interim Director

Enclosures

SUMMARY SHEET

Agencies Responding (the date of the letter is in parenthesis)

*Congressman Spark Matsunaga (October 10)
*Senator Hiram Fong (October 10)
*U. S. Geological Survey (October 30)
*Department of Agriculture (November 2)
Department of the Air Force (November 10)
Department of Traffic, City and County of Honolulu (October 12)
Bishop Museum (October 26)
Board of Water Supply (October 30)
Outdoor Circle (October 31)
Department of Health (November 1)
Department of Parks and Recreation, City and County of Honolulu (November 9)
Department of Public Works (November 3)
Environmental Center (November 13)

*Indicates that the agency does not have any comments to offer.

Agencies Offering Comments

1. Department of Traffic, City and County of Honolulu
   The additional berths will create a great demand on the existing parking facilities.

2. Bishop Museum
   Steps should be taken to improve water conditions. They offer various comments questioning the use of the Ala Wai Harbor as well as considering alternatives to increase the circulation of the harbor.

3. Board of Water Supply
   The proposed project is not anticipated to adversely affect the Board of Water Supply's resources or facilities.

4. Outdoor Circle.
   They express concern over the impact of future storm drains to be hooked up to the Ala Wai Canal.

5. Department of Parks and Recreation
   The desirability of the use of the harbor has not really been substantiated. The ill effects of the environmental collapse will have to be compared with the desirability associated with the use of the harbor.

6. Department of Public Works - see attached letter.

7. Environmental Center - see attached letter.

8. Department of Health - see attached letter.

THE OUTDOOR CIRCLE *200 No. Vineyard, Honolulu, Hawaii 96817*

October 31, 1972

Dr. Marvin T. Miura
Environmental Scientist
Office of Environmental Quality Control
State Capitol Building
Honolulu, Hawaii 96813

SUBJECT: Draft Environmental Impact Statement for Improvements at Ala Wai Boat Harbor, Phase I, Honolulu, Hawaii

Dear Dr. Miura:

Many aspects of the subject statement are very technical in nature and The Outdoor Circle can only speak to the area of concern to our organization.

Since some of the present instability of the harbor is the result of imputs via the Ala Wai Canal, we do raise the question of the future impact on the harbor when additional burden is placed upon it by adding drainage of other planned projects, namely; Kapahulu Urban Redevelopment, District Improvement to Makiki drainage, and the expanded Ala Moana Park drainage.

Thank you for this opportunity to express the interest of The Outdoor Circle.

Sincerely,

Mrs. Robert Creps,
President

LC:aa

KANEOHE OUTDOOR CIRCLE
BOX [illegible] KANEOHE, HAWAII 96744
KONA OUTDOOR CIRCLE
KAILUA-KONA, HAWAII 96740
LAHAINA OUTDOOR CIRCLE
LAHAINA, MAUI, HAWAII 96761
LANI-KAILUA OUTDOOR CIRCLE
BOX [illegible] KAILUA, HAWAII 96734
MAUI OUTDOOR CIRCLE
BOX 402 KAHULUI, MAUI, HAWAII 96732
WAHIAWA OUTDOOR CIRCLE
BOX 167 WAHIAWA, HAWAII 96786
WAI-MOMI OUTDOOR CIRCLE
BOX 435 AIEA, HAWAII 96701

JOHN A. BURNS
GOVERNOR OF HAWAII

WALTER B. QUISENBERRY, M.P.H., M.D.
DIRECTOR OF HEALTH

WILBUR S. LUMMIS JR., M.S., M.D.
DEPUTY DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HAWAII 96801

November 1, 1972

Dr. Marvin T. Miura
Environmental Scientist
OEQC, State Capitol
Honolulu, Hawaii

Dear Dr. Miura:

Subject: Draft EIS for Improvements at Ala Wai Boat Harbor, Phase I, Honolulu, Hawaii

Thank you for permitting this Department to comment on the subject draft EIS. Our engineering staff has reviewed the environmental statement and have the following comments:

The report recognizes the inadequacies of the sewage and other domestic waste facilities adjacent to the existing T-pier. However, no plans are proposed to remedy the inadequacies. We strongly recommend that a sewage collection system be incorporated into the Phase I plan.

It was also noted that pumpout facilities will be provided at Mole "B" in the near future. We feel there will be a need for such facilities at Mole "A" also. We strongly recommend pumpout facilities be incorporated into the Phase I plans.

We understand however that the construction of sewage collection facilities and domestic waste facilities in the boat harbor will have very little positive effect if the boat owners and other users of the harbor are not encouraged to utilize such facilities. We further recommend that holding tanks, approved by the Department of Health, be required for all who live aboard their boats. Strict enforcement of Harbors Division Regulations regarding discharge of domestic sewage and other wastes is essential.

By reducing the discharge of domestic wastes into the boat harbor it should be apparent that the critical limits of phosphorous and nitrogen will decrease accordingly.

This Department reserves the right to impose further requirements on the subject project should environmental problems not addressed by the draft EIS occur.

Very sincerely,

/ WALTER B. QUISENBERRY, M.D.
Director of Health

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

RICHARD K. SHARPLESS
MANAGING DIRECTOR

EDWARD Y. HIRATA
DIRECTOR AND CHIEF ENGINEER

ROBERT H. C. CHOY
DEPUTY DIRECTOR AND
DEPUTY CHIEF ENGINEER

DIR 72-193

November 3, 1972

Dr. Richard E. Marland
Interim Director
Office of Environmental Quality Control
State of Hawaii
State Capitol Building, Room 436
Honolulu, Hawaii 96813

Dear Dr. Marland:

Subject: Draft Environmental Impact Statement
Improvements at Ala Wai Boat Harbor
Phase 1

We have the following comments to make on the subject EIS which was transmitted to us on a memorandum dated October 6, 1972.

1. Background information (page 1): There is little discussion on the history of the Ala Wai Canal and Boat Harbor. The effect of the Ala Wai Canal on the Waikiki Beach area was recognized in the early 1940s. The report "Honolulu Sewage Disposal Survey"(May 1940 to September 1941) by the Territory's Bureau of Sanitation recognizes the pollutional aspects of the Canal. The Canal was constructed in 1923 to divert storm waters from the Manoa and Palolo valleys from Waikiki Beach as part of the Waikiki Reclamation Project. Discharge of storm water was into a channel constructed in 1925 crossing the reef parallel with the shore to the Ewa direction and connecting to Kewalo Basin. The Ala Moana Park site was filled from the dredged material. The original plan to construct a channel across the reef in a southwesterly direction was somehow ignored.

The yacht basin was constructed about 1930 by the Harbor Board and later expanded in 1937. During this expansion a channel was dug to a dredged area in front of Fort DeRussy. This channel was later filled in, the original channel blocked off and a jetty built in a southwesterly direction (present condition) as a result of findings of the referenced report.

The tributary drainage districts of the Manoa and Palolo Streams are residential in character with some commercial and light manufacturing activities. There are no industrial wastewater discharges in the streams.

2. Procedures and Methods (pages 3-4): The location of Station 1 is poorly situated if it was intended to show the effects of the Ala Wai Canal on the water quality of the yacht harbor. A station near the Ala Wai Golf Course would be more appropriate because it would be located outside the tidal influence of the harbor. An additional station located 500 feet offside of the channel could have been helpful in determining the effects of harbor waters on Waikiki and Ala Moana beaches.

3. Causative Agents and Sources Within the Ala Wai Boat Harbor (page 6): There are no sewage discharges into the Ala Wai Canal. The area in the drainage districts of the two streams and Waikiki are completely sewered. Wastewater collected are conveyed to Sand Island for disposal via an ocean outfall. It is anticipated that secondary treatment and disposal through a new ocean outfall sewer 9,000 feet offshore off Sand Island will be completed by 1975.

Mean values of total nitrogen and total phosphorus in the raw sewage discharge off Sand Island are 20.7 mg/l and 2.4 mg/l respectively. There are little or no nitrites or nitrates in the effluent. Honolulu's wastewater is very weak comparatively because of substantial groundwater infiltration into the sewers.

4. Data (pages 8-17): The report could be improved if proper units were shown. Since water quality standard's parameters for nitrogen and phosphorous are listed in mg/l and total and fecal bacteria counts in number (MPN)/100 ml, these units should be used. Water quality data collected for the EIS study over a five weeks period is totally inadequate. Sampling should have conducted over a one-year period to take into account the normal variation of the seasons.

During the Water Quality Program for Oahu with Special Emphasis on Waste Disposal (WQPO, 1972), Station 28 and 29 were established for the Ala Wai Harbor and Ala Wai Canal respectively. Station 28 was located where Station 1 of this report is located. Water quality data collected during WQPO are enclosed for the investigator's information.

5. Phosphorus (page 28): Special studies were contacted by WQPO using batch and continuous-flow cultures to evaluate the biostimulatory effects of wastewater discharges on Oahu. These studies were conducted at HIMB, Kaneohe. It was concluded from these studies that for Oahu oceanic waters nitrogen was probably growth limiting (0.007 mg/l) instead of phosphorus. Documentation of these studies is found in the Final Report of Work Area 5, Special Studies (WQPO).

6. Light (page 30): Light attenuation coefficients using a Hydro products Irradiance Meter Model 420 taken in the vicinity of Station 1 on February 24, 1971 (1300 hours) at the 10 foot depth gave the following values.

No filter	0.690
Red (600-900 mu)	0.958
Green (478-660 mu)	0.603
Blue (370-500 mu)	0.831

7. General Condition of the Present Environment (pages 32-33): A significant concentration of heavy metals was found in the sediments at the Ala Wai Harbor. The very high concentration found undoubtedly came from bottom paints used on boats. Arsenic and mercury were also found in these bottom paints and their presence in the sediments is apparent. The mercury concentration in the Harbor was 58.0 ppm. Considering that marine organisms are able to concentrate mercury and other metals and are acquired along the shoreline by residents, these findings are significant. Analysis for heavy metal was performed at Stoner Laboratory, Inc., Campbell, California, and are as follows:

	(ppm)
Mercury as Hg	58.00
Arsenic (AS_2O_3)	212.0
Copper (Cu)	7000.0
Zinc (Zn)	1420.0
Lead (Pb)	5000.0
Iron (Fe)	56,000.0

Nutrient analysis of the sediment sample taken in Ala Wai showed the following results:

	mg/gm
Bicarbonate Extractable Phosphorus	0.031
Ammonia nitrogen	0.00
Organic nitrogen	0.69
Total nitrogen	0.69
Sulphide	0.02
Index of Putrescibility	1.50

Using the criteria developed by Special Studies for the Water Quality Program for unstable biological communities (depressed biological diversity) at limiting concentration of 0.05 mg/gm phosphorus and 0.6 mg/gm total nitrogen, unstable benthic communities can be expected to be found in the Harbor.

8. Impact of Light (page 44): Additional shading could be beneficial initially until the Harbor was cleaned up. By limiting the available light the autotrophic component of eutrophication could be retarded.

9. General conclusions are that the draft EIS is inadequate. The proposed Department of Transportation project will have significant impact on water quality standards in the yacht harbor and could have lasting influence on the waters of Waikiki and Ala Moana beaches. The State of Hawaii should set an example for others to follow by providing adequate funds so that a comprehensive water quality study could have been made.

Toilet and shower facilities were described as totally inadequate in the report (page 42). The Harbors Division should correct this inadequacy and eliminate all cesspools in the harbor area by connecting to the municipal sewer system (page 46).

Thank you for giving us the opportunity to review and comment on the statement.

Very truly yours,

EDWARD Y. HIRATA
Director and Chief Engineer

Enclosure

DEPARTMENT OF TRAFFIC

CITY AND COUNTY OF HONOLULU

HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

RICHARD K. SHARPLESS
MANAGING DIRECTOR

GEORGE C. VILLEGAS
TRAFFIC DIRECTOR

ROY A. PARKER
DEPUTY TRAFFIC DIRECTOR

October 12, 1972

Dr. Marvin T. Miura
Environmental Scientist
Office of Environmental
  Quality Control
State Capitol Building
Room 436
Honolulu, Hawaii 96813

Dear Dr. Miura:

Subject: Draft Environmental Impact Statement for Improvements at Ala Wai Boat Harbor, Phase I, Honolulu, Hawaii

The Traffic Department feels that the expansion of the boat harbor will create a great demand on existing parking facilities in the area and this should be mentioned in the impact section on page 43.

Very truly yours,

Clifford Y. Nohara

for ROY A. PARKER
Deputy Traffic Director

MASS TRANSPORTATION
C.M. GILLISS
EXECUTIVE DIRECTOR
1140 ALAPAI ST.
PH. 546-7581

TRAFFIC ENGINEERING & PARKING
CLIFFORD NOHARA, P.E.
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ROBERT BING
TRAFFIC SAFETY EDUCATION OFFICER
CITY HALL ANNEX
PH. [illegible]

BERNICE P. BISHOP MUSEUM

P. O. Box 6037, Honolulu, Hawaii 96818 • Telephone 847-3511

October 26, 1972

Dr. Marvin T. Miura
Office of Environmental Quality Control
State Capitol Building, Rm. 436
Honolulu, Hawaii 96813

Dear Dr. Miura:

Draft Environmental Impact Statement for Improvements at Ala Wai Boat Harbor, Phase I.

It is evident that construction of new harbor facilities at the Ala Wai Boat Harbor will increase the critical water environmental crisis already facing that area unless implementation of controls outlined on pp. 45-46 of the Impact Statement is effected. Steps to improve conditions there should be taken soon, regardless of additional harbor facilities.

Yours sincerely,

Roland W. Force

Roland W. Force
Director

BERNICE P. BISHOP MUSEUM

P. O. Box 6037, Honolulu, Hawaii 96818 • Telephone 847-3511

October 26, 1972

Dr. Marvin T. Miura
Office of Environmental Quality Control
State Capitol Building, Rm. 436
Honolulu, Hawaii 96813

Dear Dr. Miura:

Draft Environmental Impact Statement for Improvements at Ala Wai Boat Harbor, Phase I.

The Museum's comments on the above Draft Statement have been conveyed to you by letter of even date. In addition, Dr. J. Randall, Museum Ichthyologist, has given me comments based on his personal experience. I thought I should share these with you.

Yours sincerely,

Roland W. Force

Roland W. Force
Director

Encl.

BERNICE P. BISHOP MUSEUM

P. O. Box 6037, Honolulu, Hawaii 96818 • Telephone 847-3511

October 18, 1972

TO: Dr. Roland W. Force, Director

FROM: Dr. J. Randall, Ichthyologist JER

SUBJECT: Draft Environmental Impact Statement for Improvements at Ala Wai Boat Harbor, Phase I.

1. Having lived for five years on my own sailing vessel at the Ala Wai Yacht Harbor I do know of the situation there and I have some views.

2. First of all, on p. 37, there is an obviously erroneous statement. It is stated that, from a survey, the average boat at the Ala Wai is used for recreational purposes 56.3 days a year. I would assume recreational means taking the boat out for a sail, not just sitting aboard and drinking beer. If it means taking the boat out, then the figure of 56.3 days per year is a gross exaggeration. Perhaps a decimal point was placed in the wrong place and it meant 5.63 days, but even then it would seem high.

3. I am making this point because the crux of the matter lies in the large number of boats in the harbor that are there merely as a place to live (i.e. avoid paying the rent of an apartment or house). Many of these boats were once seagoing vessels but are now derelicts (and a relatively high percentage of these are unsightly) and many are purely and simply houseboats. Rather than try to increase the number of slips in the harbor for still more boats, an attempt should be made to eliminate those that, say, could not safely cross the Molokai Channel. This could be done fairly by having a State-appointed group that would survey the boats and determine their seaworthiness. If not seaworthy, the boat's owner could be given a period of time such as one year to make the vessel seaworthy or get rid of it.

4. Another big problem is the lack of water circulation in the harbor. Ideally a second channel should be cut through the reef from the Diamond Head side which would be more at an angle to the usual tradewind direction, thus making it safer for sailboats. The existing channel is almost straight into the prevailing wind. Such a channel would be expensive and perhaps not feasible for one reason or another, such as possible encroachment on the man-made lagoon in front of the Hawaiian Village Hotel (which is on State land). An alternative suggestion would be to have several pipelines running from the

open sea into the Diamond Head side of the harbor to create a head of water flowing in the Ewa direction, thus providing the necessary flushing and avoiding the drift of Ala Wai Canal water and its debris into the yacht area.

5. Finally, I think more effort should be expended in developing other harbor facilities for small boats on Oahu, such as in Kaneohe Bay. Obviously, even if the additional slips are added to the Ala Wai facility, the growing demand for boats and moorage space will soon overwhelm that facility.

UNIVERSITY OF HAWAII
Environmental Center
Office of the Director

MEMORANDUM

November 13, 1972

TO: Marvin Miura, OEQC

FROM: Jerry M. Johnson

SUBJECT: Draft Environmental Impact Statement for Improvements at Ala Wai Boat Harbor

The Environmental Center was joined by Gordon Dugan, Civil Engineering and WRRC; Henry Gee, WRRC; Alison Kay, General Science; Morris Miyagi, E.C.; Jackie Miller, WRRC; James Moncur, Economics; Thomas Newbury, Oceanography; Richard Scudder, E.C.; Edward Stroup, Oceanography; and Hiroshi Yamauchi, WRRC.

Overall we find the statement to contain several major errors. These errors pertain to basic data presented, data assessment, and conclusions based on the data and data assessment. In addition, we find ourselves in the unusual position of presenting the opinion, overall, that the environmental impacts of the proposed action are likely to be significantly smaller than those estimated by the authors of the EIS.

I. INTRODUCTION

1. Background Information (page 1)

The construction of Magic Island and the breakwater at the southernmost end of the harbor were not responsible for the formation of the Ala Moana curl (actually called the Ala Moana bowl). The breakwater did intensify the current, especially with high surf, although it has had no effect on the size of the waves. The site, reef bottom combined with a certain height of water above it, formerly created rideable waves up to fifteen feet or more. Today, with a large swell, the waves become unrideable (too much of the wave breaks lengthwise at one time) at about 8 to 10 feet. This decrease in rideable wave height is due partially to the stacking up (surging) of water inside the break. This phenomenon causes the waves to be bumpy and causes parts of the waves to break prematurely (called sectioning or closing out).

II. CAUSATIVE AGENTS AND SOURCES WITHIN THE ALA WAI BOAT HARBOR

1. Current Movements (page 6)

The authors exhibit a lack of understanding of the variability of currents in their attempt at the general description of flow patterns. The detail of the pattern they portray is absurd considering the inadequate number of observations, and is, besides, physically highly unlikely.

The authors also reveal a lack of comprehension of the techniques of current measurement by the way they have reported their data. Ekman-Merz meters are useless for currents below 2 to 3 cm/sec, and at low speeds long periods of observations must be used to average out fluctuations in speed and direction. The authors used runs of only a few minutes (Table 1, p. iv), and report current to one-thousandth of a cm/sec. This would be equivalent to using a yardstick marked only to the nearest inch, and reporting the measurements to thousandths of an inch.

The authors are apparently unaware of the nearshore currents in the vicinity of station 5. They have not taken into account the strong wave-driven flow which crosses the reef flat off the outer breakwater, entering the side of the channel between Sta. 5 and the end of the breakwater. During high surf, so much water enters the channel in this flow that there is a rip-current outflow in the outer channel no matter what the stage of the tide. Under such conditions, the water which enters the harbor must come from the reef flat, not from the outer channel. (The dead lobsters observed at Sta. 5 may have been washed off the reef flat by the wave-driven current.)

The authors were careless in preparing some of the figures -- see, for example, the curve for Sta. 1, 8-8-72, in Fig. 2, p. viii. The directions indicated by this curve do not match the data in Table 1, p. iv. (This mistaken curve is referred to in the text.)

Some of the current directions reported by the authors seem physically impossible. This is most clearly seen in Sta. 1, which seems to show a strong outflow beneath the surface during an incoming tide. (The correction of the curve for this station, mentioned in the above paragraph, makes the situation worse.) This cannot be. During strong rising tide the flow must be inward at mid- and bottom depths (it could be out at the surface, if there had been heavy rainfall). On examining their data and figures to try to resolve this very serious question, suspicion begins to emerge. The currents at 2 and 3 m at Sta. 1 during incoming tide are plotted in Figs. 4(c) and 4(d). Looking at Table 1, these same currents are found to be in the directions 050° (2 m) and 065° (3 m). The authors have plotted these as currents flowing from 050° and 065°, respectively. Can they possibly not be aware that, in oceanography, currents are given in the direction the water is flowing toward? Can they possibly not know that the direction indicated by their Ekman-Merz meter (or any other meter) follows this convention -- it is the direction the vane of the instrument is pointing, i.e., the direction toward which the water is moving? Is it possible that all their current directions should be exactly reversed? (Certainly an oceanographer, starting with their tabulated data, would have drawn everything in the reverse direction!) If they have, in fact, got everything backward -- and the evidence for this is very strong -- their entire current analysis is totally invalid.

Recommendation: They would be well advised to eliminate all their current measurements and their flow analysis from the Statement. It would be much better to make only a very few physically sensible comments based on the shape and depth of the basin, the tidal range, and previous current measurements in the Canal.

3. Data Interpretation (page 7)

a. The $S^2/\bar{x}$ ratio is an indication of the homogeneity/heterogeneity of samples. The larger the ratio the more heterogeneous the universe from which the samples were taken. Thus the conclusion, the larger the ratio the more near-by the source, is incorrect. The opposite should be true in that the larger the ratio, the further away the sample would be, assuming the body of water was sufficiently homogeneous in all other aspects to allow such a conclusion.

b. We question the validity of the source conclusions as they are based on statistical evaluation of water quality data of very small sample size. For example: page 9, para. 1, line 1 "Total P would originate at this station (station 1) from the canal waters as almost 90% of its concentration can be explained on the basis of its association with lower salinity waters"; page 9, para. 2, line 1, "The high $S^2/\bar{x}P$ ratio could be explained by a localized discharge of detergents"; page 11, para. 1, line 1, "A significant input of untreated sewage is discharged into Channel 1. It has already been demonstrated that the canal is not the major source of this material at station 2. This is confirmed by high $S^2/\bar{x}$ ratios for both fecal and total coliform concentrations which indicate nearby sources." Rather than formulate conclusions on questionable data base and skeptical application of statistical tools, we would recommend a more complete survey of effluent sources within the bay and the monitoring of those sources to determine their respective contributions to the water quality characteristics of the harbor and canal waters. With respect to live aboards, simple calculations could have been carried out which would have given a reasonable indication of the contribution of those sources to nitrogen/phosphorus and coliform levels in the harbor as compared to the canal and bay contributions.

c. The nitrogen and phosphorus correlation studies appear to be based on composites of data from different universes (i.e. incoming and outgoing tides, surface, 2 meters and bottom samples). If this is so, then the correlations would be meaningless, even if they were derived from an adequate population size. A further complication is that only nitrate-nitrogen data is utilized. Slow nitrogen release fertilizer such as those used by professional turf managements (Ala Wai Golf Course) are organic in form and not nitrates. The identification of eutrophication with NO_3-N is basically correct but the source of the nitrate can be organic, ammonium or nitrate nitrogen. The correlation of N/P should have been made with the total nitrogen to indicate the total potential source. Not only is NO_3-N being taken up by the organisms at different rates, which changes the NO_3-N/P ratio, but the transformation of organic nitrogen and ammonium nitrogen to the nitrate form is dependent upon bacterial action. The assumption that untreated sewage waters have a NO_3-N + NO_2-N/P ratio of 0.4 is not necessarily correct inasmuch as this ratio can vary significantly depending upon the freshness of the sewage.

5. & 6. Phosphorus, Nitrogen (pages 28-31)

The phosphorus correlation study was based on total phosphorus rather than available P. Since these two values can differ widely, the correlation as presented may be grossly inaccurate. Further, phosphorus concentration vs. productivity rate is not usually linear at all phosphorus ranges. Generally it is a rectangular hyperbola, exponential function, or a linear function with 2 phases (first order and zero order relationship). P might be limiting to productivity, considering the very low N/P ratios observed at each of the sampling stations. If other chemical forms of nitrogen, ammonium-N and organic-N, had been measured, the ratios would have been enlarged to some degree, although these very low ratios suggest that fertilizers may be a major source of nitrogen and phosphorus contamination at the 5 sample stations.

Runoff from urban land can contribute significantly amounts of nutrients to the Ala Wai Canal. [Wet weather flow from Palolo and Manoa streams can contribute 2 times the phosphorus and 1.5 times the total nitrogen concentration from dry weather flow (Ching, 1972).] Data of these streams taken during wet and dry weather flows showed concentrations of T-P to be 0.57 and 0.43 mg/l, respectively (Ching, 1972) and analysis of ocean water off Waikiki at 50 foot depth showed total phosphorus to be greater than 0.03 mg/l. Thus it is doubtful that phosphorus can be a limiting factor for productivity in the Ala Wai Harbor. Only the degree of *eutrophication* can be controlled by limiting the amounts of nutrients discharged from the boats. Convenient sanitary waste pump out stations and mandatory "no direct discharge" holding facilities for boats would undoubtedly help control nutrient release in the harbor.

III. INFLUENCE OF CAUSATIVE AGENTS UPON PRODUCTIVITY

1. Temperature and Salinity (page 19)

Data acquired by Jackie Miller, WRRC and others*during a three-year comprehensive study of the Ala Wai Canal ecosystem (final draft in preparation) are pertinent to the salinity results shown in the EIS.

The average surface salinity (Table 1), recorded at 20cm. on an incoming tide at Station 1 just mauka of the Ala Moana Bridge in the midline of the canal (see Figure 1.), was 18.62‰. Considering the entire section of the canal from the Ala Moana Bridge to the Kalakaua Street Bridge, the surface salinity on an incoming tide ranged from 18.6 to 25.0. This average was not significantly different from that recorded for an outgoing tide (18.2 - 26.2). Bottom salinities showed no significant difference between incoming and outgoing tides; ranging from 31.6 to 34.8 over the same area.

The salinity values are considerably lower than those reported in the EIS. Their significance is in illustrating the great variability of water quality parameters in the canal; and to the extent that the canal waters flow into the Ala Wai Boat Harbor, a high variability can be expected in the boat harbor. (The variation from hour to hour can be as great as the day to day variation which in turn exceeds the seasonal variation.)

*Pre-Management Study of the Ala Wai Canal, Department of Oceanography. (Garth Murphy, Principal [illegible]

2. Dissolved Oxygen (page 19)

The O_2 values presented are highly suspect. Algal population densities which would be necessary to produce the supersaturated O_2 conditions would serve as a barrier to light penetration to lower depths. Thus a pronounced O_2 gradient with depth would be expected. Further, the algal population would have exerted a very large night-time demand on the available dissolved oxygen, yet no pronounced difference between diurnal and nocturnal dissolved O_2 values are observed. These anomalies in dissolved oxygen time/depth profiles cannot be explained in terms of canal water influences. First, the lighter canal waters would have a tendency to float on the more dense harbor water, thus having little influence on the dissolved oxygen depth profiles. Secondly, algal-laden canal waters would exhibit the same nocturnal decrease in dissolved O_2.

Jackie Miller's dissolved oxygen data (Table 2) at the Station 1 described earlier in Section III, 1 (Temperature and Salinity) is similar to that presented in the EIS although her surface and bottom values are generally lower during both incoming and outgoing tides. In addition, her data shows a more pronounced variation with depth and the overall variability is great.

3. Carbon Dioxide (page 23)

Total carbon dioxide is calculated from pH and temperature measurements. The carbon source for productivity can also come from HCO_3^-, $CO_3^=$ by way of carbon dioxide. A better measurement for the potential carbon source would have been total inorganic carbon. At a pH of about 8.3, as found in the Ala Wai Harbor waters, the major ion is HCO_3^-. As CO_2 is extracted additional carbon dioxide is provided by the reaction.

$$2\ HCO_3^- \rightleftharpoons CO_3^= + H_2O + CO_2$$

and

$$HCO_3^- + H_2O \rightleftharpoons H_2O + CO_2 + OH^-$$

In highly active algal systems, as CO_2 is taken up and thus, creating an increase in the pH, the $CO_3^=$ can be a major source of carbon, as shown in the reaction

$$CO_3^= + H_2O \rightleftharpoons CO_2 + 2\ OH^-$$

A decrease of free CO_2 to a point where it cannot be met by atmospheric CO_2 exchange would create the condition that CO_2 would have to be supplied from HCO_3^- and $CO_3^=$ forms. Thus under the present conditions it is doubtful that carbon should be limiting in the Ala Wai Boat Harbor.

IV. GENERAL CONDITION OF THE PRESENT ENVIRONMENT

Based on our earlier comments regarding O_2, CO_2 and phosphorus, we cannot agree with most of the conclusions concerning the general condition of the present environment. We seriously doubt that either phosphorus or CO_2 is limiting to productivity. We also question the conclusion that the vertical water column is saturated with O_2, or even near so, from top to bottom. In fact, the discussed lobster kills would suggest that H_2S might have been the causative factor. H_2S production would depend upon anaerobic conditions within the lower portion of the water column or in the sediments. Of course, other unmeasured toxic materials could have been responsible for the deaths or the lobsters could have died on the reef flat and then washed into the channel.

The heavy metal data presented shows significant concentrations which are not low compared with undeveloped areas on Oahu. Significant amounts of Zn, Cu and Hg are contributed by boats and studies of their effects on marine biota living in the boat harbor have yet to be made.

It is important to note that the previously mentioned study by Jackie Miller et al. showed a significant population of phytoplankton, zooplankton, nekton and benthic marine organisms exist in all areas and at all depths in the canal with the exception of the bottom region between the intersection of Kaiulani and Liliuokalani Streets. (Those populations were observed even though circulation in this region is severely restricted due to the bottom topography; hence the area is subject to occasional low oxygen levels.)

V. SOCIO-ECONOMIC ENVIRONMENTAL ANALYSIS

Section V on "Socio-Economic Environmental Analysis" bears little relevance to existing environmental conditions of the Harbor and also to the potential environmental impact of the proposed project. The statistical procedures that have been applied are of questionable validity in view of inadequate data considerations. A stratified sampling procedure was used to obtain socio-economic data from 20 boat owners. The statement does not clearly indicate how many strata were chosen nor how they were defined. Assuming, however, that three more or less equal size subsamples of 6 to 7 boat owners were obtained from the small, medium, and large boat classes respectively, the multiple regression technique can hardly be expected to produce statistically significant results. The stepwise regression method was applied to as many as six and seven variables. The reduced degrees of freedom not to mention the expected high multicollinearities among several of the selected variables precludes the possibility of any meaningful statistical analysis of the type employed. The credibility of the results presented cannot be established without revealing the data base from which such results were obtained. Apart from the questionable relevance of the socio-economic environmental analysis in this draft statement, if such an analysis is deemed desirable at all it should at least in part be directed toward assessing the distribution of costs and benefits. Such an assessment should be made with the view toward determining whether or not there is any relationship between the existing incentive system and environmental quality conditions of the harbor. The assessment should then be extended to also cover the proposed project.

VI. ENVIRONMENTAL IMPACT OF THE PROPOSED CONSTRUCTION WITHIN THE ALA WAI BOAT HARBOR

1. Impact

a) page 43

We question the conclusions made concerning the magnitude of the effect of the proposed changes on the water circulation within the harbor. The pier alteration and the increase in the number of boats would have some effect on overall circulation but that effect should be moderate.

b) page 44

The increase in boats will, of course, reduce the amount of light reaching the harbor waters, although the estimated 30.2% seems high. Any gradual reduction in the amount of light reaching the organisms such as shading from boats will reduce productivity - which may be desirable. However, the increase in the number of boats may have a detrimental polluting effect, unless live-aboard waste discharges are eliminated from the harbor. Two additional potentially undesirable consequences of increasing the number of boats are crowding and noise. Neither has been discussed in the statement.

Finally, based on extensive collections of abundant and varied biota throughout the Ala Wai Canal over the past three years by Jackie Miller et al., it does not seem reasonable that the Ala Wai Boat Harbor whose connection with the sea and resultant circulation is eminently greater than the canal is in danger of "an environmental collapse".

2. Alternatives

An alternative that was not discussed in the EIS is the mooring of small boats in the section of Ala Wai Canal between Kalakaua Bridge and Ala Moana Bridge. That section of the canal would have sufficient depth and would certainly be an aesthetic attraction to the area. Since there would be no live-aboards, the boats would not be a source of pollution within the canal or harbor. Their removal from the harbor would provide space for additional larger boats, thus making better use of this deeper water. As a precedence for this proposed alternative, we cite the small boat moorings on the lower portion of Nuuanu Stream.

Although we may appear to have been severe in our comments, the authors should be commended for the comprehensiveness of the document. The more data that is presented in an EIS, the more opportunity the reviewers have to make a substantive critique. Thus the quality of EIS statements should not be based solely on the amount of criticism received.

We also find the approach to writing the statement refreshing. Usually authors do little more than write a justification for the proposed project. The authors of the Ala Wai boat harbor EIS, however, have presented a thorough environmental assessment without biasing their data in favor of the proposed project.

Jerry M. Johnson
Assistant Director

cc: Reviewers

Station 1.

	Salinity (%)	STD.	N	Temp. (α)	STD.	N	Oxy. (mg/l)	STD.	N
Outgoing tide	30.05	5.67	8	26.39	1.44	10	5.91	1.50	8
Outgoing tide Surface, 0-20 cm.	25.72	4.28	4	26.66	1.44	5	7.07	1.28	4
Outgoing tide Bottom data	34.37	.30	4	26.12	1.16	5	4.75	.39	4
Incoming tide	25.72	10.73	19	26.12	1.47	19	6.25	2.28	16
Incoming tide Surface	18.61	9.24	9	26.38	1.60	9	7.51	2.10	8
Incoming tide Bottom data	32.11	7.45	10	25.89	1.29	10	4.99	1.15	8

TABLE 1. Salinity Data Collected By Jackie Miller, WRRC, And Others*During a Three-Year Comprehensive Study of the Ala Wai Canal Ecosystem At A Station Just Mauka Of The Ala Moana Bridge In The Midline Of The Canal.

*Pre-Management Study of the Ala Wai Canal, Department of Oceanography (Garth Murphy, Principal Investigator).

Oxygen (mg/1)

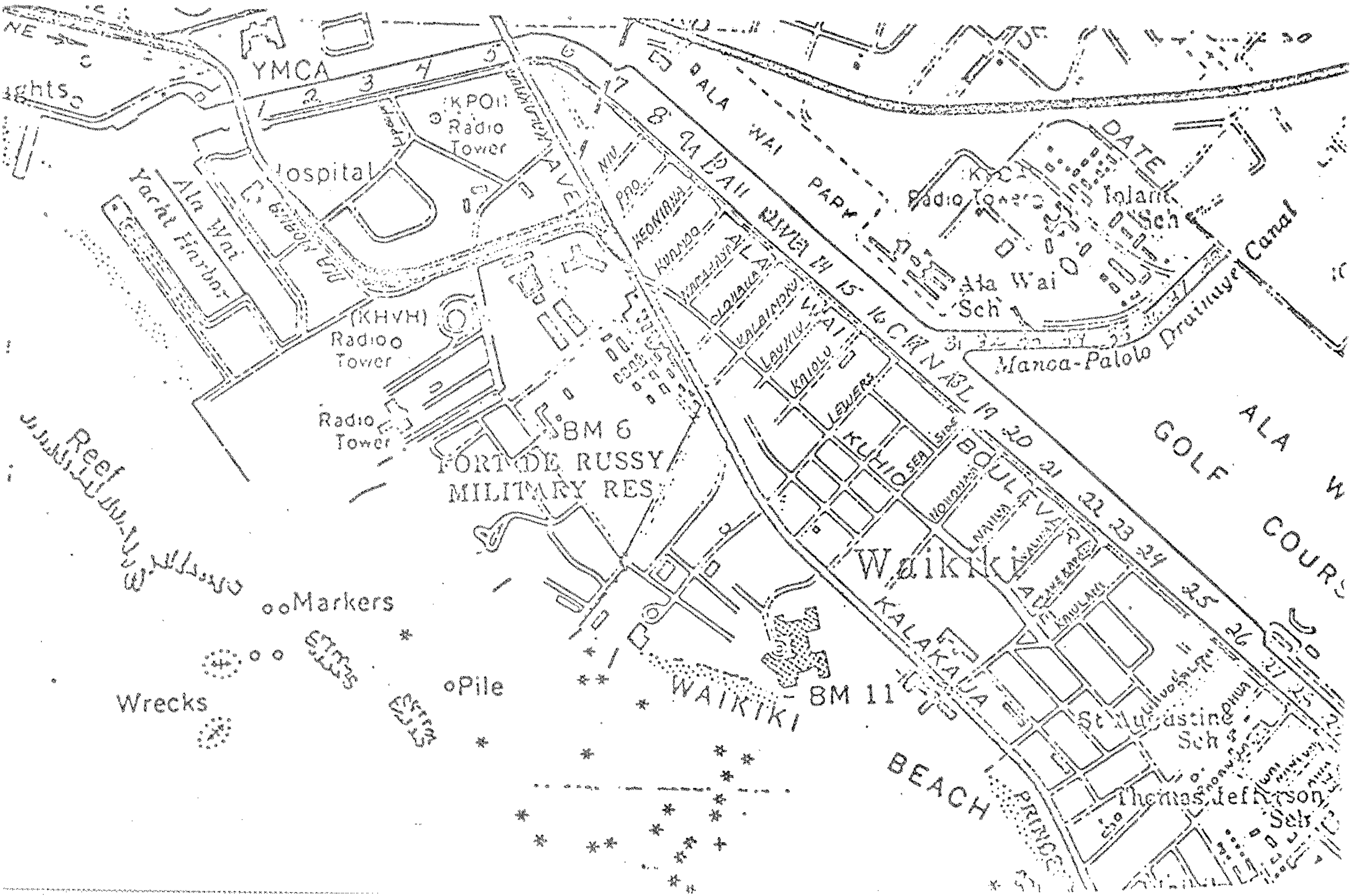
Station		Incoming Tide					Outgoing Tide				
		Range	Median	N	Mean	STD.	Range	Median	N	Mean	STD.
1	Surface	4.7 - 12.2	7.25	8	7.51	2.10	5.7 - 8.4	8.10	4	7.07	1.28
	Bottom	2.55- 6.70	4.85	8	4.99	1.15	4.2 - 5.3	4.75	4	4.75	.39
2	Surface	6.2 - 9.2	8.0	10	7.78	.86	3.20 - 6.2	6.10	3	5.17	1.39
	Bottom	4.50- 7.10	5.70	10	5.79	.71	4.2 - 5.5	4.70	3	4.80	.54
3	Surface	5.0 - 11.2	7.55	14	7.71	1.41	5.8 - 8.2	7.75	6	7.30	.94
	Bottom	2.60- 7.0	5.50	16	5.07	1.16	.30 - 5.6	3.80	5	3.72	1.87
4	Surface	8.8 - 10.5	9.65	2	9.65	.85	6.8	6.80	1	--	--
	Bottom	5.7 - 6.9	6.3	2	6.30	.60	5.7	5.70	1	--	--
5	Surface	5.7 - 9.7	8.0	7	7.77	1.35	6.3 - 7.5	6.40	3	6.73	.70
	Bottom	3.0 - 6.3	4.3	7	4.47	1.34	3.9 - 4.6	4.10	3	4.20	.37

TABLE 2. Dissolved Oxygen Data Collected By Jackie Miller, WRRC and Others* During A Three-Year Comprehensive Study Of The Ala Wai Canal Ecosystem.

*Pre-Management Study of the Ala Wai Canal, Department of Oceanography (Garth Murphy, Principal Investigator).

FIGURE 1. Ala Wai Canal Sampling Stations (Jackie Miller, WRRC and Others*)

*Pre-Management Study of the Ala Wai Canal, Department of Oceanography (Garth Murphy, Principal Investigator)



UNIVERSITY OF HAWAII
Environmental Center
Office of the Director

November 30, 1972

MEMORANDUM

To: Richard Marland, OEQC

From: Jerry M. Johnson

Subject: Revised Evaluation of the Ala Wai Boat Harbor Draft EIS

This amended review is to supercede our original evaluation of the Ala Wai Boat Harbor Environmental Impact Statement dated November 13, 1972. After lengthy consultation with the Statement authors, we find that many of our original criticisms resulted from inadequate information and explanation being presented in the draft document. The authors have corrected those deficiencies thus some of our original criticisms are no longer valid.

2. Data Interpretation (page 7)

a. Slow nitrogen release fertilizer such as those used by professional turf managements (Ala Wai Golf Course) are organic in form and not nitrates. The identification of eutrophication with NO_3-N is basically correct but the source of the nitrate can be organic, ammonium or nitrate nitrogen. The correlation of N/P would have been more accurate had it been made with the total nitrogen to indicate the total potential source. Not only is the NO_3-N being taken up by the organisms at different rates, which changes the NO_3-N/P ratio, but the transformation of organic nitrogen and ammonium nitrogen to the nitrate form is dependent upon bacterial action.

b. A comprehensive baseline water quality evaluation of all the major effluent sources entering the boat harbor should have been made in order to accurately assess the impact of the proposed modifications on the water quality characteristics of the harbor. (Such a study would have included the approximate toilet and dishwater nitrogen/phosphorus and coliform contributions of live-aboards and phosphorus from detergents used in washing boats.)

c. (5. Phosphorus, page 28) The phosphorus correlation study was based on total phosphorus rather than available P. Since these two values can differ widely, the correlation as presented may be inaccurate. However, we recognize that the identification of available forms requires some rather sophisticated and time-consuming algal assay procedures which were apparently not possible within the constraints of the study.

Runoff from urban land can contribute significant amounts of nutrients to the Ala Wai Canal. [Wet weather flow from Palolo and Manoa Streams can contribute two times the phosphorus and 1.5 times the total nitrogen concentration from dry weather flow (Ching, 1972).] Data of

2540 Maile Way · Honolulu, Hawaii 96822 · Phone 944-7361

these streams taken during wet and dry weather flows showed concentrations of T-P to be 0.57 and 0.43 mg/l, respectively (Ching, 1972) and analysis of ocean water off Waikiki at 50 foot depth showed total phosphorus to be greater than 0.03 mg/l. It is doubtful that phosphorus can be a limiting factor for productivity in the Ala Wai Harbor. Only the degree of *eutrophication* can be controlled by limiting the amounts of nutrients discharged from the boats. Convenient sanitary waste pump out stations and mandatory "no direct discharge" holding facilities for boats would undoubtedly help control nutrient release in the harbor.

III. INFLUENCE OF CAUSATIVE AGENTS UPON PRODUCTIVITY

1. Temperature and Salinity (page 19)

Data acquired by Jackie Miller, WRRC and others* during a three-year comprehensive study of the Ala Wai Canal ecosystem (final draft in preparation) are pertinent to the salinity results shown in the EIS.

The average surface salinity (Table 1), recorded at 20 cm. on an incoming tide at Station 1 just mauka of the Ala Moana Bridge in the midline of the canal (see Figure 1.), was 18.62%. Considering the entire section of the canal from the Ala Moana Bridge to the Kalakaua Street Bridge, the surface salinity on an incoming tide ranged from 18.6 to 25.0. This average was not significantly different from that recorded for an outgoing tide (18.2-26.2). Bottom salinities showed no significant difference between incoming and outgoing tides; ranging from 31.6 to 34.8 over the same area.

The salinity values are considerably lower than those reported in the EIS. Their significance is in illustrating the great variability of water quality parameters in the canal; and to the extent that the canal waters flow into the Ala Wai Boat Harbor, a high variability can be expected in the boat harbor. (The variation from hour to hour can be as great as the day to day variation which in turn exceeds the seasonal variation.)

2. Dissolved Oxygen (page 19)

The O_2 values presented are questionable. Algal population densities which would be necessary to produce the supersaturated O_2 conditions would serve as a barrier to light penetration to lower depths. Thus a pronounced O_2 gradient with depth would be expected. Further, the algal population would have exerted a very large night-time demand on the available dissolved oxygen, yet no pronounced difference between diurnal and nocturnal dissolved O_2 values are observed. These anomalies in dissolved oxygen time/depth profiles cannot be explained in terms of canal water influences. First, the lighter canal waters would have a tendency to float on the more dense harbor water, thus having little influence on the dissolved oxygen depth profiles. Secondly, algal-laden canal waters would exhibit the same nocturnal decrease in dissolved O_2.

* Pre-Management Study of the Ala Wai Canal, Department of Oceanography (Garth Murphy, Principal Investigator).

Jackie Miller's dissolved oxygen data (Table 2) at the Station 1 described earlier in Section III, 1 (Temperature and Salinity) is similar to that presented in the EIS although her surface and bottom values are generally lower during both incoming and outgoing tides. In addition, her data shows a more pronounced variation with depth and the overall variability is great.

3. Carbon Dioxide (page 23)

Total carbon dioxide is calculated from pH and temperature measurements. The carbon source for productivity can also come from HCO_3^-, $CO_3^=$ by way of carbon dioxide. A better measurement for the potential carbon source would have been total inorganic carbon. At a pH of about 8.3, as found in the Ala Wai Harbor waters, the major ion is HCO_3^-. As CO_2 is extracted additional carbon dioxide is provided by the reaction

$$2\ HCO_3^- \rightleftharpoons CO_3^= + H_2O + CO_2$$

and

$$HCO_3^- + H_2O \rightleftharpoons H_2O + CO_2 + OH^-$$

In highly active algal systems, as CO_2 is taken up and thus, creating an increase in the pH, the $CO_3^=$ can be a major source of carbon, as shown in the reaction

$$CO_3^= + H_2O \rightleftharpoons CO_2 + 2\ OH^-$$

A decrease of free CO_2 to a point where it cannot be met by atmospheric CO_2 exchange would create the condition that CO_2 would have to be supplied from HCO_3^- and $CO_3^=$ forms. Thus under the present conditions it is doubtful that carbon should be limiting in the Ala Wai Boat Harbor.

V. SOCIO-ECONOMIC ENVIRONMENTAL ANALYSIS

Section V on "Socio-Economic Environmental Analysis" bears little relevance to existing environmental conditions of the Harbor and also to the potential environmental impact of the proposed project. The statistical procedures that have been applied are of questionable validity in view of inadequate data considerations. A stratified sampling procedure was used to obtain socio-economic data from 20 boat owners. The statement does not clearly indicate how many strata were chosen nor how they were defined. Assuming, however, that three more or less equal size subsamples of 6 to 7 boat owners were obtained from the small, medium, and large boat classes respectively, the multiple regression technique can hardly be expected to produce statistically significant results. The stepwise regression method was applied to as many as six and seven variables. The reduced degrees of freedom not to mention the expected high multicollinearities among several of the selected variables precludes the possibility of any meaningful statistical analysis of the type employed. The credibility of the results presented cannot be established without revealing the data base from which such results were obtained. Apart from the questionable relevance of the socio-economic environmental analysis in this draft statement, if such an analysis is deemed desirable at all it should at least in part be directed toward assessing the distribution of costs and benefits. Such an assessment should be made with the view toward determining whether or not there is any relationship between the existing incentive system and environmental quality conditions of the harbor. The assessment should then be extended to also cover the proposed project.

VI. ENVIRONMENTAL IMPACT OF THE PROPOSED CONSTRUCTION WITHIN THE ALA WAI BOAT HARBOR

1. Impact

a. (page 43) The pier alteration and the increase in the number of boats would have some effect on overall circulation but that effect should be moderate.

b. (page 44) The increase in boats will, of course, reduce the amount of light reaching the harbor waters, although the estimated 30.2% seems high. Any gradual reduction in the amount of light reaching the organisms such as shading from boats will reduce productivity - which may be desirable. However, the increase in the number of boats may have a detrimental polluting effect, unless live-aboard waste discharges are eliminated from the harbor.

Finally, although the proposed modifications will have some impact on the water quality of the boat harbor, we believe that impact will be moderate. Elimination of all toilet and sink wastes from the harbor may result in a net improvement of the water quality.

2. Alternatives

An alternative that was not discussed in the EIS is the mooring of small boats in the section of Ala Wai Canal between Kalakaua Bridge and Ala Moana Bridge. That section of the canal would have sufficient depth and would certainly be an aesthetic attraction to the area. Since there would be no live-aboards, the boats would not be a source of pollution within the canal or harbor. Their removal from the harbor would provide space for additional larger boats, thus making better use of this deeper water. As a precedence for this proposed alternative, we cite the small boat moorings on the lower portion of Nuuanu Stream.

Jerry M. Johnson
Jerry M. Johnson
Assistant Director

cc: Gordon Dugan
Henry Gee
Alison Kay
Morris Miyagi
Jackie Miller
James Moncur
Thomas Newbury
Richard Scudder
Edward Stroup
Hiroshi Yamauchi
Lawrence Raymond, OI

Station 1.

	Salinity (%)	STD.	N	Temp. (α)	STD.	N	Oxy. (mg/l)	STD.	N
Outgoing tide	30.05	5.67	8	26.39	1.44	10	5.91	1.50	8
Outgoing tide Surface, 0-20 cm.	25.72	4.28	4	26.66	1.44	5	7.07	1.28	4
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*Pre-Management Study of the Ala Wai Canal, Department of Oceanography (Garth Murphy, Principal Investigator).

Oxygen (mg/1)

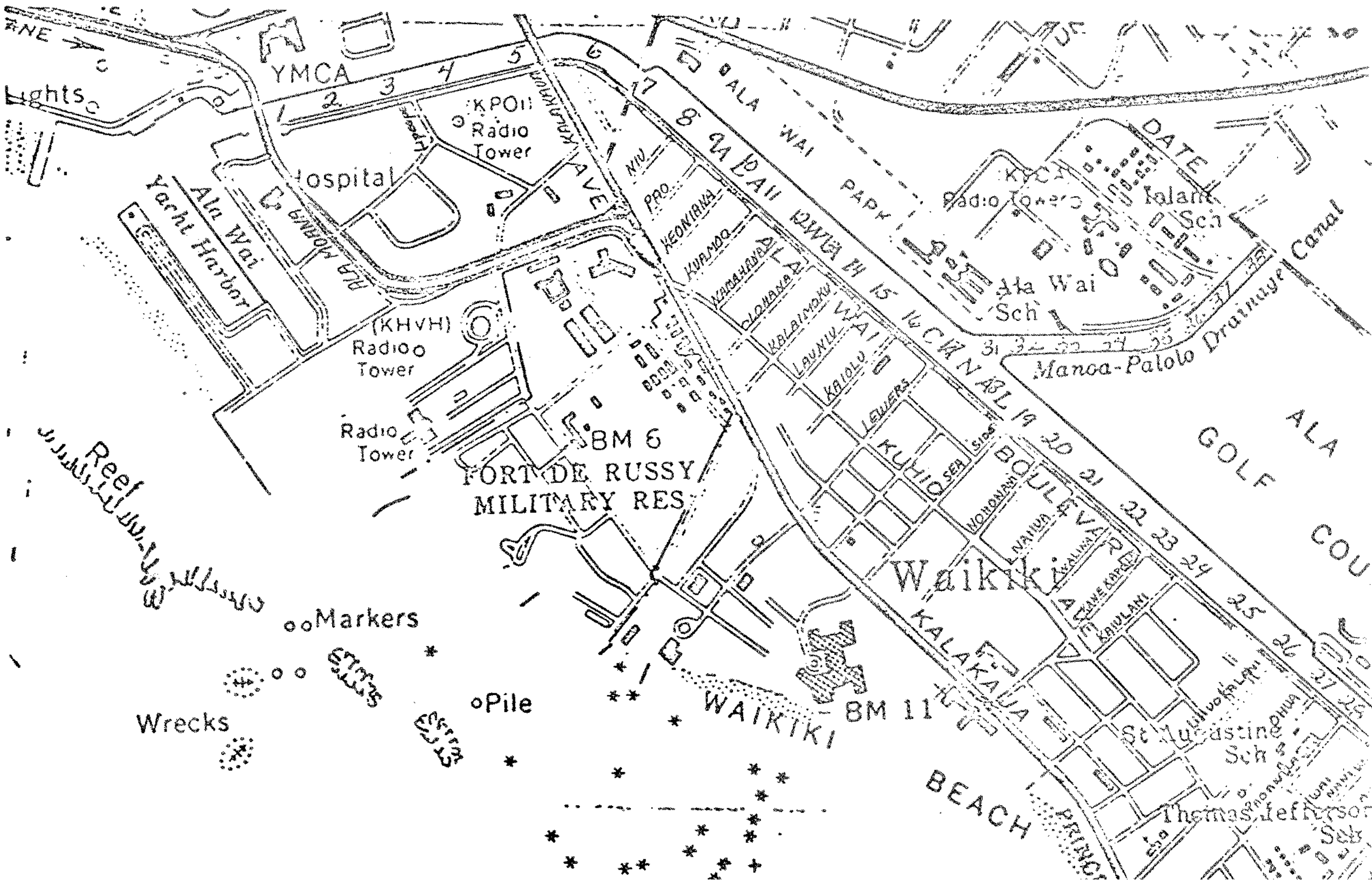
		Incoming Tide					Outgoing Tide				
Station		Range	Median	N	Mean	STD.	Range	Median	N	Mean	STD.
1	Surface	4.7 - 12.2	7.25	8	7.51	2.10	5.7 - 8.4	8.10	4	7.07	1.28
	Bottom	2.55- 6.70	4.85	8	4.99	1.15	4.2 - 5.3	4.75	4	4.75	.39
2	Surface	6.2 - 9.2	8.0	10	7.78	.86	3.20 - 6.2	6.10	3	5.17	1.39
	Bottom	4.50- 7.10	5.70	10	5.79	.71	4.2 - 5.5	4.70	3	4.80	.54
3	Surface	5.0 - 11.2	7.55	14	7.71	1.41	5.8 - 8.2	7.75	6	7.30	.94
	Bottom	2.60- 7.0	5.50	16	5.07	1.16	.30 - 5.6	3.80	5	3.72	1.87
4	Surface	8.8 - 10.5	9.65	2	9.65	.85	6.8	6.80	1	--	--
	Bottom	5.7 - 6.9	6.3	2	6.30	.60	5.7	5.70	1	--	--
5	Surface	5.7 - 9.7	8.0	7	7.77	1.35	6.3 - 7.5	6.40	3	6.73	.70
	Bottom	3.0 - 6.3	4.3	7	4.47	1.34	3.9 - 4.6	4.10	3	4.20	.37

TABLE 2. Dissolved Oxygen Data Collected By Jackie Miller, WRRC and Others* During A Three-Year Comprehensive Study Of The Ala Wai Canal Ecosystem.

*Pre-Management Study of the Ala Wai Canal, Department of Oceanography (Garth Murphy, Principal Investigator).

FIGURE 1. Ala Wai Canal Sampling Stations (Jackie Miller, WRRC and Others*)

*Pre-Management Study of the Ala Wai Canal, Department of Oceanography (Garth Murphy, Principal Investigator)



JOHN A. BURNS
GOVERNOR

FREDERICK C. ERSKINE
CHAIRMAN, BOARD OF AGRICULTURE

WILLIAM E. FERNANDES
DEPUTY TO THE CHAIRMAN

STATE OF HAWAII
DEPARTMENT OF AGRICULTURE
1428 SO. KING STREET
HONOLULU, HAWAII 96814

November 2, 1972

MEMORANDUM

To: Dr. Marvin T. Miura, Environmental Scientist
Office of Environmental Quality Contrd

Subject: Draft Environmental Impact Statement for Improvements at Ala Wai Boat Harbor, Phase I, Honolulu, Hawaii

We have reviewed the above draft statement and do not foresee any major adverse environmental effects.

Thank you for the opportunity to review the statement.

FREDERICK C. ERSKINE
Chairman, Board of Agriculture

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 15th AIR BASE WING (PACAF)
APO SAN FRANCISCO 96553

10 NOV 1972

REPLY TO ATTN OF: DE

SUBJECT: Draft Environmental Impact Statement for Improvements at Ala Wai Boat Harbor, Phase I, Honolulu, Hawaii

TO: Office of Environmental Quality Control
ATTN: Dr Marvin T Miura
State Capitol Building, Room 436
Honolulu, Hawaii 96813

1. Reference is made to your letter of 6 Oct 1972, same subject.

2. This office has no comments to render relative to the draft environmental impact statement for "Improvements at Ala Wai Boat Harbor, Phase I, Honolulu, Hawaii".

ALLAN M. YAMADA
Asst Dep Comdr for Civil Engrg

UNIVERSITY OF HAWAII
Department of Civil Engineering

MEMORANDUM November 2, 1972

MEMO TO: OEQC

FROM: R. H. F. Young

SUBJECT: Review of Draft Environmental Impact Statements

1. Lunar Laser Ranging Station, Haleakala, Maui

No Comment

2. Nanakuli Planned Development Housing

The first four pages of this IES are not well written and needs some clarification, particularly in phrases such as - "buffer areas, etc." (p.1), "difference in elevation ranges" (p.2), "project site being contingent to residential area" (p.4), "feral cars" (p.4). A statement on p.2 indicates that there should be little effect on population density despite the fact that the project provides for patiohouses, townhouses, and 3-story units as opposed to the single-family dwellings presently predominate in Waianae.

There should be some enlargement on the game habitat and open space loss identified on p.6 and the possible effect of the chemical usage identified on p.7 on the water quality of surface runoff from the project area.

The impact of the project on certain specific community services, police and fire protection, refuse collection, and sewage disposal, is not indicated.

3. Ala Wai Boat Harbor Improvement, Phase I

Principal criticism is directed toward the water quality data. Since organic and ammonia nitrogen data were not collected, the evaluation of N/P relationships may lead to erroneous results, particularly if sewage discharge is taking place into the canal or harbor waters since those forms of nitrogen constitute the major proportion of the total nitrogen load in domestic sewage. The fertilizer and detergent contributions should be quantified to determine whether there are sources of major import or whether sewage discharge is the major factor in water quality deterioration in the harbor. Some characterization of the sediment -- nutrient and carbon content, suspended solids -- should be made to quantify its effect on water quality in the harbor.

4. Waimanalo Beach, State Recreation Area

This statement is well-written and documented. A real effort should be made to have the water quality survey performed on Inaole Stream (p.6). Perhaps some clarification should be included in the statement as to what injury would occur to the Beach Park from a sewer outfall terminating beyond the outer reef edge (p.6).

5. Police and Fire Training Facilities, Koko Head Firing Range

Although a site plan of the proposed facilities is provided, an evaluation of the visual and esthetic effects of the project cannot adequately be made without some form of elevation sketches or architectural conceptual sketches. Further, there is no exposition of the economic benefits or improvements in community services from this project, or the adverse effect on the police and fire departments if the training facilities are not provided.

It is indicated that surface drainage is collected in a pond on the site (p.10) but no mention is made of the ultimate disposal of the collected run-off, nor is it indicated whether the pond is adequate for the increased runoff that may result after completion of the training facilities with the paved access areas. Perhaps some of the runoff, and the collected drainage from fire extinguishing exercises (p.22) could be filtered and recirculated as a means of water conservation.

PLANNING DEPARTMENT
CITY AND COUNTY OF HONOLULU
629 POHUKAINA STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

ROBERT R. WAY
PLANNING DIRECTOR

GEORGE S. MORIGUCHI
DEPUTY PLANNING DIRECTOR

November 21, 1972

P10/72-4787

MEMORANDUM

TO : DR. RICHARD MARLAND
INTERIM DIRECTOR
OFFICE OF ENVIRONMENTAL QUALITY CONTROL

FROM : ROBERT R. WAY, PLANNING DIRECTOR

SUBJECT : IMPROVEMENTS AT ALA WAI HARBOR, PHASE I
DRAFT EIS, SEPTEMBER 7, 1972

The Planning Department does not have the technical capabilities to make a detailed review of this project. Our review of the environmental impact statement does suggest, however, that a broader problem of water quality does exist and should be addressed as recommended in the report. Our concern is that the project may be approved without provision for addressing the broader problems.

Implementation of the project may have some impact on onshore facilities, particularly parking and traffic in the immediate vicinity of the harbor. Consideration should be given to this impact which could result in some modification to the size of the project or the provision of additional facilities, particularly parking and sewage disposal.

ROBERT R. WAY
Planning Director

RRW/RWR:cag

BOARD OF WATER SUPPLY
CITY AND COUNTY OF HONOLULU
630 SOUTH BERETANIA
POST OFFICE BOX 3410
HONOLULU, HAWAII 96801

October 30, 1972

Dr. Marvin T. Miura
Environmental Scientist
Office of Environmental Quality Control
State Capitol Building, Room 436
Honolulu, Hawaii 96813

Dear Dr. Miura:

Thank you for sending to us the "Draft Environmental Impact Statement - Administrative Action for Improvements at Ala Wai Boat Harbor, Phase I - Job H.C. 2004" for our review and comments.

The proposed project is not anticipated to adversely affect any present or future Board of Water Supply water resources or facilities in the area.

Please feel free to contact us if we can be of further assistance in this matter.

Very truly yours,

Sakai Kawakami
Acting Manager and Chief Engineer

United States Department of the Interior

GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
Room 330, First Insurance Bldg.
1100 Ward Avenue
Honolulu, Hawaii 96814

October 30, 1972

Dr. Marvin T. Miura
Environmental Scientist
Office of Environmental Quality Control
State of Hawaii Executive Chambers
State Capitol
Honolulu, Hawaii 96813

Dear Dr. Miura:

The Draft Environmental Impact Statement for Improvements at Ala Wai Boat Harbor, Phase I, Honolulu, Hawaii, transmitted with your memorandum dated October 6, 1972, has been reviewed by this office.

We have no comments to offer. Fresh water resources of the area should not be affected by the project.

The foregoing is provided informally for technical assistance and is not intended to represent the position of the Department of the Interior.

Sincerely,

W. L. Burnham
District Chief

cc: Regional Hydrologist, WRD, WR
Chief Hydrologist, WRD
Code 4000 0000 (Attn: George H. Davis)

SPARK M. MATSUNAGA
1ST DISTRICT, HAWAII

WASHINGTON OFFICE:
442 CANNON BUILDING
20515

HONOLULU OFFICE:
218 FEDERAL BUILDING
96813

Congress of the United States

House of Representatives

Washington, D.C. 20515

MEMBER:
COMMITTEE ON RULES
COMMITTEE ON AGRICULTURE

SECRETARY:
STEERING COMMITTEE

October 10, 1972

Dr. Marvin T. Miura
Environmental Scientist
Office of Environmental Quality Control
State of Hawaii
Honolulu, Hawaii 96813

Dear Dr. Miura:

On behalf of Congressman Matsunaga who is presently in Hawaii, I am acknowledging receipt of your letter of October 6, 1972, together with a copy of the draft environmental impact statement for the Ala Wai Boat Harbor.

Please be assured that your communication will be brought to Mr. Matsunaga's attention when he returns to Washington.

Aloha and best wishes.

Sincerely,

David

David S. Nahm
Staff Executive

United States Senate

COMMITTEE ON APPROPRIATIONS
WASHINGTON, D.C. 20510

October 10, 1972

Dr. Marvin T. Miura
Environmental Scientist
Office of Environmental
Quality Control
State Capitol-Room 436
Honolulu, Hawaii 96813

Dear Dr. Miura:

I am writing to acknowlege receipt of the draft environmental impact statement for the Improvements at Ala Wai Boat Harbor, Phase I, Honolulu, Hawaii.

Your courtesy in sending me this statement is appreciated.

With kind regards and aloha -

Sincerely yours,

Hiram L. Fong

Hiram L. Fong

HLF:vl

The Outdoor Circle, Mrs. Robert Creps

Comment: Additional drainage into the Ala Wai Canal from future developments which will affect the harbor.

Disposition: We share the concern of the Outdoor Circle as to the possible impacts of these proposed developments. Attempts are currently being made to avoid the realization of these impacts.

State of Hawaii, Department of Health, Walter B. Quisenberry, M.D.

Comment: Incorporation of a sewage collection system into the Phase 1 plan.

Disposition: A sewage collection system has been incorporated into the Phase 1 plan which consists of connecting a pump-out facility at the Texaco fueling dock with the City and County sewage system. The plan will also connect existing comfort stations to the sewage system. An additional comfort station will be constructed at Mole B

Comment: Additional pump-out facilities at both Moles A and B.

Disposition: Funds are only adequate for the incorporation of one pump-out facility with the Phase 1 plan. The selection of the Texaco fueling station as the site of this facility is predicted upon its accessibility and frequency of use relative to other possible sites.

Comment: Recommendations for holding tanks on boats used by permanent residents, and enforcement of regulations.

Disposition: Present EPA requirements are that by 1975 all new boats are required to have onboard sewage holding and treatment facilities and by 1980 all boats, regardless of age, will be required to have this equipment. We concur with these recommendations.

Comment: Reduce discharge of domestic wastes to decrease the critical limits of phosphates and nitrogen accordingly.

Disposition: While we fully concur with this statement it should be pointed out that the boats constitute only a portion of the total nutrient discharge into the harbor and that stabilization of the harbor environment will require reduction of domestic waste discharges from other sources as well.

City and County of Honolulu, Department of Public Works, Edward Y. Hirata

Comment: Background information.

Disposition: The additional information provided by the Department was interesting and has been included in the text.

Comment: Procedures and methods; location of stations.

Disposition: We concur with this comment as many more stations would have been desirable. However, there were limitations of time and funding, compelling the stations to be few and restricted to the harbor itself.

Comment: Causative agents and sources within the harbor.

Disposition: The fecal coliform counts near the Ala Moana Bridge are above permitted state levels. The study by Gonzalez (1971) demonstrated a decrease in fecal coliform concentrations from upper regions of the canal towards the harbor. It is agreed that there are no direct sewage discharges from the City and County system, but it is apparent that some sources of fecal discharge must exist within the vicinity of the canal.

Comment: Data - units.

Disposition: The comment on the units is valid. While the units for fecal and coliform concentrations are in numbers of 100 ml, this was not clear in the text and has been so amended.

The units phosphorus and nitrate are in an acceptable scientific form and are readily converted to mg/l.

Comment: Phosphorus.

Disposition: Our data shows no suggestion of nitrate limitations by the population of organisms in the harbor during the time of our study.

It is known that soluable nitrogen is not a universal limitation upon plant growth. This is particularly important in tropical waters where representatives of atmospheric nitrogen fixing blue green algae are ubiquitous. In the absence of other limitations pronounced blooms of these algae can, and in fact do, occur in Hawaiian waters.

The only chemical limitation that was suggested by the data was the limitation of phosphates upon productivity.

Comment: Light.

Disposition: The data provided was of interest but the quoted levels are in techniques not readily compared with the values of the EIS. However, the information provided demonstrated that the light environment is eminently suited to the subsurface growth of diatoms, dinoflagellates, and blue-green algae.

Comment: General condition of the present environment - heavy metals.

Disposition: The additional information provided is valuable. During the EIS study it was observed that sediment depth was highly variable and ranged from 1-2 inches to 2-3 feet at the same locations during this five week period. This indicates that large variability in sediment composition can be anticipated, as well as demonstrating that concentrations of heavy metals may periodically reach unacceptable limits.

Comment: Nutrient analyses.

Disposition: The additional information is valuable.

Comment: Impact of light.

Disposition: While the statement is correct when evaluating the impact of the construction on the harbor water environment, it does not take into account the possible effects upon the waters outside of the harbor. Presently the harbor is viewed as a treatment pond for the discharge of the wastes from the Ala Wai Canal and from other sources. With additional shading the capacity for organisms to assimilate nutrient components from the waters is reduced and thus an increase in soluble nutrient concentrations within the effluent waters is anticipated. Further, it is not considered advantageous to place a natural population under light limitations, particularly in tropical waters since large variations and considerable instability can be generated from such a system.

Comment: Inadequacy of the statement.

Disposition: It is assumed from the context of the letter that the inadequacy of the EIS refers solely to the quantity of information provided.

A comprehensive water quality study would have been preferable but present national policy does not enforce such action.

Comment: Toilet and facilities.

Disposition: The Harbors Division makes a contingency for additional facilities in an overall reconstruction plan. The EIS was specific to Phase 1 of this plan. It is their intent to eliminate all cesspools in the harbor and connect to the municipal sewer system by 1973.

City and County of Honolulu, Department of Traffic, Roy A. Parker

Comment: Parking facilities.

Disposition: Additional parking will be provided by the Harbors Division as part of the overall plan. This will not occur during Phase 1 construction. However, the statement by the Traffic Division is duly noted and has been included in the text.

Bernice P. Bishop Museum, Dr. J. Randall via Dr. Roland W. Force

Comment: Recreational use of boats, and capacity of harbor.

Disposition: The data as specified is directly from a census made among owners of boats in the harbor.

Dr. Chennat Gopalakrishnan, socio-economic consultant on this EIS responded to Dr. Randall's comments:

"Point 2 expressed objected to the statement that the average boat is used for recreational purposes 56.3 days a year. This is the correct figure obtained from the survey and, as indicated in the report, includes both pleasure sailing and sport fishing activities. Boat use from the 20 owners surveyed ranged from 6 to 182 occasions per year. It was typical on the part of the enthusiastic recreational boater interviewed in the survey to criticize those boats that are largely used for accommodation. The extent to which this occurs is over exaggerated. The Ala Wai Boat Harbor is a public resource and as such should not be considered for prestigious use by the privileged strata of society."

University of Hawaii, Environmental Center, Jerry M. Johnson

As a preface to the dispositions to the comments by the University of Hawaii's Environmental Center, the authors wish to acknowledge the time and effort of the Environmental Center to discuss at length some of their interpretations and analyses of the EIS.

Comment: Correlations of total nitrate and phosphate do not include transformed organic and ammonium nitrate forms.

Disposition: We agree that it would have been advantageous to conduct analyses on all forms of soluble nitrogen in the harbor waters. The original proposal to the Harbors division included such determinations, but time and money constraints made it possible to select only one form for analysis. Nitrate- + nitrite-nitrogen was chosen so that comparisons could be made with existing published data (Gonzalez, 1971; Harris, 1972) for the canal.

It is well known that bacteria are capable of converting ammonia-N to nitrite (nitrosomonas) and then to nitrate (nitrobacter), but this process is not dependent upon their presence. There is a constant conversion to nitrate through chemical oxidation by both free oxygen and by induced photochemical oxidation from direct sunlight. Bacteria serve simply to accelerate this natural process.

It is a reasonable assumption that such bacteria are present. Organic fertilizers are not in a form for nitrogen to be readily utilized by grasses and terrestrial plants. Organic nitrogen must first be converted to nitrate for assimilation to occur. Organic fertilizers are used at the Ala Wai Golf Course. The general abundance of the constant discharge of waters from the golf course into the canal must contribute to the presence of these bacteria.

Comment: Accurate assessment of the impact of proposed changes depends upon a prior comprehensive baseline water quality evaluation of all major effluent sources entering the boat harbor.

Disposition: When this study was initiated, little historical data was available on which to assess the condition of the harbor environment.

When water quality conditions are adequate and appropriate precautions are taken, a high density of boats can be accepted. It was considered that an assessment of the present environmental condition of the harbor should be established first.

This is now known and the excessive nutrient concentrations are of concern. It is agreed that a comprehensive study which defines and categorizes all the major effluent sources is required and should now be undertaken.

Comment: Comparison with other environments suggest phosphorus cannot be limiting to production.

Disposition: It is agreed that the strong correlation of total phosphorus with surface productivity rates does not conclusively demonstrate phosphate limitation. However, the analysis presented shows that it is likely, especially when nitrate-nitrogen is shown not to be limiting.

It is the authors' opinion that total phosphorus gives a better representation of "available" phosphorus than does the determination of reactive phosphorus. It has been demonstrated by an extensive body of literature)Provasoli et al., 1957; Pinter and Provasoli, 1962; provasoli and McLaughlin, 1962; etc.) that organic phosphates are widely utilized by phytoplankton. Standard laboratory analyses of reactive phosphorus do not provide measurement of these organic forms, while techniques for total phosphorus do. Within the constraints of the study, there was neither sufficient time nor funds to conduct more sophisticated studies.

It is well known that populations of phytoplankton can vary tremendously both in number and composition between different environments. One reason for this is that nutritional requirements and abilities to tolerate various nutrient loads are specific for each phytoplankter. The examples presented in the critique are for two entirely different environments and do not take into account factors such as proportionate nitrogen concentrations, salinities, temperature, light availability or circulation.

It is not desirable to make alternate comparisons of the type presented, as there exists unanimous agreement that oceanic waters at 50 ft depth and freshwater streams are not characteristic of an estuarine harbor. Such a comparison does not demonstrate that P cannot be limiting to production within the harbor.

Comment: That only the degree of eutrophication can be controlled by limiting discharges from boats cannot be argued.

Disposition: The implication was not intended in the EIS that to limit boat discharges would halt eutrophication. Neither was it implied that the boats within the harbor contributed the majority of nutrient inputs. More studies would be required to demonstrate the relative contributions and importance of these discharges to the total nutrient load of the harbor.

Comment: Observations on variability of salinity within the Ala Wai Canal.

Disposition: The information provided is of interest. It shows that a considerable amount of variability can be anticipated and that the conditions during the time of our sampling were possibly unusual when compared to more normal conditions.

Comment: Dissolved oxygen values presented are questionable.

Disposition: We fully concur with your analysis describing conditions which would normally be expected. The suspicion of high oxygen demand creating stress conditions during night hours prompted the the decision for a day-night study.

We also concur with your feelings that a precise explanation is not possible considering that the analyses were conducted for only one 24-hour period. However, the operational components of the oxygen monitor were checked against Winkler titrations and found to be accurate within 6% of the actual value. Thus, although unusual, the oxygen data cannot be dismissed.

Comment: Calculation of total carbon dioxide.

Disposition: The methods used for sample collection and analyses of total CO_2 followed standard procedures and measured the total concentration of the various forms of CO_2 ($CO^{=}$, $HCO_3^{=}$, and free CO_2). The analytical method does not distinguish between the various forms and thus provides a value which is a summation of all reaction products mentioned within this critique.

The accuracy of the data can be checked by comparing with results based entirely upon theoretical calculations. Johnson et al. (1942) show that total CO_2 in seawater may be calculated from the expression

$$\Sigma CO_2 = \frac{[A_{CO_2}]}{1 + \frac{2k_2'}{[H^+]}} \times \left(\frac{[H^+]}{k_1'} + \frac{k_2'}{[H^+]} + 1 \right)$$

Where:

k_1' = first dissociation constant for carbonic acid

k_2' = second dissociation constant for carbonic acid

$[H^+]$ = hydrogen ion concentration

$[A_{CO_2}]$ = alkaline fraction bound directly to the CO_2 components

$[A_{CO_2}]$ is calculated from the following expression:

$$[A_{CO_2}] = [A] - \frac{k_3' \times H_3BO_3}{[H^+] + k_3'} + [H^+] - \frac{K_w}{[H^+]}$$

Where:

k_3' = dissociation constant for boric acid

$[\Sigma H_3BO_3] = 0.0221 \times Cl\ ^o/_{oo} \times 10^{-3}$

$[A]$ = total alkalinity

K_w = dissociation constant for water $= 10^{-pK_w}$

pK_w is given by the following expression:

$$pK_w = 14.170 - 0.1517\ (Cl\ ^o/_{oo})^{\frac{1}{3}} + 0.0083\ Cl\ ^o/_{oo}$$

Given the following measured values:

pH = 8.500

$Cl\ ^o/_{oo} = 19.0$

Temperature = 26^o C

[A] = .140 milliequivalents/l

the total expected CO_2 concentration is 0.058 milliequivalents/l or between 0.058 and 0.116 m moles/l depending upon the molecular species composition.

The derived value compares favorably with laboratory figures having the same field conditions, .320. The data should therefore be considered reliable.

The data do not conclusively demonstrate CO_2 limitation. This interpretation is arrived at by noting that productivity rates depleted the total CO_2 concentration sevenfold from normal, dropping values well below the 1 m mole/l threshold value taken as adequate CO_2 in freshwater systems (McIntire & Phinney, 1965).

Comment: The Socio-Economic Environmental Analysis bear little relevance to existing environmental conditions of the Harbor and also to the potential environmental impact of the proposed project. The statistical procedures that have been applied are of questionable validity in view of inadequate data considerations.

Disposition: The following disposition was provided by Dr. Chennat Gopalakrishnan and D. Clive Drew of the Department of Resource and Agricultural Economics, University of Hawaii and consultant to the Oceanic Institute on the Socio-Economic assessment portion of the EIS.

" . . .The report presents a thorough analysis of the socio-economic environment existing at the Harbor as well as the impact of the proposed project. The objective of the study was to present as many relevant aspects as possible in empirical terms. The stratified random sampling procedure was first justified and the design explained in the statement. The design is reproduced in detail for those still experiencing difficulty with this report.

Design of Ala Wai Boat Harbor Survey

Boat type	Boat Size			Total
	≦30'	31-40'	≧41'	
Cabin cruiser	2	3	2	7
Sail boat	2	4	3	9
Miscellaneous	2	1	1	4
Total	6	8	6	20

"The original sample size selected was 40 boat owners, but taking into consideration the number of owners who could not be contacted (many have private telephones) as well as time and budget constraints, the number of owners contacted was reduced. However, the original design of the experiment was retained.

"Another criticism expressed by the reviewer(s) concerned the appropriate nature of statistical estimation. Again, the reviewer(s) failed to interpret the results presented. The essence of using a stratified random sample design was to allow all observations (the 20 of them) to be considered in estimating aggregate functions characterizing the total Harbor. Thus, sufficient degrees of freedom were preserved. The problem of multicollinearity between some of variables was expected, but initial bunch mapping of the data (e.g., the relation between household size and income) did not show significant linear relations to warrant omitting any of the variables.

"The comments by the reviewer(s) with respect to the distribution of costs and benefits are not sufficiently clear for interpretation.

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"We should again stress that it was our objective in the socio-economic environmental analysis to characterize recreational behavior to the best of our ability, subject to the time and budget constraints. We could have gathered emotional views from the public for our presentation, but we felt an impact statement of this nature involving a large commitment of public funds required empirical evidence. The survey design and statistical analysis provided the means to achieving this end. The information contained in the impact statement is based on the most reliable methods we could use. The methods have been used in approaches to recreational behavior by other researchers who have also found the techniques to their satisfaction."

Comment: Degree of impact of construction on overall circulation.

Disposition: It is impossible to predict clearly the magnitude of the effects that the additional mooring facilities and boat will have on the water circulation within the harbor. However, there will be an effect and in the opinion of the authors of the EIS it will be adverse. These reasons were detailed in the text, namely that even a modest reduction of circulation within the harbor will have significant influences upon the composition and stability of the environment.

Comment: Effect of increasing number of boats.

Disposition: The concern over the increased waste discharges from the additional boats is relevant and agrees with the authors' direction to eliminate all such inputs from the harbor. Such additional facilities are included in the later Phases of the DOT's master plan, but this particular EIS was confined to the alterations in the harbor under Phase 1. The advantages and disadvantages of increased shading were indicated in the prepared EIS and are mentioned in the disposition to the comments of the Dept. of Public Works, City and County of Honolulu.

Comment: Proposed modifications will have moderate impact on water quality of the boat harbor.

Disposition: The authors acknowledge the University of Hawaii Environmental Center's interpretation of available data.

Comment: Alternatives to small-boat moorings.

Disposition: The alternative suggested in the critique is outside the consideration of the authors of the EIS. The harbor is a state owned and operated facility. The waters of the canal leeward of the Ala Moana Bridge are under the jurisdiction of the City and County of Honolulu

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