HANALEI EXCURSION BOAT STAGING OPERATIONS
Hanalei, Kauai
TMK 5-5-01:33, 5-5-01:2 (por.)

DRAFT ENVIRONMENTAL IMPACT STATEMENT

Prepared for:

NORTH SHORE CHARTER
BOAT ASSOCIATION

Prepared by:

WILSON OKAMOTO & ASSOCIATES, INC.

October 1990

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PREFACE

This draft environmental impact statement is prepared pursuant to Chapter 343, Hawaii Revised Statutes, and Title 11, Chapter 200, Administrative Rules, Department of Health, State of Hawaii. Proposed is an applicant action by the North Shore Charter Boat Association.

An earlier environmental assessment was filed with the County of Kauai Planning Department in April, 1989. On June 26, 1989, the Department ruled that the proposed activity may have a significant environmental impact and that an environmental impact statement would be required.

SUMMARY SHEET

Project Description:

The North Shore Charter Boat Association proposes to conduct excursion boat staging operations along the southern bank of the Hanalei River on the north shore of Kauai. These include the launching and recovery of commercial excursion boats and the loading and unloading of passengers. Specifically, the activity is proposed to originate and terminate from the riverbank fronting the privately owned and operated Hanalei Excursion Boat Base Yard at Weke Road. The existing boat yard was approved, with conditions, through a temporary Special Management Area permit and zoning permit by the County of Kauai Planning Commission on June 24, 1987 (SMA Permit No. SP-87-9).

Potential Impacts:

The proposed use of the river bank for excursion boat staging operations is requested because it is the only place to safely conduct such activities in the Hanalei area and has long been the primary staging area for commercial tour boats, particularly those offering Na Pali Coast tours. The boating activities have a positive economic impact on the North Shore area and offers opportunities for diversified jobs within the visitor industry. The excursion operations are renown worldwide and serve to promote the beauty of Kauai and the State as a whole.

The primary reason for establishing the Hanalei Excursion Boat Base Yard was to relocate the excursion boating operations out of Black Pot Park. The State Department of Transportation has also establish an ingress and egress zone through Hanalei Bay in its Ocean Recreation Management Area rules to support the operation of the boat yard. Thus, the establishment of the proposed excursion boating operations is a positive impact on the recreational resources of the adjoining park and Hanalei Bay.

Inasmuch as no construction is proposed, there will be no short-term impacts associated with the proposed excursion boat staging operations. Thus, potential impacts are those which will be associated with the long-term conduct of those operations. The operations in the boat yard were assessed and subsequently approved through a separate SMA permit action.

The proposed excursion boat staging operations are similar in nature and scale to those which were permitted by the County of Kauai under an SMA minor permit issued to the DOT. This similarity in scale is a net result of adding relocated passenger loading and unloading activities presently conducted at "Tunnels" Beach and the attrition of permitted operators who are not proposing to pursue SMA permit approval.

Potential impacts include those on noise, aesthetics, water quality and the aquatic biota. Noise and aesthetic impacts are judged to be negligible while a water quality study was conducted with regard to petrochemical introductions by outboard motors. The minute levels of petrochemical introduction detected during simulated "worst case" conditions are unlikely to have acute toxic impacts on aquatic biota.

Mitigation Measures:

The North Shore Charter Boat Association proposes the following to alleviate and relieve congestion in the area, as well as to avoid conflicts with other users of the Hanalei River and Black Pot Beach Park:

* *Parking will be located away from Weke Road;*

* *Boats will be stored in trailers;*

* *No other commercial tour boat operation will use the facility except for those with DLNR/DOT permits and those which are approved under the proposed SMA permit;*

* *The North Shore Charter Boat Association does not intend to establish an industrial enterprise in the area or on the property and only minor boat and engine repairs will be done;*

* *Petroleum storage and dispensing will be done with portable facilities, such as tanks, that can be hauled away in the event of a flood or heavy surf. All boats except one will be fueled on land within the Hanalei Excursion Boat Yard. Only one boat will be fueled in the water using 5-gallon fuel tanks. This boat will be fueled in a designated area with a special petroleum containing boom surrounding it. Petroleum-specific absorbent pads will be stored nearby in the event that any spillage should occur; and,*

* *The North Shore Charter Boat Association agrees to reasonable measures to minimize noise impacts generated by motors being flushed. The flushing process will take place in a collection sump area on the property.*

Other potential mitigation measures which may be deemed appropriate could include:

- Conducting periodic testing of water and sediments for petrochemicals, particularly during low streamflows to determine if there is a potential concern.

- Regulating the number of outboard motors running at any given time in the estuary when streamflow is low, or for a few days after the first heavy rains, to assure that larvae of native stream species are not exposed to significant levels of petrochemical introductions.

Alternatives Considered: Alternative excursion boat staging sites in the Hanalei area were considered in the preparation of the ORMA. The only other site receiving serious consideration was Puu Poa marsh on the north bank of the Hanalei River mouth. Due to the wetland environment and private ownership, this alternative was not pursued. With regard to sites outside of the Hanalei Bay region, sites such as Port Allen have been suggested. However, the distance from Port Allen to the Na Pali Coast makes this alternative unfeasible. A site near Mana, Polihale or the Barking Sands Military Reservation could overcome the problem of distance, however, such an alternative was not pursued primarily since the Hanalei Excursion Boat Base Yard presently offers the most readily available site that has been approved by both State and County agencies. Such areas could be regarded as offering a long-term alternative site if satisfactory arrangements could be made. For the short-term, the Hanalei Excursion Boat Base Yard offers the most practical site for the proposed activity.

Unresolved Issues:

The examination of potential petrochemical introductions from outboard motor operations indicates that such introductions are unlikely to be at levels that would be acutely toxic to aquatic life. Nevertheless, there conceivably could be unique situations or conditions when impacts on specific species could result. Such conditions and studies on individual species are more difficult to assess and would not necessarily address all conceivable circumstances.

Also the potential for impacts of gasoline spillage during inwater fueling has not been assessed. Except for one boat, all fueling will be done on land within the Hanalei Excursion Boat Yard.

Compatibility with Plans/Policies:

The Hanalei Excursion Boat Staging Operations is compatible with the Hawaii State Plan, the State Recreational, the State Tourism Functional Plan, Statewide Ocean Recreation Management Plan, the State Land Use District Map, County of Kauai General Plan, North Shore Development, and the Comprehensive Zoning Ordinance for the County of Kauai.

Required Permits and Approvals:

The County of Kauai is requiring a Special Management Area (SMA) permit for the Hanalei excursion boat staging operations.

I. INTRODUCTION

The North Shore Charter Boat Association proposes to conduct excursion boat staging operations along the southern bank of the Hanalei River on the north shore of Kauai (See Figure 1). Specifically, the activity is proposed to originate and terminate from the riverbank fronting the privately owned and operated Hanalei Excursion Boat Base Yard at Weke Road (See Figure 2). The existing boat yard was approved, with conditions, through a temporary Special Management Area permit and zoning permit by the County of Kauai Planning Commission on June 24, 1987 (SMA Permit No. SP-87-9).

II. PROJECT DESCRIPTION

A. OBJECTIVE

The proposed use of the river bank for excursion boat staging operations is requested because it is the only place to safely conduct such activities in the Hanalei area and has long been the primary staging area for commercial tour boats, particularly those offering Na Pali Coast tours. In July, 1985, use of the river bank area for boat launching/landing was authorized under a temporary SMA minor permit issued by the County of Kauai to the Department of Land and Natural Resources (DLNR) which had assumed responsibility for managing commercial excursion boating activities through a revocable permit system. Extensions of the temporary SMA permit continued through September 30, 1988. In September, 1987 the State Department of Transportation (DOT) assumed management responsibility from the DLNR by Legislative directive. In October, 1988, the DOT Ocean Recreation Management Rules and Areas (acronym ORMA) went into effect, thereby establishing the first rules and regulations comprehensively managing ocean recreation statewide in Hawaii (Chapter 19-86, Hawaii Administrative Rules Shore Waters and Shores).

Expiration of the temporary SMA permit in September, 1988 was intended to coincide with the DOT implementation of the ORMA and DOT obtaining a new SMA permit for managing commercial boating activities along the Hanalei River. The DOT possesses a Right-of Entry to manage commercial boating activities in the Hanalei River, including the proposed activity site. The DOT also has a pending request to obtain full control over the area from the DLNR through Executive Order. Prior to securing approval of the SMA permit request, however, the DOT withdrew its SMA permit application contending that their permit system, as an administrative process, did not constitute a "development" as defined by Chapter 205A, Hawaii Revised Statutes and, therefore, was not subject to SMA permit review. This left unresolved whether the proposed action itself is a "development" under the law. The County of Kauai contends that the activity constitutes a

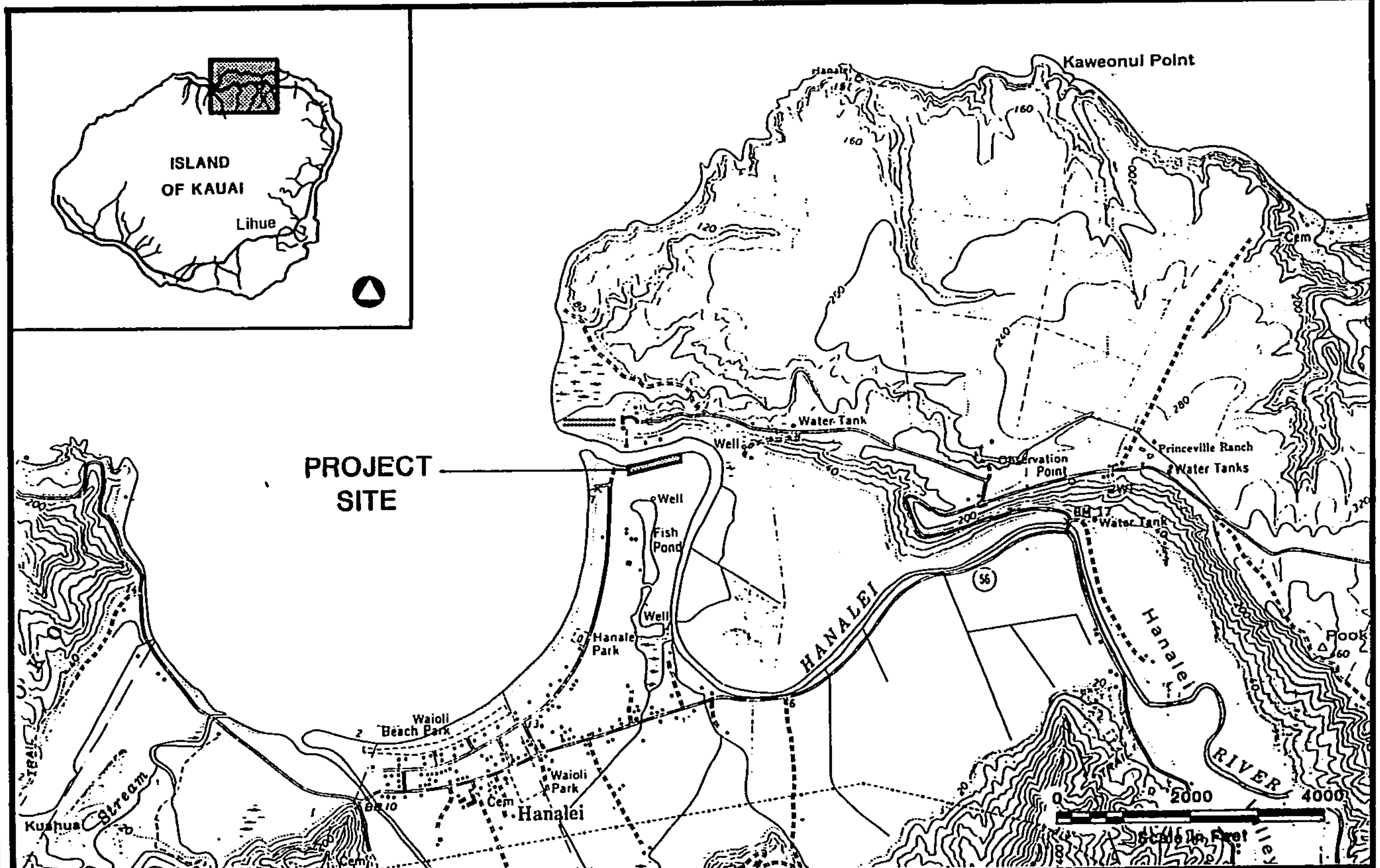

Figure 1 LOCATION MAP

HANALEI EXCURSION BOAT STAGING OPERATIONS

Prepared for:
NORTH SHORE CHARTER BOAT ASSOCIATION
Prepared by:
Wilson Okamoto & Associates, Inc.

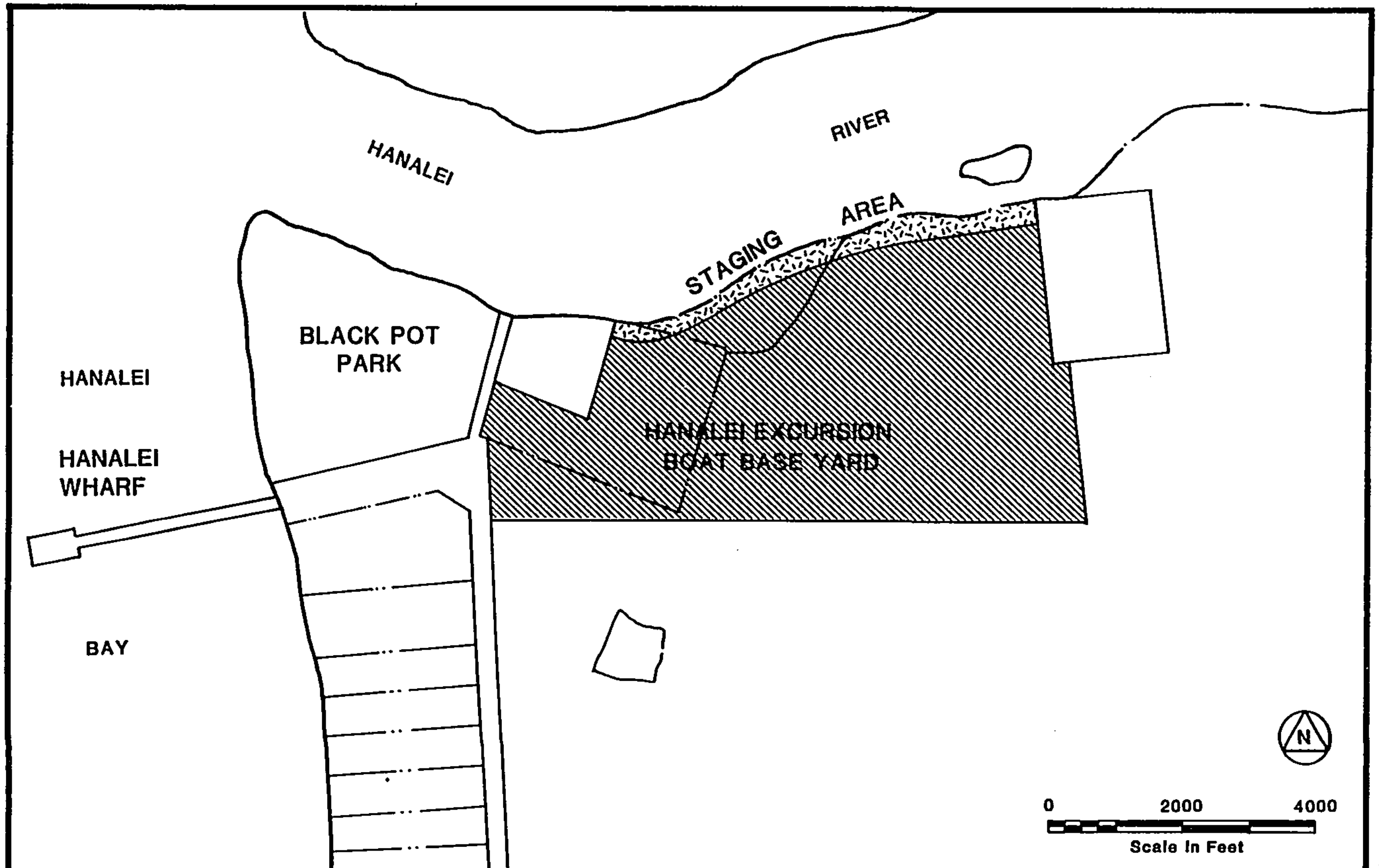

Figure 2 PROJECT SITE

HANALEI EXCURSION BOAT STAGING OPERATIONS

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"development" and a preliminary injunction has been filed against boating operations within the SMA.

This draft environmental impact statement is prepared in conjunction with an SMA permit application seeking to establish commercial boating as a "development" activity originating from the Hanalei River County Boat Ramp and the Hanalei Excursion Boat Base Yard. An earlier environmental assessment was filed with the County of Kauai Planning Department in April, 1989. On June 26, 1989, the Department ruled that the proposed activity may have a significant environmental impact and that an environmental impact statement would be required.

Without approval of the proposed activity, boat launching/landing and passenger loading/unloading will be confined to an area outside of the SMA that has been designated as an ingress/egress zone under the ORMA rules. This area is sited along the makai face of Black Pot Park. Several major disadvantages are inherent in the use of this site for the proposed activity:

1. When seas are even slightly rough, passenger loading in these areas is potentially hazardous, particularly for clientele who are mostly visitors to the island and inexperienced with oceanic conditions near the shoreline;

2. Because passenger safety is paramount, the number of operating days would be severely diminished, to the point of jeopardizing the economic viability of the boating operations, particularly the smaller companies;

3. Refueling, a prohibited activity in the SMA, would need to be accomplished at sea from a moored fuel tender vessel, increasing the potential for fuel spillage;

4. Since boats could not be landed for storage at the boat yard, they would need to be anchored offshore and manned at night in the event of sudden damaging swells known to occur in the area.

5. Submerged rocks and other impediments present may damage boats when they approach the shoreline for passenger loading and unloading; and,

6. Lastly, launching activities in the area fronting Black Pot Park may result in potential conflicts with public use of the park. Notably, in its Findings of Fact for the SMA permit issued to the boat yard

operation, the Planning Department Considerations included the following statement:

> *"Should the DOT choose to designate the launching/landing area to be the sandbar area on the river side of the Applicant's property, further reduction to the congestion and conflicts at or around the beach park can be anticipated."*

B. PROPOSED ACTIVITY

The North Shore Charter Boat Association proposes to conduct excursion boat staging operations on the river bank fronting the existing Hanalei Excursion Boat Base Yard. These proposed activities were integral to the purpose for which the boat yard was designed and approved through the SMA permit. As discussed above, however, the County has determined that launching and landing of boats was no longer permitted when the DOT's SMA permit for managing boating activities in the Special Management Area expired. All other activities conducted at the boat yard, including parking for clientele, operation of passenger support facilities, boat storage and routine maintenance is presently allowed and will continue to be managed in compliance with conditions of the existing SMA permit.

The proposed activity is a partial restoration of previously permitted excursion boat staging operations, including launching and recovery of boats by trailer from the river bank on a daily basis and passenger loading and unloading while the boats are in the water. No new construction is proposed.

The SMA permit for the boat yard specifies that only tour boat operations authorized to conduct such activities by the DOT will be allowed to use the boat yard for the proposed staging operations. Of the 31 operators which have been issued permits by the DOT, only 21 are currently proposing to conduct staging operations in the Hanalei River mouth. See Table 1. The previously prepared environmental assessment was based on the 31 permitted operators.

The total number of vessels proposed to conduct excursion boat operations from the Hanalei River mouth is 41, which is down from the 51 proposed in the previous environmental assessment. Operation of the 41 motorized vessels is on the same order of magnitude as the 41 motorized vessels that were staging operations under the previous SMA permit issued to the DOT. The currently proposed 41 vessels includes the addition of 10 boats which were launched and recovered at the Boat Yard, but conducted passenger loading and unloading at "Tunnels" Beach, approximately 4 miles to the west, under a permit from the

TABLE 1

HANALEI EXCURSION BOAT STAGING OPERATIONS

PERMIT	NUMBER OF BOATS	LENGTH IN FEET	BOAT TYPE	LANDINGS PER DAY	PASSEN-GERS/DAY
1	2	23	Zodiac	6	66
	1	20	Zodiac		
2	1	23	Zodiac	4	60
	1	30	Powercat		
3	1	30	Monohull	2	12
4	1	30	Powercat	4	48
	1	20	Zodiac		
5	2	23	Zodiac	4	56
6	1	30	Powercat	3	45
	1	23	Zodiac		
7	1	23	Zodiac	8	48
	1	20	Zodiac		
8	1	26	Mantacat	2	26
9	1	30	Mantacat	2	36
10	1	29	Mantacat	4	24
11	1	25	Monohull	4	24
12	1	22	Monohull	2	12
13	1	28	Inflatable	2	40
14	1	28	Inflatable	2	32
15	1	48	Monohull	6	36
	1	23	Zodiac		
16	1	20	Zodiac	3	18
	1	24	Monohull		
17	1	23	Zodiac	4	24
	1	20	Zodiac		
18	1	20	Zodiac	3	18
	1	20	Monohull		
19	1	36	Mantacat	4	24
20	1	21	Monohull	2	12
21	10	23	Zodiac	20	300
TOTAL	41			91	961

DLNR. Due to growing concern about use of "Tunnels" Beach for commercial excursion tours, it is anticipated that passenger loading and unloading will be relocated to Hanalei. The breakdown of vessels, by type, is shown in Table 1.

The maximum number of passengers the tour boat operations can accommodate per day is 961 persons, which includes 300 passengers per day that would be added by the relocation of passenger loading and unloading operations from "Tunnels" Beach. The total passenger capacity proposed is comparable to the 1,018 maximum capacity allowed under the DOT's previous SMA permit and much less than the 1,418 passengers proposed in the previous environmental assessment. Achieving maximum capacity of all tour boats is rare, however. The North Shore Charter Boat Association estimates an average daily passenger count of less than 400 passengers per day during the months of April through September and less than 200 passengers per day during the months of October through March.

The Na Pali Coast tours, which account for most of the permits and passenger capacity, are generally between 3 to 5 hours long. These tours usually begin two hours after daylight to allow time for observing weather and sea conditions, making a determination to conduct the tour, and notifying clients who then must come from as far away as Poipu Beach. The morning departure generates the most intense level of activity at the river mouth for a period of 1 1/2 to 2 1/2 hours as shown in Table 2. The mid-day turnaround generates less intense activity since the tours end at different times and vessels may or may not depart for a second tour. The evening returns are fewer and spaced further apart than the mid-day turnarounds.

Other commercial boating activities may or may not fall within the departure/return windows of the Na Pali Coast tours. Charter fishing boats and those dropping off campers and hikers generally depart earlier in the morning while sunset sails in the summer depart and return later in the evening. It is estimated by the North Shore Charter Boat Association that less than 5 percent of the total number of departures occur outside of the time frames shown in Table 2.

The number of boats that may be present in the river mouth during any of the operating windows will be far fewer than the 41 vessels permitted. According to the North Shore Charter Boat Association, rarely will there be more than 10 boats in the river mouth at the same time, even during the busiest morning window at peak season. Due to the relatively significant "down-times" for engine and vessel repair and maintenance, full usage cannot be achieved, particularly for inflatable craft. Weather and sea conditions, as well as lack of bookings and "no-shows" also limit the number of boats in the water.

TABLE 2

VESSEL DEPARTURE AND RETURN TIME FRAMES FROM HANALEI EXCURSION BOAT BASE YARD

Peak Season Departure/Return Schedule (April - September)

Morning Departure Window	7:30 AM - 10:00 AM
Mid-day Turnaround Window	11:30 PM - 2:30 PM
Evening Return Window	4:00 PM - 7:00 PM

Off Season Departure/Return Schedule (October - March)

Morning Departure Window	8:30 AM - 10:00 AM
Mid-day Turnaround Window	12:30 PM - 2:30 PM
Evening Return Window	4:30 PM - 6:30 PM

All boats that can be trailered are stored and fueled within the Hanalei Excursion Boat Base Yard. With one exception, all fueling will soon be accomplished completely on land within the boat yard. The boat to be fueled in the water at the proposed staging area will be confined to an area surrounded by a plastic boom to contain any accidental spills. Manufactured by PENCO, the boom has been specially designed and tested to provide an impermeable barrier to all fuel and oil spillage. Petrochemical-specific absorbent pads are stored nearby to remove any spilled fuel for proper disposal. Fueling in the water will be accomplished by 5 gallon fuel containers.

Passenger parking for the excursion boat tours is accommodated at the Hanalei Excursion Boat Base Yard. Passengers checking-in at the various offices maintained by charter boat companies outside of the boat yard are issued permits for parking at the boat yard.

III. PROJECT SETTING

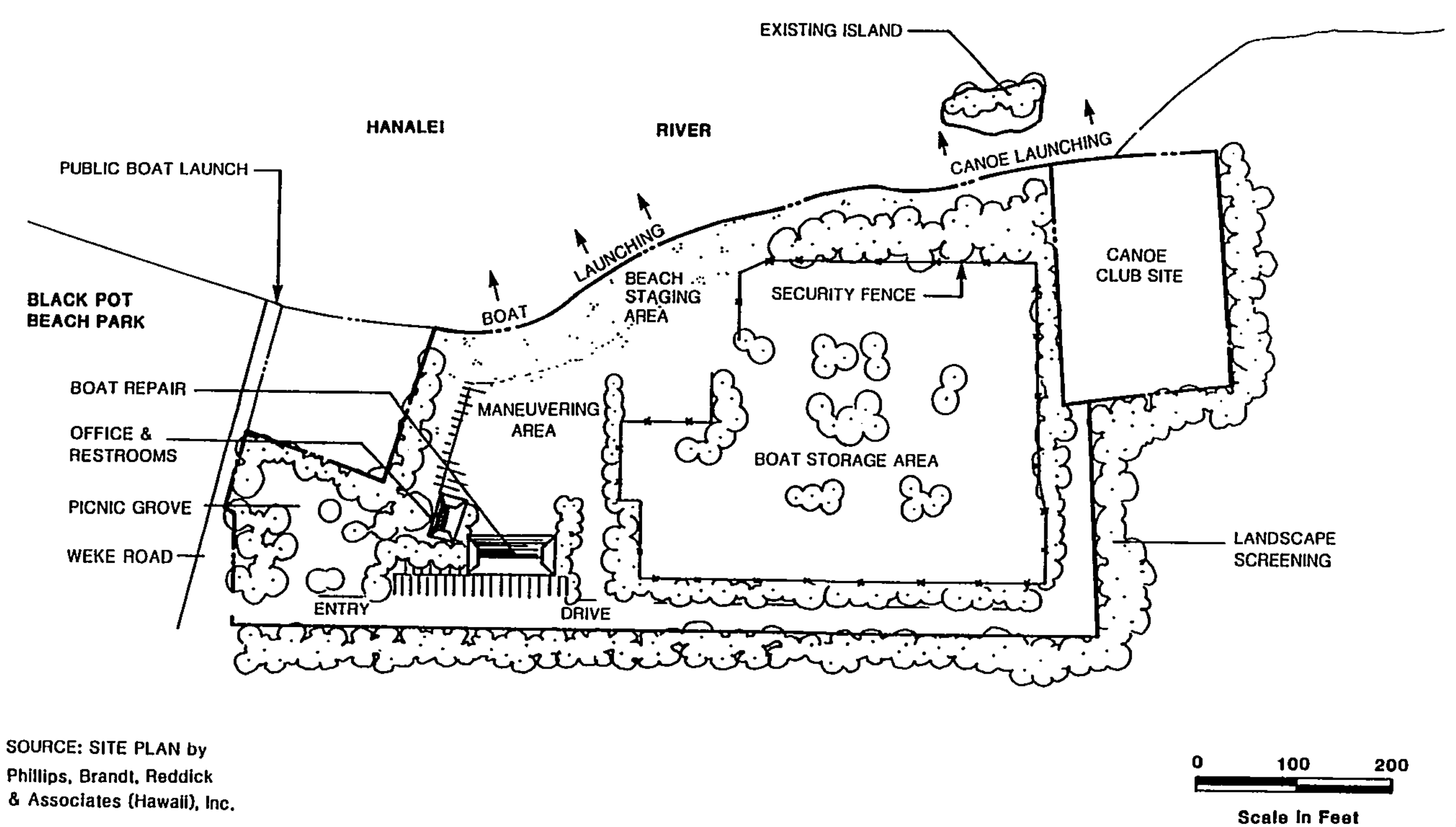
A. HANALEI EXCURSION BOAT BASE YARD

The Hanalei Excursion Boat Base Yard is located on the mauka side of Weke Road where it dead ends at the County boat launching ramp on the southern bank of the Hanalei River (See Figure 3). The boat yard encompasses 8.4 acres, including all of TMK 5-5-01:33 and a portion of 5-5-01:2. It is adjacent to the Hanalei River, beginning about 600 feet from the river mouth and extending another 600 feet inland. Approved under a temporary Special Management Area permit and zoning permit, the purpose of the boat yard is to provide a conveniently located staging area, and boat storage and maintenance facilities for excursion boat operators in the Hanalei area. The boat yard includes security fencing, restrooms, showers, enclosed office and storage space, covered areas for boat and engine repairs, driveways and parking areas, pedestrian walkways, a wash-down area, a paved area for fuel truck parking, crushed rock-paved storage areas, and perimeter landscape screening. The hours of operation for the facility are generally between 8:00 a.m. and 6:00 p.m.

The boat yard was developed in response to growing concern over use of the adjacent Black Pot Beach Park by the excursion boats.

B. BLACK POT PARK

Abundant recreational resources in the Hanalei River mouth are centered around the Black Pot County Park which is located across Weke Road from the Hanalei Excursion Boat Base Yard (See Figure 4). The 2.5 acre park is maintained by the County of Kauai as a passive recreational area providing opportunities for



SOURCE: SITE PLAN by
Phillips, Brandt, Reddick
& Associates (Hawaii), Inc.

Figure 3 HANALEI EXCURSION BOAT BASE YARD

HANALEI EXCURSION BOAT STAGING OPERATIONS

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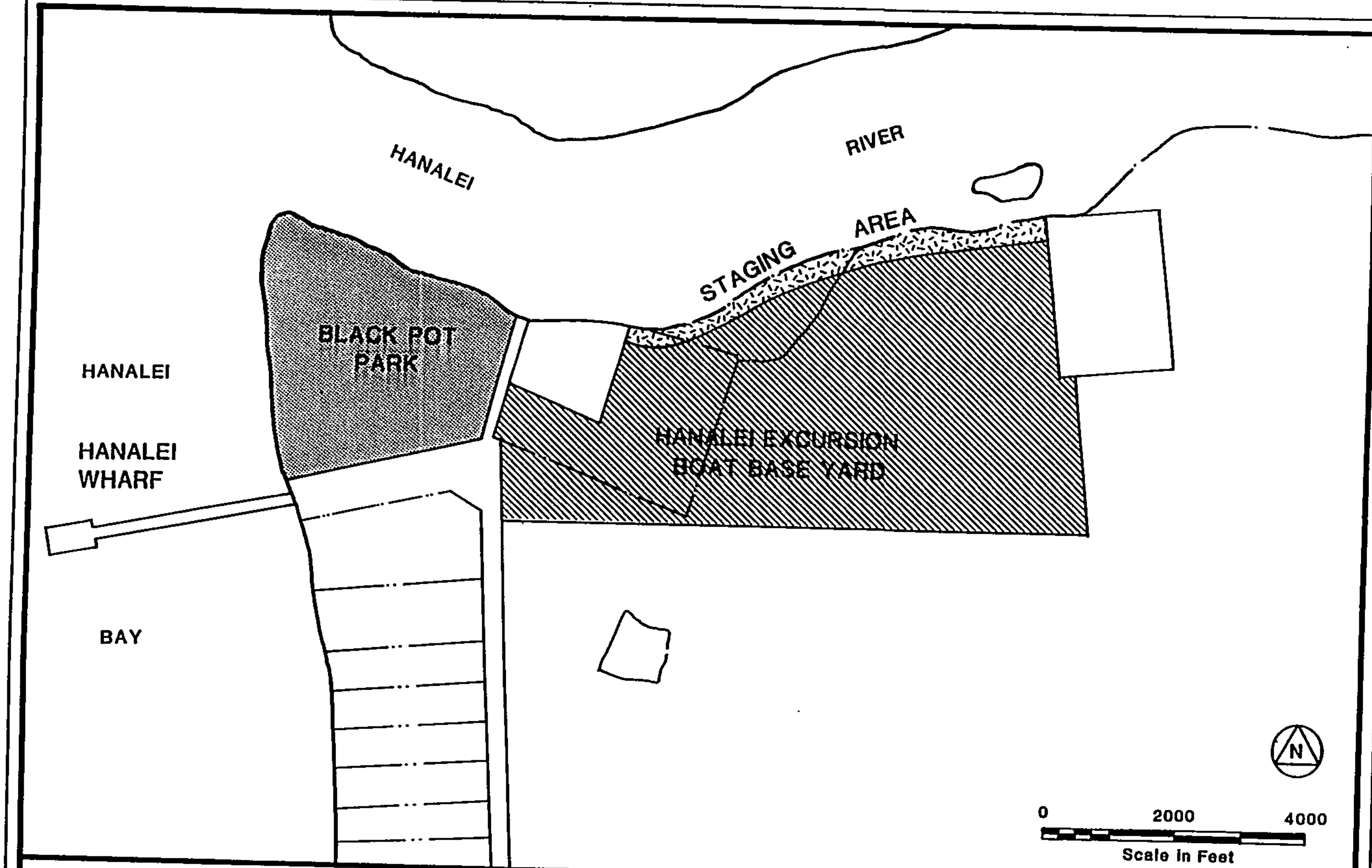

Figure 4 BLACK POT PARK

HANALEI EXCURSION BOAT STAGING OPERATIONS

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picnicking, camping (limited to weekends only), boat launching, fishing, sunbathing and swimming. The Park is bounded on the north by the Hanalei River, on the west by the sea, on the south by the Hanalei Wharf and on the east by Weke Road. Among County facilities at the Park is a boat launching ramp at the end of Weke Road. The ramp is buried under accreted sand and serves as a driveway to the sandy river bank where boats are launched. Facilities available at the park include a parking lot, a boat wash-down hose bib near the launch ramp, restrooms, showers, sinks, picnic tables, barbecue grills and trash containers.

The State of Hawaii owns the Hanalei Wharf which has long been used for sightseeing, fishing and swimming but is presently condemned. Along the north side of the Wharf is a roadway leading onto the beach. The road is also owned by the State and is used as a boat launching ramp.

The sandy beach bordering Black Pot Park extends south past the Hanalei Wharf and all along Hanalei Bay to Makahoa Point. Sunbathing, walking and jogging along this long stretch of beach are common activities. Surfing sites are located offshore of the Park. Hawaiian canoe paddling is practiced in the Hanalei River and Bay, particularly by the Hanalei Canoe Club, which maintains a canoe shed within the Hanalei Excursion Boat Base Yard. The canoe club site is planned for relocation to the eastern side of the boat yard.

Historically, the primary users of Black Pot Beach Park include commercial and recreational fishermen and local residents. Since the park is not located alongside Kuhio Highway, it is not frequented by the visitors touring the island. A survey conducted in conjunction with preparation of the Kauai Coastal Recreation Management Plan indicated that less than 20 percent of the cars observed in the parking lot were rental cars. By comparison, at Haena Park on Kuhio Highway, 90 percent of the cars were rented vehicles. As a camping area, use of Black Pot Park is dominated by residents who accounted for 90 percent of the 1,345 campers in 1985, according to County camping permits issued. While camping in the park is restricted to weekends, during the summer long-term camping is common and unaccounted for in the camping permits.

By 1985, commercial excursion boats using the park as a staging area for their activities were recognized as conflicting with public use of the park. Use of the County parking lot, restroom and shower facilities, monopolization of the beach and overall number of people in the park were problems cited.

To assess and develop management alternatives for Black Pot Park and other recreation areas on the North Shore, the County of Kauai contracted preparation of the Kauai Coastal Recreation Management Plan. One of the management alternatives presented in the Plan is the establishment of a private facility on the

Hanalei River or at Puu Poa Marsh to relieve impacts of commercial boating activities on the park. With the opening of the parking area across Weke Road in 1986, pressure on the parking lot at the park was relieved. Subsequently, when the Hanalei Excursion Boat Base Yard was established, all commercial boating activities were relocated out of the park. While the County boat ramp area is frequently used for launching and recovery, the hose bib is no longer used for wash-downs by commercial operators.

Since the establishment of the Hanalei Excursion Boat Base Yard, the recreational capacity of Black Pot Park has been increased. On weekends when park use is intensive, overflow parking from Black Pot Park has been accommodated at the boat yard parking lot. Other boat yard facilities have also been made available for the general public using the park. Moreover, use of the park by excursion boat clients after tours has been reduced by the provision of picnic tables and other park-type amenities at the boat yard.

IV. DESCRIPTION OF EXISTING ENVIRONMENT

A. PHYSICAL ENVIRONMENT

1. Climate

The climate of Hawaii generally revolves around two primary seasons, summer and winter. During the summer season, between May and October, the weather is warmer and drier, and the tradewinds most persistent. The winter season, between October and April, brings cooler weather and the trade winds are often interrupted by other winds and by intervals of rain.

Kauai has a mild and generally uniform climate. The North Shore is located on the windward side of the island and is exposed to the northeast trade winds. The official climate monitoring station for the North Shore area is located at Kilauea where temperature, wind conditions, and rainfall are recorded.

2. Temperature

In the North Shore area, the annual temperature is 75°F. Temperatures during the summer period normally range between 76°F and 80°F, with the hottest months being July, August, and September. The coolest months are January, February, and March, with a temperature range of 68°F to 72°F. The least variation in temperature between day and night generally occurs along the windward coasts exposed to tradewind blowing in from the sea.

3. Wind

The prevailing winds over the Hawaiian Islands are the northeast trade winds. Generally, the trades blow more than 90 percent of the time during summer and at least 50 percent of the time during winter. They are usually stronger in the afternoon than at night.

On Kauai, the trade winds are forced to flow around the central mountain mass, and thus, easterly winds prevail in the north. Wind studies for the Kilauea Bay area indicate velocities of 2 to 7 mph 40 percent of the time and 7 to 12 mph almost 50 percent of the time.[1]

During the winter months, Hawaii may come under the influence of Kona storms accompanied by southerly winds. The trade winds may also be interrupted by the southwesterly winds that precede and the northerly winds that follow cold fronts.

4. Rainfall

On the north shore of Kauai, rainfall is heavy and varies greatly over short distances from 70 inches along coastal areas to about 300 inches in the higher elevations. On a monthly basis, coastal rainfall fluctuates from eight to ten inches during the remainder of the year.

Major rainfalls are associated with: 1) vigorous trade winds, 2) easterly winds, 3) frontal passages, 4) Kona storms, 5) local convective storms or thunderstorms, and 6) tropical cyclones. Most of the heavy rains occur between November and January. Storm rainfall follows a pattern of short duration (3 to 6 hours) and high intensity.

5. Topography

The project site, situated near the mouth of the Hanalei River, lies on a flat sandy bank at the water's edge. The land area behind the river bank is on a level coastal plain.

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[1]Peat, Marwick, Mitchell & Co. "Wind and Weather Studies-Potential Airline Airport Sites, Island of Kauai", June 1971.

6. Soils

Three soil types have been identified in and around the project area by the Soil Conservation Service (SCS), U.S. Department of Agriculture Soil Survey of the Island of Kauai. A brief description of the characteristics of each soil type follows.

Beaches (BS): This soil type comprises the river bank where the proposed excursion boat operations will be staged. It is found along both banks of the Hanalei River mouth and extends south along the shoreline of Hanalei Bay. *Beaches (BS) occur as sandy, gravelly, or cobbly areas on all islands. They are washed and rewashed by ocean waves. The beaches consist mainly of light-colored sands derived from coral and seashells. A few of the beaches, however, are dark colored because their sands are from basalt and andesite. Beaches have no value for farming. Where accessible and free of cobblestones and stones, they are highly suitable for recreational uses and resort development.*

Mokuleia Fine Sandy Loam (Mr): This type of soil is found inland of the sandy beach and banks of the Hanalei River mouth and extends throughout the coastal plain. *This soil occurs on eastern and northern coastal plains on Kauai. Permeability is moderately rapid in the surface layer and rapid in the subsoil. Runoff is very slow, and the erosion hazard is no more than slight. The available water capacity is about 1.0 inch per foot in the surface layer and about 0.7 inch per foot in the subsoil. This soil is used for pasture.*

Mokuleia Clay Loam, poorly drained variant (Mta): This type of soil is found near the project area along the Hanalei River and is characterized by poor drainage, which makes it different from other soils in the Mokuleia series. *This soil is used for pasture, taro, or sugar cane.*

7. Flood and Tsunami

According the Flood Insurance Study for the County of Kauai, the river bank from which the excursion boat staging operations will be conducted is in Zone VE, special flood hazard area subject to coastal waves. Specifically, the hazard designation is described as "*Coastal flood with velocity hazard (wave action); base flood elevations determined.*" The base flood elevation is established at approximately 16 feet on the river bank.

8. Hanalei River

The Hanalei River is one of 56 perennial streams recognized on the Island of Kauai and is the largest river on the north coast of Kauai. It is influenced by tidal changes for about three miles upstream from the ocean. The river originates near Mt. Waialeale and drains the northeast edge of the central caldera. Most of its length lies in the forest reserve. The mean natural flow was reported to be approximately 75 million gallons per day (mgd), however, a flow averaging 25 mgd is exported by tunnel from the headwaters area to the north fork of the Wailua River. Additional diversions are made downstream for wetland irrigation, however, much of this flow returns to the stream. Thus, mean flow is estimated to be 50 mgd. Minimum flows are considerably less than 10 mgd.

In 1977, the U.S. Fish and Wildlife Service's Stream Channel Modification in Hawaii study classified perennial streams into one of four categories. The categories are based upon both the environmental quality and the appropriate use of the streams. The State Department of Health (DOH) Water Quality Standards were used as a guide to categorize the streams. The four categories are:

Pristine-Preservation: Streams with high environmental and biological quality. Intended uses for this category range from non-consumptive to special exploitive but non-degrading uses.

Limited-Consumptive: Streams with moderate to high quality water or natural values whose use is controlled to prevent excessive modification.

Exploitive-Consumptive: Streams with moderate to low natural (environmental-biological) and/or water quality (those which are well exploited, modified or degraded) and are intended for water related recreation activities.

Construct-Alter: Streams with environmental and biological quality which may be restricted to the public for health or safety reasons.

The Hanalei River is classified as Limited-Consumptive. Although the river has not been channelized or altered, there are six diversions in the river system and six roadway crossings.

By reason of its tidal behavior, the lower portion of the Hanalei River is included in Class A of coastal waters. However, Department of Health sampling for coliform bacteria in 1976 indicated values for total coliform and fecal coliform bacteria exceeded the State's Standard for Class A waters. See Table 3. On a monthly basis, the total coliform bacteria counts exceed the State's standard eleven months out of twelve, and fecal coliform counts exceeded the standard six months out of twelve.

The presence of coliform bacteria may be an indication of sewage pollution from defective cesspools or runoff from cattle pastures.

9. Fauna

The Hanalei River mouth is the lower reach of an estuarine environment that extends approximately 3.4 miles (5.5 km) upstream. Within this stretch of the river, a tidally influenced saltwater "wedge" lies beneath a more than three foot thick layer of freshwater which flows to the sea. Estuarine environments in Hawaii provide important habitats for a variety of fauna, serve as a nursing area for marine species and is an area where migrating stream species acclimate themselves when passing between the marine and stream environments.

Migrating stream species include various endemic gobis, or o'opu, some of which must return to the ocean to complete their reproductive life cycle. Ten species of conspicuous invertebrates and fishes commonly found in streams throughout Hawaii are considered native (See Appendix B, Table 4). Of these ten species, seven are known to be diadromous, meaning that they require passage to the ocean and back to insure reproductive success. These species live and spawn in freshwater and hatchlings from their eggs must spend a period of development in the ocean before migrating upstream. During their passage, species such as these will traverse the area where the excursion boat staging operations will be conducted. Two of the other fish species, o'opu okuhe (*Eleotris sandwicensis*) and aholehole (*Kuhlia sandvicensis*) are principally found near the mouths of streams in estuarine environments and probably inhabit the proposed boat staging area.

A 1977 aquatic survey of streams on the North Shore of Kauai found a substantial population of native aquatic species in the Hanalei River. Of the streams sampled, the Hanalei River yielded the greatest number of endemic species and the highest percentage of endemic species, at 74 percent. Endemic species of concern include the gobis o'opu nakea, and o'opu nopili, as well as the shrimp o'pae kalaole. Other more common endemic fish include the gobis o'opu naniha, o'opu okuhe, as well as aholehole.

Although the estuarine environment of the Hanalei River has not been intensively studied, studies of other estuaries provide an indication of the faunal life likely to be present. For example, a study of the Kahana Estuary on Oahu identified 35 species of crustaceans and fish (See Appendix B, Table 3). Eleven native species (seven species of fish and four species of crustaceans) were regarded as representative members of the community (See Appendix B, Table 2). Five of these species are relatively common.

TABLE 3

HANALEI RIVER COLIFORM COUNTS (1976)

TYPE OF COUNT	STATE CLASS A STANDARD	SAMPLE*
Median coliform bacteria during a 30-day period	1,000 per 100 ml	7,900 per 100 ml
Median fecal coliform bacteria during a 30-day period	200 per 100 ml	205 per 100 ml

* Annual mean State of Hawaii sampling

Based on these studies, it is estimated that there may be as many as 50 native fish alone which inhabit or visit estuarine environments in the State. Since only juvenile individuals of marine species were collected in the Kahana Estuary study, the nursery value of the estuary is apparent.

10. Flora

The Hanalei River bank where the proposed excursion boat operations will be staged is composed of bare sand. Bordering the sandy bank and common along the bank itself further upstream is the hau plant (*Hibiscus tiliaceus*). Other trees in the vicinity of the river are ironwood (*Casuarina equestifolia*), java plum (*Eugenia cumini*), and Guava (*Psidium guajava*). Also common along the upstream banks is California grass (*Brachiaria mutica*). Open areas near the river mouth, including the boat yard and Black Pot Park are landscaped with bermuda grasses and have been invaded by various common weed species.

11. Archaeological/Historical

There are no known archaeological or historic resources in the immediate vicinity of the project area. The sandy river bank is historically a changing feature which has repeatedly eroded and accreted, but there is no documentation available of archaeological resources having been revealed by erosion.

B. SOCIO-ECONOMIC ENVIRONMENT

The socio-economic environment deals primarily with the population and its characteristics, and the general economic trends of the Hanalei Area.

1. Population

Hanalei Town is one of three major communities in the North Shore area; Princeville and Kilauea Town being the other two. The project site is located within Census Tract 401, which extends across the North Shore westward from Moloaa Bay. With a 1980 population of 2,668, Census Tract 401 represents almost 7 percent of the County of Kauai population of 39,082.[2]

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[2]Department of Business and Economic Development, State of Hawaii <u>Data Book 1989</u>.

2. Economy

The economy of the North Shore area is mainly agriculture and tourism. Agriculture has historically been the dominant industry in the North Shore. The major crop was sugarcane until operations at Kilauea Sugar Plantation were terminated in 1970. Currently in the North Shore area, primary agriculture products include guava and other diversified crops, taro, and cattle and bison ranching. Hanalei is one of the most significant taro growing areas in the State and has the highest yield per acre. Pasture land is also abundant in the Hanalei area.

With the decline of the sugar and pineapple industries, tourism has become the leading industry on Kauai. In the North Shore area, resort development is concentrated between the Princeville Resort and the Hanalei Bay Resort. The Hanalei Bay Resort recently underwent remodeling and has 241 visitor units.[3] The Princeville Resort is currently undergoing major renovation and is projected to have 360 visitor units.[4] Tourism plays a major role in the economy of the North Shore area. With its natural beauty and splendid beaches combined with a rural atmosphere, the area will continue to attract visitors.

3. Employment

In 1986, the civilian labor force for the County of Kauai was approximately 23,100.[5] Civilian employment was 21,700 and the average unemployment rate was 6.0 percent.[6]

4. Public Facilities and Services

The following is a summary of existing public facilities that service the North Shore area.

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[3] Thompson, Michelle, "Hanalei Bay Resort: Target Market Changes with $8 Million Revamp," Pacific Business News. September 17, 1990. p.47.

[4] Hawaii Visitors Bureau, Visitor Plant Inventory. 1988.

[5] State of Hawaii Department of Business and Economic Development, "Facts and Figures-1987: Kauai County."

[6] Ibid.

a. Highways and Roads

There are approximately 391 miles of State and County roads in the County of Kauai.[7]

The main transportation corridor between the North Shore and other points on Kauai is Kuhio Highway, Route 56, which has two lanes throughout the North Shore area. The pavement width of the Highway varies from 24 feet near Moloaa Bay to 20 feet near Wainiha Bay to its end in Haena. The width of the highway shoulder varies with terrain. Most of the area west of Kalihiwai has little or no shoulder.

While traffic congestion is not generally evident and roadway capacities are adequate, increased traffic, particularly as a result of more rental cars driven by visitors touring the island, has somewhat affected driving quality by reducing the freedom to pass, lengthening lines behind slower moving vehicles and increasing waits at single lane bridge crossings. These are relatively minor inconveniences, however, in relation to the potential maximum capacity of the roads.

b. Water Supply

Currently, water supply is considered adequate to support island-wide capacity.

Three municipal water systems and one private system serve the communities of the North Shore area. The project site is serviced by the Hanalei municipal system which serves Hanalei Town through Makahoa Point at the western extremity of Hanalei Bay.

c. Sewage Disposal

Within the North Shore area, there are no municipal sewage treatment facilities. The Princeville resort community is serviced by a sewage treatment plant which is privately owned and operated. Also connected to this treatment plant via a sewage lift station is the Hanalei Bay resort. The Ching Young Village Shopping Center is currently being renovated and shall be equipped with a "package"

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[7]State of Hawaii Department of Business and Economic Development, The State of Hawaii Data Book 1989: A Statistical Abstract. p. 437.

sewage treatment station. All other communities and improvements are served by individual cesspools, including the Hanalei Excursion Boat Base Yard.

d. Solid Waste Disposal

Currently, the Halehaka Sanitary Landfill in Lihue is the nearest solid waste disposal facility for the North Shore, but it is nearing its capacity. Once the landfill is closed, the Kekaha Landfill will be the sole disposal site for the island.

e. Electrical Power

Electrical power is generated and distributed by the Kauai Electric Company. In 1986, sales for the County of Kauai exceeded 252 million kilowatt-hours or 5,306 kilowatt-hours per household.[8] Electrical service is available for all communities on the North Shore of Kauai.

f. Recreational Facilities

The existing public recreational facilities in the North Shore area consist of several beach and town parks. Other recreational areas include unimproved beaches and upland wilderness areas. The project site is adjacent to Black Pot Park.

g. Schools

There are two elementary schools in the North Shore area - Kilauea and Hanalei Elementary Schools.

h. Police and Fire

A combination fire and police station serves the North Shore area. It is centrally located along Kuhio Highway near Princeville. Notably, excursion boat operators have long been instrumental in ocean rescue operations in support of rescue services provided by fire station and the U.S. Coast Guard based at Nawiliwili Harbor.

[8]State of Hawaii Department of Business and Economic Development, "Facts and Figures-1987: Kauai County."

i. Medical Services

Emergency medical services are provided by paramedics on duty at the Hanalei Fire Station. There are also two medical clinics serving the North Shore area, the North Shore Medical Clinic and the Princeville Clinic.

V. RELATIONSHIP TO PLANS, POLICIES AND CONTROLS

The Hanalei excursion boat staging operations will be conducted in consonance with various governmental land use plans, policies, and regulatory controls. The following is a review of these controls.

A. LAND USE PLANS

1. Hawaii State Plan

The purpose of the Hawaii State Plan is to establish a statewide planning system that will serve as a long range guide to Hawaii's future. One of the State's goals is to achieve "*A strong, viable economy, characterized by stability, diversity, and growth, that enables the fulfillment of the needs and expectations of Hawaii's present and future generations.*"

Among the State's objectives for the general economy are:

* *Increased and diversified employment opportunities to achieve full employment, increased income and job choice, and improved living standards for Hawaii's people; and*

* *A steadily growing and diversified economic base that is not overly dependent on a few industries.*

To achieve the general economic objectives, the following State Plan policies are considered:

* *Promote Hawaii as an attractive market for environmentally and socially sound investment activities that benefit Hawaii's people;*

* *Encourage labor-intensive activities that are economically satisfying and which offer opportunities for upward mobility;*

* *Stimulate the development and expansion of economic activities which benefit areas with substantial or expected employment problems;*

* *Encourage businesses that have favorable financial multiplier effects within Hawaii's economy; and*

* *Promote and protect intangible resources in Hawaii, such as scenic beauty and the aloha spirit, which are vital to a healthy economy.*

Kauai's excursion boat operations promote the scenic beauty of the Island in areas which would otherwise be inaccessible to visitors. It does this in a manner which does not consume these resources or permanently degrade them through development. Although the operations are visitor industry related, they provide a service that requires unique skills and thereby promotes diversification of employment opportunities.

The State's objective for the visitor industry is:

* *The achievement of a visitor industry that constitutes a major component of steady growth for Hawaii's economy.*

To achieve the visitor industry objective, the following State Plan policies are considered:

* *Support and assist in the promotion of Hawaii's visitor attractions and facilities;*

* *Ensure that visitor industry activities are in keeping with the social, economic, and physical needs and aspirations of Hawaii's people;*

* *Improve the quality of existing visitor destination areas;*

* *Encourage the cooperation and coordination between the government and private sectors in developing and maintaining well-designed, adequately serviced visitor industry and related developments which are sensitive to neighboring communities and activities; and*

* *Develop the industry in a manner that will continue to provide new job opportunities and steady employment for Hawaii's people.*

The excursion boating industry has become a significant visitor attraction on Kauai and an integral part of Kauai's visitor industry, providing job opportunities on the North Shore. It offers a visitor activity that has gained worldwide recognition and serves to promote Kauai and the State of Hawaii, in general. Establishment of the Hanalei Excursion Boat Base Yard from which the proposed operations will be staged was a cooperative effort by the State (Departments Transportation and Land

and Natural Resources), the County of Kauai (Planning Department), a private landowner and the excursion boat operators, to develop a facility that would be sensitive to the neighboring community and recreational activities at Black Pot Park.

Among the State's objectives for land-based, shoreline and marine resources are:

* *The prudent use of Hawaii's land-based, shoreline, and marine resources; and*

* *Effective protection of Hawaii's unique and fragile environmental resources.*

To achieve the physical environment objective for land-based, shoreline, and marine resources, the following State Plan policies are considered:

* *Exercise an overall conservation ethic in the use of Hawaii's natural resources;*

* *Ensure compatibility between land-based and water-based activities and natural resources and ecological systems;*

* *Take into account the physical attributes of areas when planning and designing activities and facilities;*

* *Manage natural resources and environs to encourage their beneficial and multiple use without generating costly or irreparable environmental damage;*

* *Pursue compatible relationships among activities, facilities, and natural resources; and*

* *Promote increased accessibility and prudent use of inland and shoreline areas for public recreational, educational, and scientific purposes.*

As primarily a sightseeing activity, the proposed excursion boat staging operations do not involve any development activities or the taking or consumption of marine resources. At the same time, the activity also promotes the appreciation of Hawaii's unique and beautiful marine and remote wilderness resources. The establishment of the Hanalei Excursion Boat Base Yard facilitated compatibility among land-based and water-based recreational and boating activities at Black Pot Park. While boating activities could conceivably have an impact on fishery and ecological resources in Hanalei River and the ocean, studies indicate that the potential for impact is slight.

The State's objective for scenic, natural beauty, and historic resources are:

* *Enhancement of Hawaii's scenic assets, natural beauty, and multicultural/historic resources.*

To achieve the physical environment objective for scenic, natural beauty, and historic resources, the following State Plan policies are considered:

* *Promote the preservation and restoration of significant natural and historic resources; and*

* *Promote the preservation of views and vistas to enhance the visual and aesthetic enjoyment of mountains, ocean, scenic landscapes, and other natural features.*

As primarily a sightseeing activity, the proposed excursion boat staging operations do not involve any development activities which could affect significant natural, historic or scenic resources. At the same time, the activity promotes the appreciation of Hawaii's unique and beautiful marine and remote wilderness resources.

2. State Recreation Functional Plan

The State Recreation Plan, prepared by the Department of Land and Natural Resource (DLNR), is one of twelve State functional plans prepared to implement the Hawaii State Plan. This plan documents available supplies of recreation facilities as related to public outdoor recreation demands and needs.

The purpose of the State Recreation Plan is to implement the goals, objectives and policies of both the Hawaii State Plan and the County General Plan through a well coordinated program for acquiring, developing, conserving, and utilizing Hawaii's recreational resources. Under the State Recreation Plan, recreation and open space are viewed as related concerns within a broader framework of sound resource management.

The State's objectives include:

A. *Achieve a pattern of land and water resources usage which is compatible with community values, physical resources, recreation potential, and recreation uses which support comprehensive public land use policies.*

B. *Establish a system of maintaining natural and cultural resources for present and future generations, and of managing recreation and other uses in accordance with sound conservation principles.*

C. *Provide a comprehensive range of opportunities which fulfill the needs of all recreation groups effectively and efficiently.*

D. *Assure the provision of adequate public access to lands and waters with public recreation value.*

E. *Provide adequate recreation opportunities which meet expressed needs and are available as a result of the cumulative effectiveness and cooperation of recreation suppliers and users.*

The Hanalei Excursion Boat Yard is located in State Recreational Planning Area 16, North Shore. Planning Area 16 represents the North Shore of Kauai County, which includes the towns of Kilauea, Hanalei,and Haena and the resort area of Princeville. Major recreation features include Kilauea Point National Wildlife Refuge, Haena State Park, Anini Beach Park, Hanalei Beach Park, the 27-hole Princeville Golf Course, and a portion of the Na Pali Coastal State Park. Proposed recreation/facilities include hiking trails; beach parks at Princeville Beach, Wainiha Beach, and Waipa Beach; identified resources at Hanalei Bay, Kalihiwai Bay,or Waipa Beach; and a second golf course at Princeville.

The Proposed Alternatives Actions for Planning Area 16 include: *Provide for boating activities, including provisions of more boat lanes and moorages.*

The proposed excursion boat staging operation will not affect the State Recreation Plan's program for acquiring, developing, conserving and utilizing recreational resources on the North Shore of Kauai.

3. **State Tourism Functional Plan**

The State Tourism Functional Plan, prepared by the State Department of Business and Economic Development, is one of twelve State functional plans prepared to implement the Hawaii State Plan.

The State's objectives include:

A. *Maintenance and enhancement of Hawaii's share of existing and potential visitor markets.*

B. *Development and maintenance of a well-designed and adequately serviced visitor industry and related developments in keeping with the needs and aspirations of Hawaii's people.*

C. *Enhancement of career and employment opportunities in the visitor industry.*

D. *Development of better relations and mutual awareness and sensitivity between the visitor industry and the community.*

The excursion boating industry has become a significant visitor attraction on Kauai and an integral part of Kauai's visitor industry, providing job opportunities on the North Shore. It offers a visitor activity that has gained worldwide recognition and serves to promote Kauai and the State of Hawaii, in general. Establishment of the Hanalei Excursion Boat Base Yard from which the proposed operations will be staged was a cooperative effort by the State (Departments Transportation and Land and Natural Resources), the County of Kauai (Planning Department), a private landowner and the excursion boat operators, to develop a facility that would be sensitive to the neighboring community and recreational activities at Black Pot Park.

4. **Statewide Ocean Recreation Management Plan**

The Statewide Ocean Recreation Management Plan was prepared by State of Hawaii Department of Transportation - Harbors Division in order to alleviate conflicts between all forms of ocean recreation and ocean use. The plan has been in effect since July 1, 1988.

Management of commercial tour boating activities at the Hanalei River mouth by the DOT also addresses recreational activities at Black Pot Park and provides for staging of commercial excursion boating operations at the Hanalei Excursion Boat Base Yard (See Figure 5). Among its <u>Ocean Recreation Management Rules and Areas</u> are:

1. A permit system that accommodates boating operations legally permitted at the time its rules were implemented, but with provisions to achieve, through attrition:

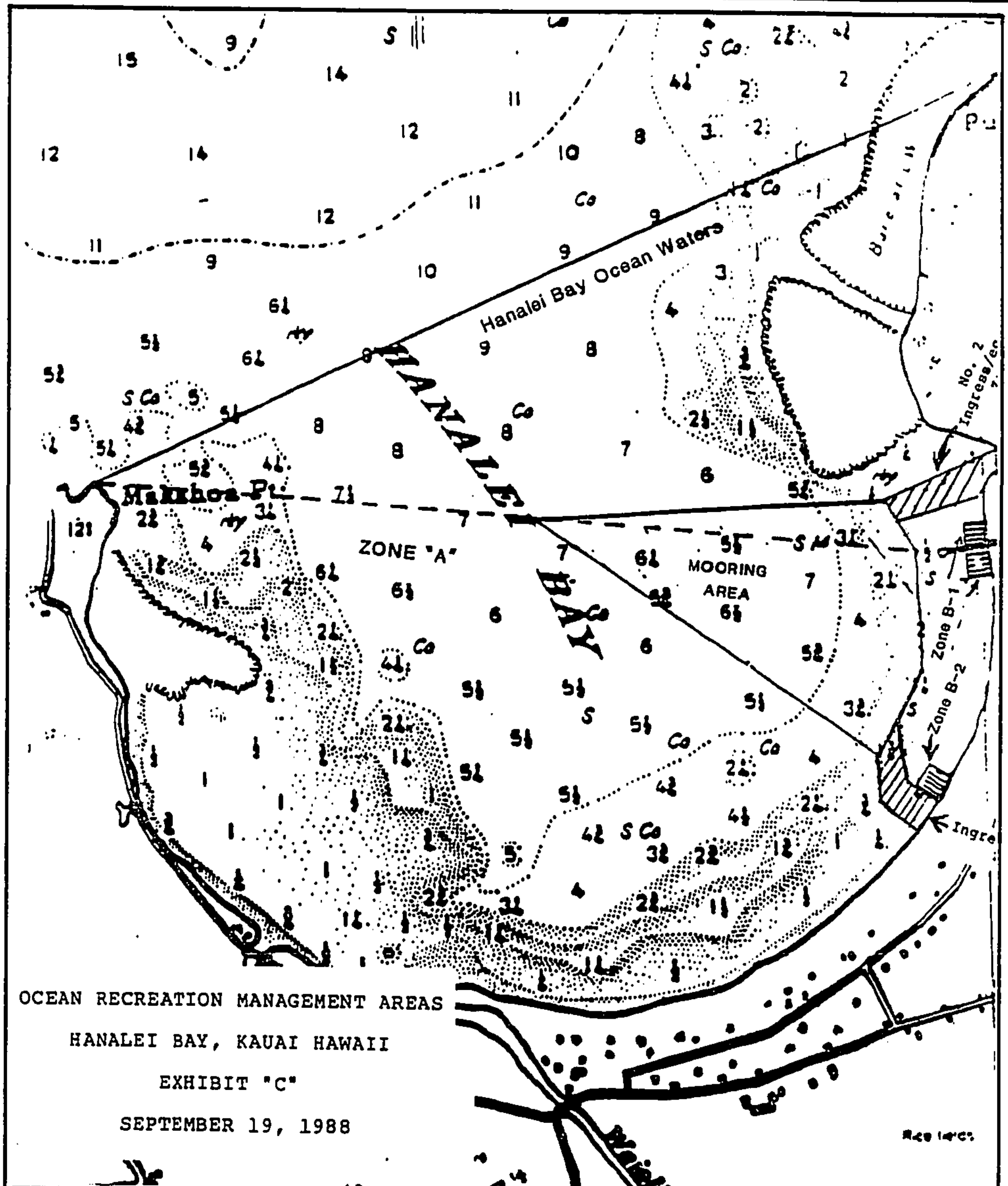

Figure 5 DOT OCEAN RECREATION MANAGEMENT AREA

HANALEI EXCURSION BOAT STAGING OPERATIONS

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a. a limit of 15 commercial vessel permits for operations out of Hanalei River mouth;

b. a limit of 25 passengers per commercial vessel, a limit of 30 passengers to be carried per day and a limit of 2 landings per day;

2. "Slow-no-wake" speed limits (5 MPH) within 500 feet of the shoreline or designated mooring area;

3. A minimum 500 foot vessel operating distance from shore, except through the designated ingress and egress corridor at the mouth of Hanalei River (Ingress/egress zone No. 2);

4. Exclusive swimming areas on either side of the Hanalei Wharf (Zone B-1); and,

5. Designation of most of Hanalei Bay as a recreation area (Zone A) within which commercial boaters can only enter the mooring area at "slow-no-wake" speed.

The proposed Hanalei Excursion Boat Staging Operations is consistent with and shall be conducted in compliance with the Ocean Recreation Management Rules and Areas. Although the limits on the number of permits, vessels and passengers have yet to be achieved through attrition, the current proposal involves fewer operators than proposed in the previous environmental assessment.

B. LAND USE POLICIES

1. State Land Use District

Pursuant to the Hawaii Land Use Law (Chapter 205, HRS) the State Land Use Commission has all lands in the State into four land use districts: Urban, Agricultural, Conservation and Rural.

The project site is located within both the Conservation and Agricultural Land Use Districts (See Figure 6).

According to the Hawaii Revised Statutes:

Agricultural Districts shall include activities or uses as characterized by the cultivation of crops, orchards, forage, and forestry; farming activities or uses

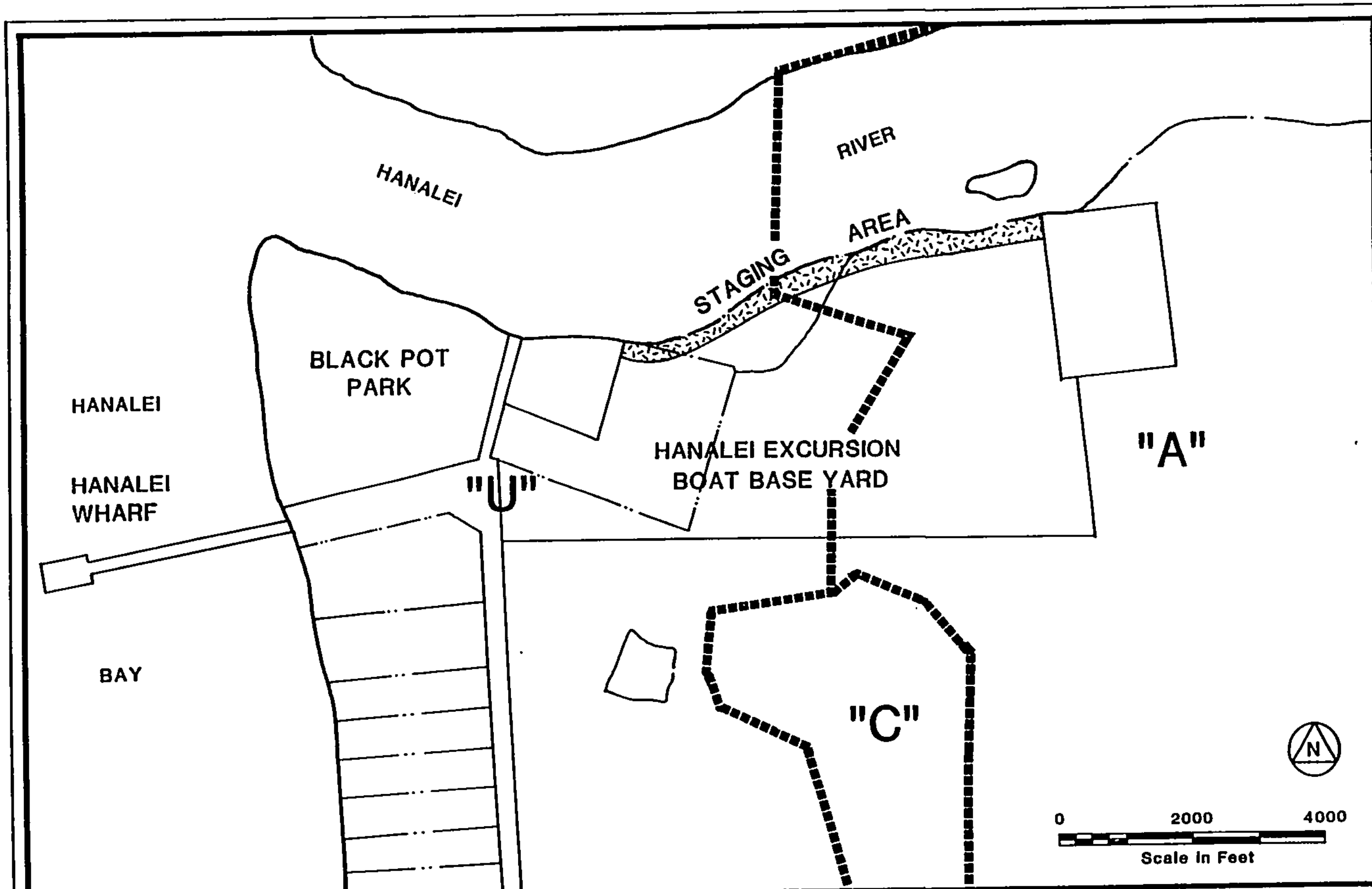

Figure 6 STATE LAND USE DISTRICTS

HANALEI EXCURSION BOAT STAGING OPERATIONS

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*related to animal husbandry, aquaculture, game and fish propagation; aquaculture, which means the production of aquatic plant and animal life for food and fiber within ponds and other bodies of water; wind generated energy production for public, private and commercial use; services and uses accessory to the above activities including but not limited to living quarters or dwellings, mills, storage facilities, processing facilities, and roadside stands for the sale of products grown on the premises; wind machines and wind farms; agricultural parks; and **open area recreational facilities**, including golf courses and golf driving ranges, provided that they are not located within agricultural district lands with soil classified by the land study bureau's detailed land classification as overall (master) productivity rating class A or B. (Emphasis added)*

Conservation districts shall include areas necessary for protecting watersheds and water sources; preserving scenic and historic areas; providing parklands, wilderness, and beach reserves; conserving endemic plants, fish, and wildlife; preventing floods and soil erosion; forestry; open space areas whose existing openness, natural condition, or present state of use, if retained, would enhance the present or potential value of abutting or surrounding communities, or would maintain or enhance the conservation or natural or scenic resources; areas of value for recreational purposes; other related activities; and other permitted uses not detrimental to a multiple use conservation concept.

The proposed excursion boat staging operations are consistent with the Agricultural district designation. Control over the boating operations in the Conservation District was transferred from the Department of Land and Natural Resources, which manages the Conservation District, to the Department of Transportation (DOT) in September 1987 through Legislative Directive. The DOT manages the boating operations through the Ocean Recreation Management Area rules.

2. County of Kauai General Plan

The County of Kauai formulated and adopted a General Plan in 1971 to provide guidance to the County for growth and prosperity. The General Plan was updated in 1981 in order to review, evaluate, and make the necessary and desirable changes to the General Plan. The project site is designated as "OPEN" (See Figure 7).

According to the Kauai General Plan, open lands are defined as:

Lands included within the open classification shall remain predominantly free of development involving buildings, paving and other similar construction. Where such construction are permitted (with the exception of very small lots of *record), they shall be clearly incidental to the prevalent nature of the surrounding open areas.*

The intent of the open designation is to preserve, maintain or improve the natural characteristics of non-urban land and water areas that are of significant value to the public as scenic or recreational resources; or perform essential physical and ecologic functions important to the general health, safety and welfare of the public; or define and regulate use and development within potentially hazardous areas; or form a cultural, historic or archaeologic resource of significant public value.

The proposed excursion boat staging operations do not involve any new buildings, paving or construction activity of any kind. Thus it is not regulated by the General Plan.

3. North Shore Development Plan

The North Shore Development Plan was prepared in 1972 and was updated in 1980 to include the Kilauea Community as well as to include the changes in the needs and values of the North Shore Planning Area.

The North Shore Development Plan is a statement of policy that reflects the community's desires, intentions, and aspirations. Notably, the plan emphasizes preserving the rural atmosphere of the area by controlling population growth and development and conserving land and water resources. Economic development objectives call for maintaining tourism at current levels while encouraging agriculture and smaller industries and commercial enterprises. Several of the recommendations relating to <u>Outdoor Recreation</u> speak directly to the management of coastal recreational resources:

1. *Only basic supportive facilities should be provided at outdoor recreation areas selected for widespread public use in order to enhance the experience. Generally, improvements should be limited to such things as access, comfort stations, trash receptacles, water fountains, emergency telephones, and parking.*

2. *Multiple activity recreation areas must be managed to avoid hazardous conflicts between recreators and allow maximum use of resources (e.g. area suitable for swimming, paddling, and fishing; or area suitable for hunting).*

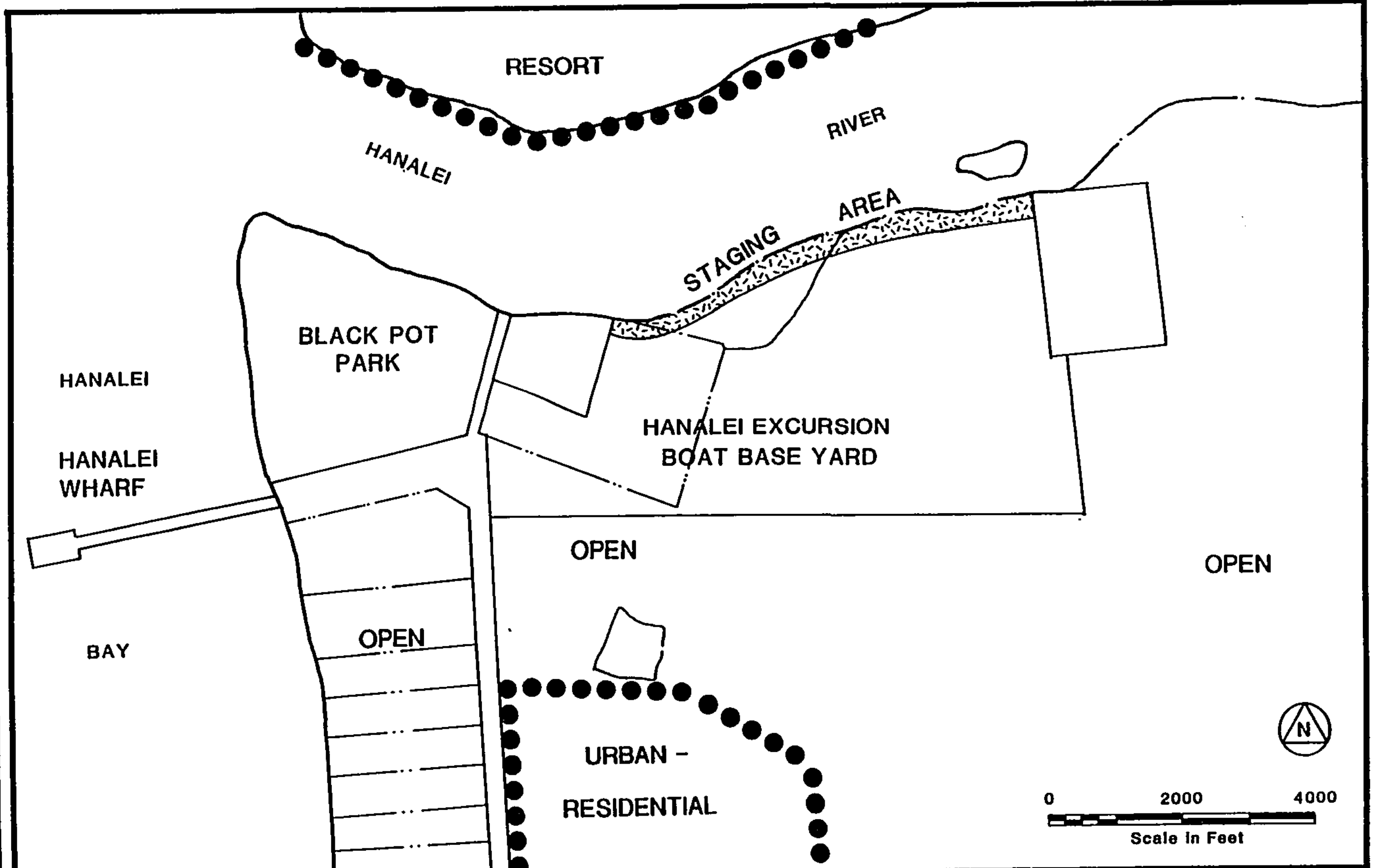

Figure 7 KAUAI GENERAL PLAN

HANALEI EXCURSION BOAT STAGING OPERATIONS

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3. *More camping areas should be developed at Anini Beach, and in Wainiha Valley with adequate security measures.*

4. *The Slippery Slides in Kilauea should be made available for public use. Supportive concession activities may be permitted to offset operational costs, provided there are no significant impacts to the natural environment or to the Kilauea community.*

5. *Procurement of public access to beach, stream, and backcountry wilderness should be actively pursued throughout the North Shore Area, particularly in conjunction with proposed private development.*

6. *Although public access is obtained to recreational resource areas, publicity should be minimized unless the appropriate agency can measure adequate management and security measures. In this manner, local residents would be allowed to continue traditional patterns of resource use.*

7. *New public access to resource areas should be limited to pedestrian trails rather than vehicular roads, if control of use is an objective. Vehicular access should be allowed only for maintenance and emergencies.*

8. *Access to Na Pali coast area should be limited to foot trails by hikers, and campers with permits. Other modes of commercial access such as helicopters and boats should be discouraged, except for maintenance and emergency purposes.*

The following are the goals of the North Shore Development Plan.

A. *To preserve the unique natural beauty of the North Shore Planning Area.*

B. *To preserve the special charm of the North Shore Planning Area.*

C. *To provide for the safety and welfare of the people and their property of the North Shore Planning Area.*

D. *To provide for the economic growth and development of the North Shore Planning Area.*

E. *To preserve the wildlife and flora of the North Shore, recognizing man's dependence upon this preservation for his own health and welfare.*

F. *To insure the preservation of the historic-archaeological sites in the North Shore Planning Area.*

G. *To create a development program for evolutionary growth that depends upon a planning process whereby conflicts can be resolved through the establishment of priorities and community participation.*

H. *To provide for recreational opportunities that are compatible with the unique qualities and natural features of the North Shore.*

On the North Shore Development Plan map, the project site is designated as both "OPEN" and "AGRICULTURE" districts (See Figure 8).

The open designation is applied to lands having natural, historic, scenic or recreational resources of value, which should be protected and preserved. It also used to limit or restrict development in hazardous areas having excessive slopes, unsuitable soil conditions, subject to tsunami inundation, or flood hazard. Public use spaces are frequently designated as open.

Prime agricultural land is a diminishing non-renewable resource, currently subject to increasing speculation pressures for non-agricultural uses.

The proposed excursion boat staging operation conflicts with the recommendation regarding access to the Na Pali coast. Views reflecting this recommendation were considered in the formulation of the Ocean Recreation Management Area rules. With respect to the North Shore Development Plan goals, the boat staging operations do not involve development activities which the goals address.

4. The Comprehensive Zoning Ordinance for the County of Kauai

The Comprehensive Zoning Ordinance for the County of Kauai (CZO) regulates land use in accordance with adopted land use policies. The CZO classifies all lands within the territory of the County of Kauai into six (6) major Use districts as well as two (2) Special Districts. The six Use districts are Residential, Commercial, Industrial, Resort, Agricultural, and Open. The project site is located in both the Agricultural and Open Use Districts (See Figure 9). Outdoor Recreation is a permitted use in both Use districts.

5. Kauai Coastal Recreation Management Plan

The Kauai Coastal Recreation Management Plan is a response to public concern over commercial activities on Kauai's North Shore. It provides a

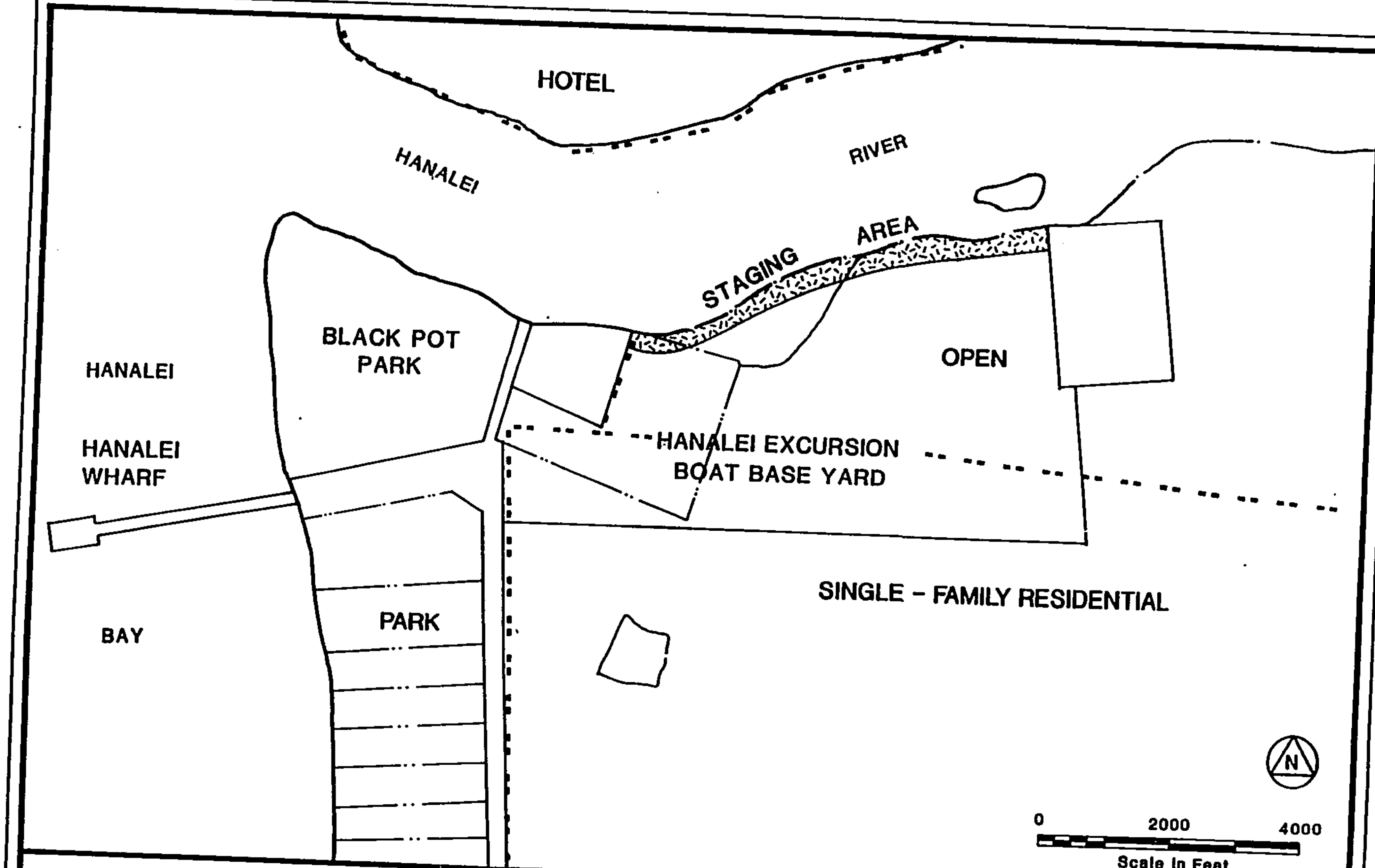

Figure 8 NORTH SHORE DEVELOPMENT PLAN

HANALEI EXCURSION BOAT STAGING OPERATIONS

Prepared for:
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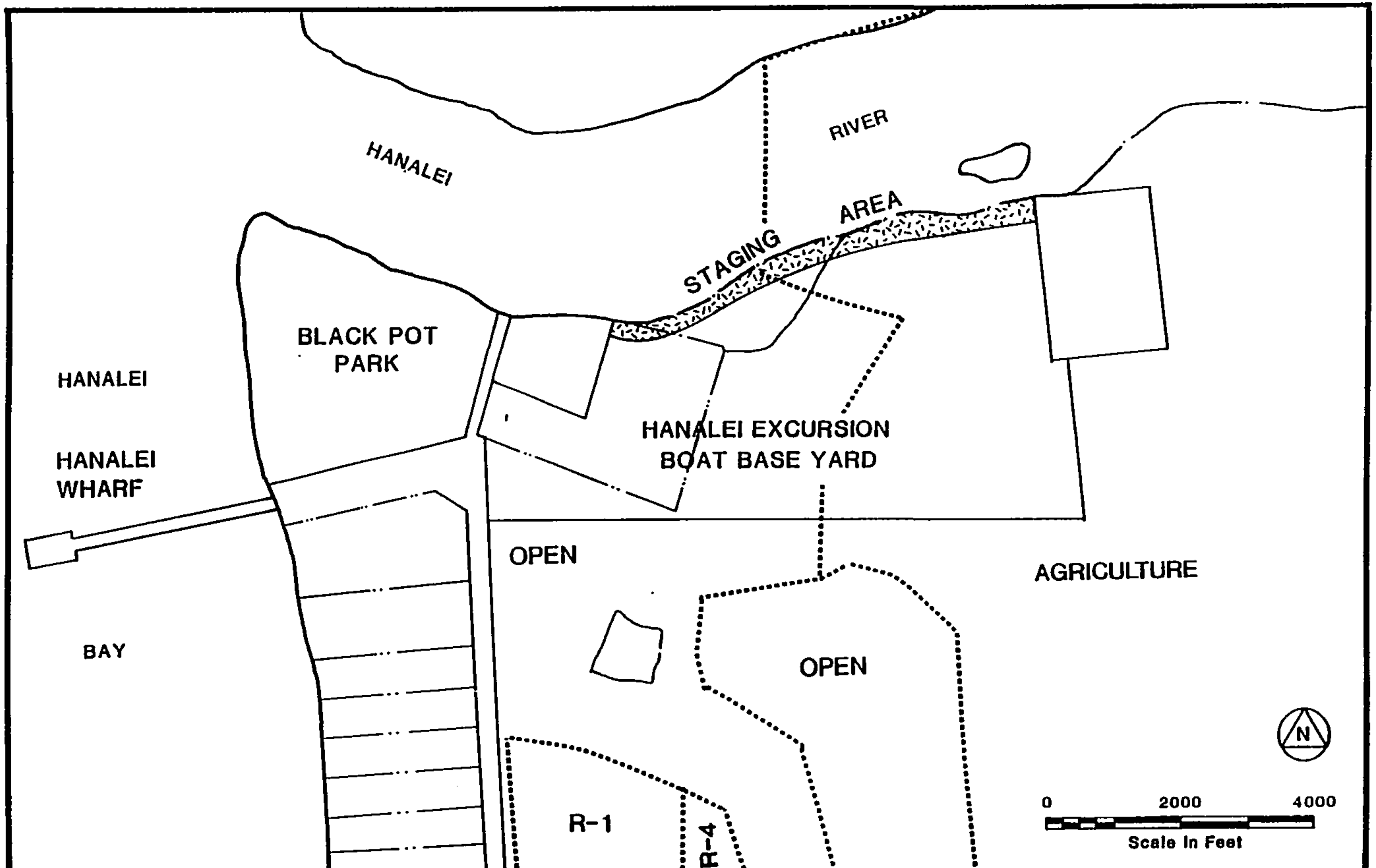

Figure 9 COUNTY OF KAUAI ZONING

HANALEI EXCURSION BOAT STAGING OPERATIONS

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general objectives and management alternatives for controlling impacts of commercially promoted recreational activities in public recreational areas on the North Shore of Kauai. While the plan offers a variety of recommendations for controlling excursion boating operations within Black Pot Park, where they were being conducted, one of the management options was to completely remove such operations to a private passenger loading facility. Establishment of the Hanalei Excursion Boat Base Yard implemented this management option.

C. SHORELINE AND ENVIRONMENTAL PERMITS

1. Special Management Area Permit

The Hawaii Coastal Zone Management Law (Chapter 205A, HRS) charged the Counties with designating and administering Special Management Areas (SMA) along the State's coasts. Any "development", as defined by Chapter 205A, HRS is subject to review and approval through the SMA permit process administered by the County of Kauai Planning Department.

The proposed site of the excursion boat staging operations lies within the SMA boundary. According the County of Kauai Planning Department, the boating operations are a "development" and, therefore, subject to review under the SMA permit procedures. The existing Hanalei Excursion Boat Base Yard where the boating operations will be conducted was approved through a temporary Special Management Area permit by the County of Kauai Planning Commission on June 24, 1987 (SMA Permit No. SP-87-9).

VI. PROBABLE IMPACTS

Inasmuch as no construction is proposed, there will be no short-term impacts associated with the proposed excursion boat staging operations. All potential impacts will be associated with the long-term conduct of those operations. Moreover, since the operations in the boat yard were assessed and subsequently approved through a separate SMA permit action, the currently proposed excursion boat staging operations are examined only in the context of activities occurring on the Hanalei River bank and in the river itself.

The proposed excursion boat staging operations are similar in nature and scale to those which were permitted by the County of Kauai under an SMA minor permit issued to the DOT. This similarity in scale is a net result of adding relocated passenger loading and unloading activities presently conducted at "Tunnels" Beach and the attrition of permitted operators who are not proposing to pursue SMA permit approval.

A. RECREATIONAL RESOURCES

Management solutions to mitigate adverse impacts of commercial excursion boating on recreational resources and activities have been implemented by the DOT on the seaward side of the shoreline as well as by the County of Kauai on the landward side of the shoreline. While these solutions do not entirely resolve potential conflicts among recreational activities such as swimming, boating and fishing, they are intended to provide a reasonable compromise among various uses and activities. In response to House Resolution NO. 298, H.D. 1, 1985, the DOT has developed and implemented its Ocean Recreation Management Rules and Areas (ORMA) governing the North Shore of Kauai (Chapter 19-89, Subchapter 2, Administrative Rules, DOT) to minimize the recreational impact of commercial boating on recreation and other boating activities on the North Shore of Kauai. Based on recommendations developed through extensive efforts of public and private interests represented on the Ad Hoc Committee for a Management Plan for the North Shore of Kauai, the rules specifically provide for the use of the Hanalei River mouth as a staging area for a limited number of commercial boating operations. (The North Shore Charter Boat Association provided a position paper that was referred to in the Committee proceedings). Some of the rules pertinent to the management of the recreational impacts were cited previously (See Relationship to Plans, Policies and Controls, 4. Statewide Ocean Recreation Management Plan, page 29).

On the landward side of the shoreline, the County of Kauai has implemented a management alternative recommended by the Kauai Coastal Recreation Management Plan: North Shore, Kauai. This management alternative called for the establishment of private facility on the Hanalei River or at Puu Poa Marsh to relieve impacts of commercial boating activities on the park. In July, 1987, the County of Kauai approved the SMA permit for the establishment of the Hanalei Excursion Boat Base Yard. This effectively relocated all permitted commercial boating activities previously staged in Black Pot Park into the new boat yard.

B. WATER QUALITY

In response to concerns expressed about the effect of petrochemicals that may be introduced in the Hanalei River estuary, a petrochemical study was conducted by AECOS (See Appendix A). In addition, an examination of potential impacts that petrochemicals detected in the AECOS study may have on stream fauna, particularly the gobies, was prepared by Kelly M. Archer (See Appendix B).

The AECOS study initially determined through water sampling that during conditions of moderate flow, contributions of soluble petrochemicals from the watershed of the Hanalei River are not detectable at parts per billion (ppb) levels.

This result is consistent with the prolonged rainy period preceding the sampling and the non-urban setting of northern Kauai.

A conservative "worst-case" excursion boat staging operation was then simulated by running outboard motors at a density in excess of those that would be experienced during the maximum use of the lowermost portion of the Hanalei River. A simulation was required since there is an injunction against conducting tour boat operations in the river. The simulation was conducted during an in-coming tide when the flushing action of the river would be reduced by the tide. Water sampling during the boating operations indicated the presence of aromatic hydrocarbons at less than one part per million (ppm) levels in the upper water layer amid and immediately downstream of the boating activity. The most likely source of these compounds was condensation from outboard motor exhausts. Within an hour after the outboard motors were shut-down, petrochemicals were again undetectable.

In general, the studies conclude that the level of petrochemical input from outboard motors operating at rare "worst case" maximum boating operations, will be at levels that are highly unlikely to have acute toxic effect on important stream fauna, including endemic goby species. Key considerations leading to this conclusion include the following:

- The "worst-case" level of boating activity would rarely be achieved and would generally be confined to the relatively short morning departure window. Thus, soluble petrochemical levels at any given time would likely be at undetectable levels;

- In the water samples tested, the level of soluble petrochemicals ranged from undetectable parts per billion level to 0.172 parts per million (ppm). While the toxicity of some components of petroleum to aquatic organisms has long been know, establishing lethal and sublethal concentrations has been difficult. One study of effects of outboard motor operations found no acute biological effects either in the field or the laboratory while another laboratory study concluded that "...the concentration necessary to produce a fish kill or damage to the ecological balance would require extremes far beyond the normal use of marine engines on rivers and lakes." In an experiment conducted locally by Mr. Michael H. Kido, a vocal opponent of excursion boat operations in the Hanalei River, mortality of adult and juvenile 'o'opu-nakea (*Awaous stamineus*) is claimed to have been achieved at approximately 13 ppm concentration of gasoline. (as opposed to condensation from outboard motor exhaust, which may have a radically different chemical make-up)

- No soluble petrochemicals were detected upstream of the boating operations, indicating that habitats upstream of the boat staging area will not be impacted.

- The soluble hydrocarbons found in the river following the outboard motor operations are quickly lost from the aquatic environment through evaporation, photochemical oxidation (exposure to the sun), microbial degradation, and dilution, dispersion and emulsification. Streamflow in particular would play a dominant role of dispersing any petrochemicals introduced near the river mouth that were not quickly evaporated.

- The relatively swift current through most of the year prevents the settling of non-soluble petrochemicals in the sediments. In addition, the seasonal exchange of sand in the river mouth with sand from adjacent beaches and offshore areas further inhibits the accumulation of petrochemicals in the river bottom. Sand movement is primarily driven by ocean wave action.

- Chronic effects of the soluble petrochemicals are probably not a major concern since long-term repeated exposure of native aquatic fauna is doubtful, even if there was an extended period of daily "worst case" boat operation for three primary reasons: 1) the native species tend to avoid areas of stream disturbance such as the boating activities; 2) their benthic nature would keep them in the underlying saline layer where the petrochemicals are less soluble and were not detected during the petrochemical study; and, 3) the relatively short time that the species spend in the lower estuary.

- It is probable that larval stages of goby development are more susceptible to harm from outboard motor operations than during later stages of life. This is because they tend to stay near the water surface immediately after they hatch and as they are washed out to sea. The upper layer of water is where the petrochemicals were detected and where they could be sucked into the outboard motor cooling systems or exposed to the propellers and associated turbulence. Larval forms are also more likely to be sensitive to petrochemical exposure. On the other hand, they are only present in the estuary within a day or two of the first heavy rains in the area. At such times stream flow will likely be high and the dilution and dispersion of any petrochemicals will be greater. The greater flow also assures that the larvae will be more dispersed and their chances of being entrained in outboard motors or propeller thrust will be reduced. It should be note that the volume of water flowing through the outboard motors and thrusted by the propellers is extremely small in proportion to the volume of water passing through the estuary, particularly during high flow conditions. Another mitigating factor is the likely reduction in excursion boating activity as a result of the rain. If necessary, boating operations in days following the initial heavy rains could be modified to reduce engine running times within the river mouth when larval forms may be present.

Chronic effects on the ecology of the estuary from the levels of petrochemicals observed in the study are highly unlikely but cannot be entirely dismissed. Circumstances which may result in a greater contribution of petrochemicals to the estuary from any source and/or conditions which substantially reduce the factors responsible for the rapid dissipation observed, if obtained over a prolonged period of time, might result in chronic impacts to the estuarine ecology.

C. SOCIO-ECONOMIC IMPACTS

Commercial boating activity at Hanalei reflects the growing importance of the visitor industry on Kauai and is a unique opportunity to promote a visitor attraction that would otherwise be unavailable. The tour boating industry on Kauai has a direct impact on employment with associated multiplier effects, although its growth has been limited by both the DOT and the County of Kauai in response to public concerns for the protection of recreational and environmental resources. During the peak season, 300 - 400 people are directly employed by commercial boating operations, while another 100 - 150 jobs are indirectly dependent upon the boating operations (e.g. hotel activity desk personnel, North Shore retail and restaurant business, boat parts suppliers and boat repair services, fuel dispensers, etc.). The boating industry grosses $6 -7 million per year.

D. NOISE

The Hanalei River, as a navigable waterway, has no restrictions on its access by all vessels, whether or not they are associated with the proposed excursion boat staging operations. Thus, noise impacts from vessels rightfully navigating the river are unavoidable. Noise impacts of the proposed commercial boating activity would be similar to that experienced while the operations were conducted from the Hanalei Excursion Boat Base Yard. During the morning boat launching and passenger loading activities, noise levels are likely to achieve their highest levels. However, there are no noise sensitive uses such as residences within the immediate area which would be significantly impacted. To some extent, recreational activities occurring at Black Pot Park could be affected, however, such outdoor recreational uses are generally not regarded as particularly noise sensitive. At worst, noise impacts in the park are likely to be perceived as a temporary nuisance.

E. AESTHETICS

Again, as a navigable waterway, the Hanalei River is freely accessible to all vessels and, therefore, is unavoidably subject to any resulting visual impact. The visual impact of the proposed commercial boating activity would be similar to that which occurred while the operations were conducted from the Hanalei Excursion Boat Yard. From Black Pot Beach Park, vegetation and landscaping obscures most of the staging activities occurring at the Hanalei Excursion Boat Base Yard. The most significant visual impact is that of boats entering and exiting the river mouth.

F. TRAFFIC/PARKING

Traffic and parking concerns previously associated with the commercial tour boating operations have been addressed to a large degree by the Hanalei Excursion Boat Base Yard. The boat yard eliminated use of the Black Pot Park parking lot and street parking on Weke Road by clients of the tour boat operations. The boat yard also provided for boat storage, which eliminated the need to transport the vessels to the staging area on a daily basis. Due to the size of these craft, concern had been expressed about their daily commutes on Kuhio Highway and the County streets in the vicinity. Parking congestion in the vicinity of the County ramp has also been alleviated.

G. PUBLIC UTILITIES/SERVICES

The adequacy of public utilities and services to accommodate the proposed operations were addressed in the SMA and zoning permit approvals for the Hanalei Excursion Boat Base Yard. Conditions imposed on the facility included those governing water systems and sewage disposal.

VII. SHORT TERM USE VS. LONG TERM PRODUCTIVITY

The proposed excursion boat staging operations involve no development which could impose a long-term impact on the environment. Thus, there should be no impact on the long-term productivity of the site.

VIII. MITIGATIVE MEASURES

The North Shore Charter Boat Association proposes the following to alleviate and relieve congestion in the area, as well as to avoid conflicts with other users of the Hanalei River and Black Pot Beach Park:

* *Parking will be located away from Weke Road;*

* *Boats will be stored in trailers;*

* *No other commercial tour boat operation will use the facility except for those with DLNR/DOT permits and those which are approved under the proposed SMA permit;*

* *The North Shore Charter Boat Association does not intend to establish an industrial enterprise in the area or on the property and only minor boat and engine repairs will be done;*

* *Petroleum storage and dispensing will be done with portable facilities, such as tanks, that can be hauled away in the event of a flood or heavy surf. All boats except one will be fueled on land within the Hanalei Excursion Boat Yard. Only one boat will be fueled in the water using 5-gallon fuel tanks. This boat will be fueled in a designated area with a special petroleum containing boom surrounding it. Petroleum-specific absorbent pads will be stored nearby in the event that any spillage should occur; and,*

* *The North Shore charter Boat Association agrees to reasonable measures to minimize noise impacts generated by motors being flushed. The flushing process will take place in a collection sump area on the property.*

Other potential mitiation measures which may be deemed appropriate could include:

- Conducting periodic testing of water and sediments for petrochemicals, particularly during low streamflows to determine if there is a potential concern.

- Regulating the number of outboard motors running at any given time in the estuary when streamflow is low, or for a few days after the first heavy rains, to assure that larvae of native sream species are not exposed to significant levels of petrochemical introductions.

IX. ALTERNATIVES

A. NO ACTION

The "no action" alternative would require that all commercial tour boat staging activities be located outside of the County SMA. To comply with DOT rules, such staging activities would occur within the designated ingress/egress area of the river mouth, seaward of an imaginary line drawn across the river mouth from the vegetation line on either side of the river bank. This line lies approximately along the seaward boundary of Black Pot Park. This location is potentially hazardous for such staging operations due to frequently rough wave conditions. In addition, use of this location would again create conditions that may adversely impact recreation at Black Pot Park. Passengers would likely cross the park to get to the loading area, again increasing the number of persons present in the park. Incidental use of park facilities would also likely increase.

B. ALTERNATIVE SITE

Alternative excursion boat staging sites in the Hanalei area were considered in the preparation of the ORMA. The only other site receiving serious consideration was Puu Poa marsh on the north bank of the Hanalei River mouth. Due to the wetland environment and private ownership, this alternative was not pursued. With regard to sites outside of the Hanalei Bay region, sites such as Port Allen have been suggested. However, the distance from Port Allen to the Na Pali Coast makes this alternative unfeasible. A site near Mana, Polihale or the Barking Sands Military Reservation could overcome the problem of distance, however, such an alternative was not pursued primarily since the Hanalei Excursion Boat Base Yard presently offers the most readily available site that has been approved by both State and County agencies. Such areas could be regarded as offering a long-term alternative site if satisfactory arragements could be made. For the short-term, the Hanalei Excursion Boat Base Yard offers the most practical site for the proposed activity.

X. UNRESOLVED ISSUES

The examination of potential petrochemical introductions from outboard motor operations indicates that such introductions are unlikely to be at levels that would be acutely toxic to aquatic life. Nevertheless, there conceivably could be unique situations or conditions when impacts on specific species could result. Such conditions and studies on individual species are more difficult to assess and would not necessarily address all conceivable circumstances.

Also the potential for impacts of gasoline spillage during inwater fueling has not been assessed. Except for one boat, all fueling will be done on land within the Hanalei Excursion Boat Yard.

XI. PREPARERS OF THE EIS

PRINCIPAL EIS CONSULTANT:

Wilson Okamoto and Associates, Inc.	Earl Matsukawa, Project Manager Edwin Kagawa, Researcher

SPECIALISTS:

AECOS, Inc.	Eric Guinther
Kelly M. Archer	

XII. CONSULTATION

The following comments and responses from governmental agencies and the the general public were received on the Environmental Assessment for Hanalei Excursion Boat Staging Operations. Both comments and responses are reproduced in this section.

<u>Federal Agencies</u>

Department of the Army

<u>State Agencies</u>

Department of Health
Department of Land and Natural Resources
Office of Environmental Quality Control
University of Hawaii, Environmental Center

<u>General Public</u>

Michael H. Kido

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
BUILDING 230
FT. SHAFTER, HAWAII 96858-5440

May 18, 1989

REPLY TO
ATTENTION OF:
Planning Branch

MAY 22

Mr. Thom Shigemoto
Planning Director
County of Kauai, Planning Department
4280 Rice Street
Lihue, Kauai, Hawaii 96826

Dear Mr. Shigemoto:

Thank you for the opportunity to review the environmental assessment for Hanalei Excursion Boat Staging Operations, Hanalei, Kauai. The following comments are offered:

a. A Department of the Army permit is not required for the proposed activity.

b. According to the Flood Insurance Study for the County of Kauai, project parcel TMK 5-5-01:2 is located in Zone AE (special flood hazard area inundated by the 100-year flood), with base flood elevation of 13-14 feet MSL. Parcel TMK 5-5-01:33 is located in Zone VE (special flood hazard area subject to coastal waves), with base flood elevation of 13-14 feet MSL.

Sincerely,

Kisuk Cheung
Chief, Engineering Division

WILSON
OKAMOTO
& ASSOCIATES

ENGINEERS
ARCHITECTS
PLANNERS

1150 SOUTH KING STREET
HONOLULU, HAWAII 96814
PHONE: (808) 531-5261

Mailing address:
P. O. Box 3530
Honolulu, Hawaii 96811

2844-02
October 18, 1990

Mr. Kisuk Cheung, Chief
Engineering Division
U.S. Army Engineer District, Honolulu
Department of the Army
Building 230
Fort Shafter, Hawaii 96858-5440

Attention: Planning Branch

Subject: Environmental Assessment for Hanalei Excursion Boat Staging Operations, Hanalei, Kauai

Dear Mr. Cheung:

This is in response to your June 19, 1989 comments on the subject environmental assessment. On June 26, 1989, the County of Kauai Planning Director issued a determination that an environmental impact statement would be required in conjunction with a Special Management Area permit application for the proposed boat staging operations.

Currently, we are preparing the Draft EIS for the proposed action. Your comments and this response shall be incorporated in the Draft EIS as documentation of the consultation process initiated by the County.

The following responses are in the respective order of your comments.

1. No response required.

2. Thank you for your clarification of the flood hazard designations affecting the proposed activity site. These will be incorporated in the Draft EIS.

We hope that we have satisfactorily responded to your comments. If you have any questions please call me.

Sincerely,

Earl K. Matsukawa, Project Manager

cc: North Shore Charter Boat Association
Mr. Martin Wolff
County of Kauai Planning Department

JOHN WAIHEE
GOVERNOR OF HAWAII

JOHN C. LEWIN, M.D.
DIRECTOR OF HEALTH

RON METLER, M.D.
DISTRICT HEALTH SERVICES ADMINISTRATOR

STATE OF HAWAII
DEPARTMENT OF HEALTH
KAUAI DISTRICT HEALTH OFFICE
3040 UMI STREET
LIHUE, HAWAII 96766

June 19, 1989

JUN 21 19[illegible]

Mr. Tom Shigemoto
Planning Director
County of Kauai
Planning Department
4280 Rice Street
Lihue, HI 96766

Dear Mr. Shigemoto:

Subject: Environmental Assessment
Hanalei Charter Boat Association
Commercial Tour Boat Operations
Hanalei, Kauai

We have reviewed the subject Environmental Assessment and offer the following comments for your consideration:

1. The Hanalei River and Hanalei Bay are classified as Class 1-a and Class AA, respectively, under Chapter 54, Water Quality Standards, Title 11, Administrative Rules, State of Hawaii. The EA states that all boats that can be trailered will be fueled within the Hanalei Excursion Boat Base Yard. The boats to be refueled while in the river will be surrounded by a plastic boom to contain any accidental spills that may occur.

   Refueling of all of the boats should be done on land to prevent and to eliminate the possibility of spillage of petroleum fuel into the water.

2. Sanitary facilities at the site or at the boat company offices meeting the requirements of Chapter 11, Sanitation, Title 11, Administrative Rules, State of Hawaii shall be provided for the clients. The type of wastewater system required shall be dependent upon the amount of wastewater generated. The wastewater system shall meet the minimum requirements of Chapter 62, Wastewater Systems, Title 11, Administrative Rules, State of Hawaii.

3. The study conducted by AECOS, Inc. on the impact of soluble petrochemicals on the ecology of the Hanalei River estuary should be reviewed by the Department of Health-Pollution Investigation and Enforcement Branch and the Department of Land and Natural Resources-Division of Aquatic Resources.

4. Effective water pollution control measures shall be provided to prevent drainage run-off from the boat base yard site from discharging into the Hanalei River, wetlands and ponds.

Thank you for providing this office the opportunity for reviewing and commenting on the subject EA. Should you have any questions, please call me at 245-4323.

Sincerely,

Clyde Takekuma

Clyde Takekuma
Chief Sanitarian, Kauai

CT:skh

WILSON
OKAMOTO
& ASSOCIATES

ENGINEERS
ARCHITECTS
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PHONE: (808) 531-5261

Mailing address:
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Honolulu, Hawaii 96811

2844-02
October 18, 1990

Mr. Clyde Takekuma, Chief Sanitarian,
Kauai District Health Office
Department of Health
State of Hawaii
3040 Umi Street
Lihue Hawaii 96766

Subject: Environmental Assessment for Hanalei Excursion Boat Staging Operations, Hanalei, Kauai

Dear Mr. Takekuma:

This is in response to your June 19, 1989 comments on the subject environmental assessment. On June 26, 1989, the County of Kauai Planning Director issued a determination that an environmental impact statement would be required in conjunction with a Special Management Area permit application for the proposed boat staging operations.

Currently, we are preparing the Draft EIS for the proposed action. Your comments and this response shall be incorporated in the Draft EIS as documentation of the consultation process initiated by the County.

The following responses are in the respective order of your comments.

1. We understand that the Hanalei River mouth area is classified as Class AA, as is Hanalei Bay, because it is subject to tidal influence.

   We acknowledge your recommendation that all boats be fueled on land to eliminate the possibility of gasoline spillage in the water. Our Draft EIS recognizes in-water fueling as an unresolved issue.

2. The proposed action involves no new construction of any kind, including sanitary facilities. The sanitary facilities to be used in support of the proposed activity were approved and subsequently constructed at the Hanalei Excursion Boat Base Yard under a temporary Special Management Area permit and zoning permit by the County of Kauai Planning Commission on June 24, 1987 (SMA Permit No. SP-87-9).

3. The subject environmental assessment, including the AECOS study, has been reviewed by the Department of Land and Natural Resources, and comments have been offered by the Division of Aquatic Resources. These comments, together with our response to them, shall be included in the Draft EIS.

WILSON
OKAMOTO
& ASSOCIATES

4. As discussed previously, operations at the Hanalei Excursion Boat Base Yard were reviewed and approved under a temporary SMA permit and zoning permit.

We hope that we have satisfactorily responded to your comments. If you have any questions please call me.

Sincerely,

Earl K. Matsukawa, Project Manager

cc: North Shore Charter Boat Association
Mr. Martin Wolff
County of Kauai Planning Department

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
LIBERT K. LANDGRAF
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RUSSELL N. FUKUMOTO

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

ROUTE TO:
...... Shigemoto
...... Sagum
...... Nitta
...... Laureta
...... Mamaclay
...... Harvey
...... Hironaka
...... Nakamura
...... Mateo
...... Fernandez
...... Hironaka
...... Fukushima
...... Tsuchiya
...... Yoshida
...... Fernandez
...... Kashiwabara
...... Yamashiro

JUN 1 ...

REF: OCEA-sor

FILE NO.: 89-631
DOC. NO.: 5862E

JUN 1 4 1989

Honorable Tom H. Shigemoto, Director
Department of Planning
County of Kauai
4280 Rice Street
Lihue, Kauai 96766

Dear Mr. Shigemoto:

SUBJECT: Environmental Assessment for Hanalei Excursion Boat Staging Operation, Hanalei, Kauai at TMK: 5-5-01: 33, portion of 2

Thank you for giving our Department the opportunity to comment on this matter. We have reviewed the environmental assessment you submitted and have the following comments.

Our Department's Historic Sites Section comments that historic preservation concerns are not covered in this EA. A review of our records indicates that this project area does not contain historic sites that are listed on the Hawaii Register or the National Register of Historic Places, or that have been determined eligible for inclusion on the National Register of Historic Places. However, no archaeological surveys have taken place in the area, so it is uncertain if significant historic sites are present.

For such a shoreline area, historic sites which are remnants of prehistoric houses, taro fields and fishponds are often present. Thus, we recommend that representative subsurface testing in the project area be done by a professional archaeologist to determine if subsurface historic remains are present. Any Land Commission Awards (LCA) records regarding this area should also be checked for information on land use ca. A.D. 1850, as this will help predict any archaeological sites that might be present. If subsurface remains of historic sites are found, their extent needs to be established and their nature (depth, type of deposits, midden, function and age) must be documented. With this information, the significance of such remains can then be determined. Initial significance assessments should be made by the consulting archaeologist. The archaeological report and significance assessments should be sent to the County Planning Department and to our Historic Sites Section for review and approval.

If significant historic sites are present and will be impacted by the proposed development, then an acceptable mitigation plan must be made and approved by the County Planning Department and our Historic Sites Section.

The Recreation Section notes that there are no concerns directly involving State Parks, although 3 of the boat operators using the Hanalei Excursion Boat Staging Operations Area are also providing park visitor landing services in Na Pali Coast State Park. We wish to continue these important boat trip services to the park, and note these services are included in the DOT Ocean Recreation Management Rules for the Na Pali Coast. However, the location and establishment of commercial excursion boat facilities is a separate concern under the jurisdiction of the DOT.

Our Department's Aquatic Resources Division states that from the standpoint of aquatic resources values, we see two concerns with the permit requested for staging tour boat operations (running outboard motors, generating noise and wake turbulence, loading and unloading passengers, and refueling) as proposed. The first one of environmental effect, i.e. direct effects of the activities on aquatic organisms and indirect effects on the area as habitat for aquatic life. This concern relates to impact on fishery stocks, particularly migrating young of native diadromous freshwater species such as oopu, opai and wi which spend their larval life in the ocean, and other species inhabiting the estuarine environment. The second is one of human displacement of fishermen wishing to use the public launching ramp, fish from boats in or near the river mouth, or from the shore near the proposed staging area.

The Appendix attempts to address part of this by evaluating persistence of one class of hydrocarbons introduced into the water by outboard engines operated on gasoline. The EA shows that the level of soluble petrochemicals in the estuary rises noticeably in the area near the boat staging area. We understand that a Kauai Community College instructor (Mr. Michael Kido) conducted a study on the toxicity of gasoline (but not specifically naphthalene) to adult and juvenile 'o'opu nakea and preliminary toxicity tests indicate that 'o'opu nakea have a high sensitivity to gasoline (more tests are needed due to the small sample size). It is possible that larval (hinana) and post-larval (ahina) 'o'opu may be even more sensitive to gasoline than are either juveniles or adults.

However, the EA does not present information on what aquatic life actually occurs at the affected site (including seasonal occurrences such as reproductive and larval migrations). It does not provide the range (i.e., peak) of use level expected under the permit requested, only an estimated average. It treats only the estimated effect of potential naphthalene discharges (without reference to tolerance by life stages of freshwater and estuarine species), and speaks only of the difficulty of assessing potential for impacts from chronic (unknown) exposure. It completely omits such potential affecting factors as noise and wake turbulence. Without such information the uncertainty about potential for environmental consequences, and thus the concern remain.

Similarly, the EA presents little information about other, prior uses of the potentially affected area (i.e. shoreline uses, river uses including agricultural activities and water diversions in upland areas, water quality and flow, and that part of Hanalei Bay through which the tour fleet would sweep each morning, noon and evening). It is clear that past tour use has conflicted with public recreational uses (e.g. fishing, boating): the boatyard was permitted in order to move conflict out of Black Pot Park. We believe that the continuing public controversy and legal maneuvers over Hanalei River/Bay tour operations would not be happening if other users did not fear their own use threatened by past and proposed commercial use.

The EA indicates that regulation of conflicting uses is supposed to be remedied by DOT's Ocean Recreation Management Area (ORMA) rules. However, the EA contains no information on existing levels of noncommercial uses. It does not say how the levels of proposed commercial activity (including staging operations for 10 boats shifted from "Tunnels" to the Hanalei River) relate to existing or proposed ORMA limits. The EA also does not propose any ultimate limit for, or discuss maximum capacity of the area to handle, tour boat staging operations. Further, the EA provides no quantitative estimate of or how other users would be affected by the commercial activities which the requested permit would authorize.

In summary, we believe that the EA does not relieve concern about potentially harmful effects of the requested permit on aquatic resources values.

Our Department's Division of Land Management has reviewed the subject assessment and recommends its acceptance.

We recognize the boating issue to be highly emotional and controversial.

It is clear, however, that government decision makers feel that commercial boating is a desirable activity, subject to certain controls, such controls imposed by a series of Board of Land and Natural Resources-authorized revocable permits, proposed by an AdHoc Committee covered by DOT and currently by the DOT's ORMA.

The assessment proposed a course of action that we feel to be a sensible compromise between commercial boating interests and opposing environmentalists.

Based upon comments from our Historic Sites Section and Aquatic Resources Division, the need for an Environmental Impact Statement is evident.

Please feel free to call me or Roy Schaefer of our Office of Conservation and Environmental Affairs, at 548-7837, if you have any questions.

Very truly yours,

WILLIAM W. PATY

2844-02
October 18, 1990

WILSON
OKAMOTO
& ASSOCIATES

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Mailing address:
P. O. Box 3530
Honolulu, Hawaii 96811

Mr. William W. Paty, Chairperson
Department of Land and Natural Resources
P.O. Box 621
Honolulu, HI 96809

Subject: Environmental Assessment for Hanalei Excursion Boat Staging Operations, Hanalei, Kauai (FILE NO: 89-631, DOC. NO: 5862E)

Dear Mr. Paty:

This is in response to your June 14, 1989 comments on the subject environmental assessment. On June 26, 1989, the County of Kauai Planning Director issued a determination that an environmental impact statement would be required in conjunction with a Special Management Area permit application for the proposed boat staging operations.

Currently, we are preparing the Draft EIS for the proposed action. Your comments and this response shall be incorporated in the Draft EIS as documentation of the consultation process initiated by the County.

The following responses are in the respective order of your comments.

1. Historic Sites Section: The proposed action involves no construction work or improvements of any kind. All boating activities will be conducted from the existing river bank which is composed of accreted sand and has a long history of having been used for boat launching and landing. Although the river bank has historically undergone repeated erosion and accretion, we know of no documentation of any archaeological features having been exposed. Thus, no impact on historic resources is anticipated.

2. Recreation Section: No response required.

3. Aquatic Resources Division: The AECOS study contained in the appendix was intended to determine the magnitude of petrochemical introduction in the estuary that could result from a rare "worst case" boating operation. The study demonstrated that the amount of petrochemicals introduced by such operations is extremely small and highly transient. This finding, in conjunction with prior studies of outboard motor emission impacts on aquatic species, conditions of the Hanalei River mouth, the nature of boating operations, and the behavior of species likely to be present, led to the conclusion that the potential for adverse impact of the boating operations on aquatic species in Hanalei River is remote. Studies that would be required to assess those remote impacts, if any, would be

extraordinarily costly and time consuming since even basic data such as seasonal stream flow volumes are not available. Even if such studies were to be conducted, it is unlikely that they would ever be entirely conclusive since arguments could still be raised such as the possible hyper-sensitivity of specific species at specific life stages that could not be directly tested. We acknowledge that there are remote possibilities for adverse impact which will remain unresolved. Perhaps a more reasonable alternative to interminable studies, as suggested by the University of Hawaii Environmental Center, is to allow the operations to proceed and to conduct periodic monitoring of water quality, and other relevant factors to detect potential long-term impacts.

Mr. Kido's reported experiment must be approached with caution, both in terms of its scientific merit and personal bias, since he has been a vocal opponent of the tour boating operations. Attached is our response to Mr. Kido's letter reporting his experiment.

The Draft EIS provides additional discussion of species that inhabit or traverse estuarine environments such as the Hanalei River mouth and the discusses the nature of potential effects that the excursion boating operations could have on such species.

The comment suggesting that naphthalene was measured is inaccurate. Naphthalene was used as a reference standard to calibrate the fluorometer but, as discussed in the AECOS report, the nature of the analytical method does not allow specific identification of the compounds detected or their absolute concentrations. In fact, naphthalene may or may not have been present in the samples.

Wake turbulence contributes to the reduction of toxicity through enhancement of dispersion, dilution and evaporation. There is no evidence to suggest that periodic noise events in the river mouth would have a detrimental impact on the aquatic environment.

We are puzzled by your reference to "prior uses of the potentially affected area... including agricultural activities and water diversions in upland area." We provided a discussion of uses along the shoreline and river bank in the project area. No commercial boating operations are proposed upstream of the staging area at the river mouth. Moreover, the AECOS study demonstrated that the minute petrochemical introductions by the boating operations were not detected upstream of the operations.

With respect to Hanalei Bay, we provided a description of uses occurring at Black Pot Park and areas offshore where the excursion boats would traverse. We believe that both the State and County governments have strived to develop a reasonable compromise among these and other competing uses. Since compromises forged in such heated controversy will rarely satisfy all parties, it is not unusual for dissatisfaction to persist. While we acknowledge that things will never be quite the same as before the boaters arrived, we maintain that the impacts of the excursion boat staging operations, within the context of the compromises achieved through Ocean Recreation Management Area rules and the County-approved Hanalei Excursion Boat Base yard, are minimal.

The Draft EIS shall clarify the relationship of the boating activities to the ORMA rules. Basically, all ORMA rules will be complied with except that the ultimate limit on the commercial boating activity, which shall be achieved through attrition, has yet to be achieved. As was apparent in the DOT's process for developing the ORMA rules, the types of potential conflicts among ocean uses is not conducive to quantitative analysis since they are extremely transitory and highly subjective. Much of the information on use conflicts provided was anecdotal as opposed to quantitative. This does not necessarily detract from the value of the ORMA rules since they embody a collectively forged compromise solution to a very complex and emotionally charged issue.

We hope that we have satisfactorily responded to your comments. If you have any questions please call me.

Sincerely,

Earl K. Matsukawa, Project Manager

cc: North Shore Charter Boat Association
Mr. Martin Wolff
County of Kauai Planning Department

attachment

JOHN WAIHEE
GOVERNOR

MARVIN T. MIURA, Ph.D.
DIRECTOR

TELEPHONE NO.
548-6915

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
465 SOUTH KING STREET, ROOM 104
HONOLULU, HAWAII 96813

May 16, 1989

MAY 13

Mr. Tom Shigemoto, Director
Planning Department
County of Kauai
4280 Rice Street
Lihue, HI 96766

Dear Tom:

SUBJECT: REVIEW/ANALYSIS OF THE HANALEI EXCURSION BOAT STAGING OPERATIONS ENVIRONMENTAL ASSESSMENT

After our review/analysis of the subject environmental assessment, OEQC offers the following comments with suggested mitigation measures (see attached review/analysis). If there are any further questions or concerns, please call Matthew Higashida of my staff at 548-6915.

Sincerely,

Marvin T. Miura, Ph.D.
Director

REVIEW/ANALYSIS OF THE HANALEI EXCURSION BOAT STAGING OPERATIONS

The appendix entitled "**SOLUBLE PETROCHEMICAL MEASUREMENTS IN THE LOWER REACH OF THE HANALEI RIVER, HANALEI, KAUAI, HAWAII**" addresses the solubility of aromatic hydrocarbons within the water column. However, other impacts should be addressed in light of available knowledge on the life history of the o'opu nakea (Awaous guamensis).

A report by Ego (1951-1956) entitled "**Life History of Fresh Water Gobies**" was done on the Wainiha River. The report stated that the spawning season extends from August through December. The spawning peaks are August and September. The location of these spawning sites are noted on page 11 as follows:

> "All the spawning sites located thus far were found far downstream in the lowest portion of the stream within the channel itself or in the rapids just at the head of the channel. **In this limited area just within the river mouth the most numerous batches of spawned eggs were found, and it appears that this area is the major spawning site of the o'opu nakea.** Across the river mouth a sand bar built by the wave action of the sea and the opposing river current formed an effective dam. Within the damned area in waters ranging from four to eight feet deep, eggs were found on almost all the rocks examined."

If the similarities (life history, river mouth, spawning sites and sand bar) are applied to the Hanalei River estuary, then the location of the Hanalei Excursion Boat Staging Operations may be located in an ecologically sensitive area due to the following information. The **Peak Season Departure/Return Schedule** is from April - September. This means that there is an overlap with the spawning season during the months of August and September. The probable impacts are written with respect to the findings below.

On page 1, the report states as follows:

> "The eggs which are laid attached to rocks hatch within 24 to 28 hours. Immediately after hatching the larvae are swept out to sea by the river current."

Within the first 24 to 28 hours, the larvae may be vulnerable to the acute effects of petrochemicals since the larvae display a **negative geotrophic** swimming characteristic. This means that the larvae tends to swim toward the surface where the petrochemicals would be found due the difference in densities between oil and water. Therefore, the issue of solubility may not be the real issue. Also, the tar balls that sink to the bottom may foul the filamentous green algae and other food sources which may possibly impact the fry (hinana) or adult (o'opu) because field observations indicate that the fishes are primarily browsers and bottom feeders. The need to do sediment analysis may be warranted.

The larvae may also be impacted by rotating propellers and the water intake systems of outboard motor engines. Qualitative data on larvae mortality may be obtainable, whereas quantitative data from these impacts may not be possible.

MITIGATION MEASURES

Based on the information of the life history of the o'opu, the following mitigation measures are suggested:

1) Limiting the total number of departures/returns to the Hanalei River Mouth;

2) Boats should avoid the area where the ebb current flows out to sea;

3) Disallow in-water refueling and refueling at boat baseyard;

4) Boats should be trailered away from the baseyard to be refueled; or

5) Prohibit Hanalei Excursion Boat Staging Operations during the spawning season peaks of August and September.

JOB COMPLETION REPORT

INVESTIGATIONS PROJECTS

State of Territory of Hawaii

Project No.: F - 4 - R Name Fresh Water Game Fish Management Researc

Work Plan No. 1 Life History of Fresh Water Gobies

Job No. 1 Preliminary Survey of the Fresh Water Goby Fishery

Job No. 2 Studies of Reproduction and Feeding Habits of Fresh Water Gobies

Job No. 3 Fresh Water Goby Tagging Program

Job No. 4 Fresh Water Goby Trapping Program

To avoid excessive repetition, Jobs No. 1 through No. 4 were combined into a single completion report, as information and data for the jobs were gathered in close conjunction with one another.

Period Covered: November 20, 1951 to December 31, 1956

Abstract:

Of the various species of fresh water gobies found in the Territory, the *Awaous guamensis* popularly known as the o'opu nakea is the only species for which a fishery of any importance is being conducted. Although the o'opu occasionally appear in the fresh fish market, fishing for this species today is primarily for sport and for home consumption. The methods which are commonly employed for taking the fish are by means of hook and line, set lines, spears, cast nets, gill nets and traps.

On all of the islands of the Territory where permanently flowing streams are found, the o'opu nakea occur in varying degrees of population density. Due to adverse changes brought about in many of the o'opu bearing streams by increased divergence of water for domestic, industrial, and irrigational purposes, the population of o'opu throughout the Territory has been diminishing yearly. At the present time with the possible exception of a few streams on the island of Molokai, the island of Kauai offers the best o'opu fishing. In consequence, the heaviest fishing pressure is being exerted on Kauai.

In a stream such as the Wainiha, the o'opu nakea are found from sea level situations near the river mouth to an elevation estimated at 1500 feet and located about 8 miles inland. Within this distributional range, the first five miles of the stream contain the bulk of the o'opu nakea population with the area of maximum density situated about 2½ miles above the river mouth.

During the spawning season which extends from August through December, the fish descends downstream in mass migration to spawn in the lower section of the stream. The eggs which are laid attached to rocks hatch within 24 to 28 hours. Immediately after hatching the larvae are swept out to sea by the river current. The fry re-enter the streams and begin migrating upstream after spending 4 to 7 months in a marine habitat. After reentry into a fresh water habitat, the fish attain sexual maturity in a year's time. Fecundity studies reveal that within a spawning season gravid females 4, 7, and 11 inches in total length are capable of producing 125,000, 750,000 and 1,500,000 ripe eggs respectively

Field observations made of feeding o'opu nakea show that the fish is primarily a browser and a bottom feeder. Analysis made of contents found in the digestive tract of 320 fish revealed that filamentous green algae made up the bulk of the ingested food material, forming 84% of the total volume. The remaining 16% by volume of ingested material consist of animal matter with chironomid larvae being the most important in the animal group.

For studies on growth rate and population dynamics, fish trapping and tagging experiment were conducted. Experimental tests made of three types of fish tags revealed that the best results were obtained from the streamer type tags, therefore, this type of tag was selected for use in the field. During the fish marking program inclement weather conditions made possible the tagging of only 105 fish. The small number of fish tagged and the difficulties experienced with the trapping method precluded the use of these methods for estimating population abundance. Information obtained from recovery made of three tagged fish indicate that the growth rate of the o'opu nakea is very slow, possibly being in the nature of one to two inches per year for fish in the 9 to 10 inch size class.

Objectives:

The main objectives of this project were to gather information on the goby fishery and to study various aspects of the ecology and the life history of the goby in order to obtain the necessary background of information upon which efficient management measures may be based for the protection and development of this fishery. Specifically, for Job No. 1 the objectives were to determine the major species involved and their relative abundance and distribution in relation to stream environment. For Job No. 2 the objectives were to gather information on the reproductive and feeding habits of the goby. Job No. 3 was concerned with tagging as a means of determining the growth rate and population abundance of the goby. The objectives of Job No. 4 were to determine efficient methods of collecting the fish for tagging purposes as well as for conducting studies on population dynamics.

Techniques Used:

Interviews were held with local residents familiar with the goby fishery to determine the principal fishing areas and the species involved. The information so gathered was then substantiated through field observations, creel census, and surveys made of the various streams in the Territory. Since it was felt that less error would result if data for the life history studies were collected from a discrete group of fish, the goby population of the Wainiha Stream was selected for intensive study. For this purpose, data on the physical and biological characteristics of the stream were gathered and fish sampling stations were set up. The goby samples, which were collected by angling, spearing, use of explosives, netting, seining, and trapping were subjected to various morphometric measurements and meristic counts. In addition, information on the spawning season and the fecundity of the fish were obtained from the collected gonads and feeding habit studies based on contents of digestive tracts. By keeping larval and adult gobies in tanks and glass aquaria, studies on sexual maturity, growth rate, feeding response, spawning reaction, and general behavior were made. To obtain an index of relative abundance of the goby, an enumeration method was devised which permitted a direct census of the fish population. In attempts to gather information on growth rate and population density, fish tags were used in conjunction with a trapping program.

Findings:

THE GOBY FISHERY

The species of fresh water gobies commonly found in the streams of the Territory are the Awaous guamensis (Cuvier and Valenciennes), the Sicydium stimpsoni Gill, and the

Stenogobius genivittatus (Cuvier and Valenciennes). These species together with other gobioids and goby-like fishes are collectively referred to as "o'opu" in the Hawaiian Islands and more specifically are called o'opu nakea, o'opu nopili and o'opu anihaniha, respectively. Of these three, only the *A. guamensis* or o'opu nakea is being fished to an extent today; hence, this species was selected for study. Whenever the term "o'opu" is used in this and in all subsequent reports, it will refer only to the o'opu nakea or *A. guamensis*.

In former years, when the fish were abundant and unrestricted fishing methods were permitted, a commercial fishery for the o'opu nakea existed. Unfortunately, records of past commercial landings are unavailable, but, discussions held with older residents of the islands indicate that the fishery, though mainly seasonal in nature, provided supplementary income for a number of people. Even now, o'opu nakea appear occasionally in the fresh fish market commanding a retail price of $.75 to $1.00 per pound. However, fishing for this species today is mainly for sport or for home consumption and the fish sold are either those caught in excess of what can be conveniently used at home or those taken by illegal means expressly for marketing purpose.

Today, with the use of hook and line, set lines, spears and cast nets, fishing for o'opu nakea is conducted throughout the year. However, with the approach of summer, the fishing intensity increases and attains its peak when the goby descends downstream in mass migrations to spawn. The first spawning run ordinarily occurs in late July or early in August with intermittent migrations continuing through November or even December. In its mass movement downstream, the fish always accompanies or follows the high water of a freshet and the migration is terminated near the river mouth where spawning occurs. Once word of the migration is received by the public, anglers young and old including women and children, line the banks by the hundreds with rod in hand. After a run fishing may continue to be good for two or three weeks, and in a good day's fishing it is possible for a successful angler to catch several hundred gobies. The fish caught measure about 5 to 12 inches in length with the weight of individual fishes ranging from a few ounces to nearly a pound.

Creel census data taken from anglers fishing the Hanalei River on Kauai during the principal spawning period showed an average catch rate of 4.3 fish per hour with the most successful angler having obtained a catch rate of 21.6 fish per hour, while some of the unsuccessful fishermen had little if anything to show for their efforts.

Except for minor variations, similar types of angling gear are used by each of the participants. The rod consists of a simple bamboo pole 8 to 15 feet in length to which a nylon monofilament line of 3 to 10 pounds test is attached. At the end of the line, which is usually kept the same length as the rod, a fish hook which may range in size from 2 to 10 is used with a split shot sinker placed 3 to 12 inches above the hook. Live earthworms impaled onto the hook singly or in a cluster is the only bait used. The rig is fished with the bait resting on or near the bottom or jigged very gently.

During the seasonal runs, considerable numbers of o'opu are also taken with fish spears, cast nets, gill nets and wire traps. In spearfishing, divers equipped with diving goggles and pronged or barbed spears propelled with rubber slings stalk the gobies in waters from waist to about 10 feet deep. No special skill is required to impale these gobies, for being demersal and having the habit of resting quietly on the bottom, they are easily approached within spearing distance by avoiding sudden movements.

When a cast net is used, it is thrown over gobies which may be visible from the stream banks or over areas which appear to provide likely hiding places for the fish. The portion of the stream bottom covered by the net is then disturbed by probing with a piece of stick or by dislodging rocks, which cause the fish to rush out of their hiding places and become entangled in the meshes of the net.

Gill nets and wire traps when used are generally set near the river mouth in the slower flowing channel-like sections of the stream to minimize the possibility of the gear being washed away should an unexpected freshet occur. Although it appears that gill nets and wire traps provide very efficient harvesting methods, this type of gear is not too commonly employed since only a few areas on some of the larger streams are suited for this type of fishing technique.

In addition to the methods described above, other fish taking practices, which have subsequently been outlawed, are still being conducted clandestinely. One of the practices involves the use of a trap or weir called a "Kahi". The construction of these traps entails the blocking off of a portion or the entire width of a river, which traps, if allowed to remain, would catch a considerable portion of the o'opu population migrating downstream to spawn. It seems that the bulk of the o'opu appearing in the market are taken by this means.

As an example, one of the Kahis examined during the course of this study consisted of a stone wall reaching across the stream from bank to bank and erected in the shape of a "V", at the apex of which was located the Kahi proper. The arms of the stone wall, which funnel the fish to the crib, measured 38 and 198 feet in length, were 3½ to 5 feet high and averaged about 5 feet in width. The crib, set at an incline and forming a fish sieving sluice, was 8 feet wide and 30 feet long with side-fences built 2 feet high. The framework of the sluice was built of heavy timbers and logs over which were nailed haole koa poles 1 to 2 inches in diameter and which were set about ¼ to ½ inches apart to allow the water to sieve through while still retaining the fish.

Another illegal fishing method is conducted with the use of chemicals which are toxic or which have a stupifying effect on the fish. Bleaching preparations sold under such trade names as "Chlorox" and "Purex" are some of the most common substances used as fish poisons. The despicable use of such substances cannot be condemned too strongly for it not only kills off all sizes of fish as well as other faunal life, but also renders that portion of the stream unproductive for a long time.

The taking of goby fry called "hinana" is another practice which has been prohibited through regulation but is still being continued to a very limited extent. This type of fishing occurs when the hinana, measuring less than an inch in length and still in the transparent larval stages, begin migrating upstream from the ocean. Since the larval fish travel near the surface of the water in large compacted schools and since their response to the flow of water is positively rheotropic, it is possible to direct large quantities of the fry into traps or seines made of fine window screening or mosquito netting. To guide the fry into these enclosures, fences of coconut fronds or other leafy tree branches are hung in the water. Prepared in omelets or in patties, hinana are considered delicacies, and before the taking of the fry was prohibited by regulations, considerable quantities of the larval fish were caught and sold in gallon lots.

The Sicvdium stimpsoni or o'opu nopili and the Stenogobius genivittatus or o'opu anihaniha, which were briefly mentioned earlier, are species which are ignored by the fishermen and, when taken, are done so very infrequently and only incidentally while spearfishing for o'opu nakea. The indifference displayed toward these species is because of the inconsequential size (average length 3 to 4 inches) attained by both fishes and also because the o'opu nopilo will not take a baited hook with the o'opu anihaniha very seldom doing so.

The Eleotris fusca or o'opu akupa, belonging to the family Eleotridae, is commonly caught along with the o'opu nakea and, due to its superficial resemblance and overlapping habitat, is often erroneously thought to belong to the goby family. This fish is found in the lower portions of the stream, particularly in esturine situations, and in mullet ponds. It is readily caught on a baited hook and on rare occasions appears in the market; however, the total numbers taken cannot begin to compare with that of the o'opu nakea.

THE O'OPU NAKEA. THE GOBY SELECTED FOR STUDY

Taxonomically, the o'opu nakea is classified as follows:

Order: Perciformes
Sub-Order: Goboioidei
Superfamily: Gobioidae
Family: Gobiidae
Genus: Awaous
Species: guamensis (Cuvier and Valenciennes)

The body of the fish is elongate being sub-cylindrical anteriorly and bilaterally compressed posteriorly. Photographs of the fish are presented in Fig. 1. The head is large and broad and is contained 3 to 3.3 in standard body length. The small eyes are positioned high up and located about mid-length of the head. The interorbital space is slightly less than twice the diameter of the eyes. The large valise-like mouth, equipped with thick fleshy upper and lower lips is nearly horizontal being only very slightly inclined downwards posteriorly. The 1st and 2nd dorsal fins which are both moderate in height are separate with counts of VI - I, 10 (1). The caudal fin is rounded and shorter than the head length. The ventral fins are united to form an oblong sucking disc. The head is scaleless while the body is covered with small ctenoid scales.

In life, the ground color of the dorsal side of the fish ranges from purplish black to a light brown with the color fading on the ventral side, this color tending to intensify with age. On lighter colored fishes, dark brownish or blackish reticulations and blotches are noticeable along the upper sides of the body. A distinctive black blotch is found at the base of the caudal fin.

The sexual demorphism of the o'opu nakea is very distinct. Without examination of the gonads the male and female are easily distinguished by several salient external characteristics. The head and mouth of the males are much broader than those of the females and the males usually have a much darker body coloration. With increased growth this difference in head shape and body coloration becomes more distinct. The females normally do not grow as large as the males and are heavier than the males per given body length. Mid-line drawings made of length-weight relationship of male and female o'opu nakea presented in Fig. 2 illustrate the size and weight differences of the two sexes. The sexes are most easily distinguished by the shape of the prominent anal papillae located posterior to the vent. The papillae of the males are triangular in shape ending in a smooth point distally, while the papillae of the females are semi-discordal in shape with the rounded margin of the distal end being noticeably fringed particularly during the breeding season.

The largest male and female o'opu examined during the course of the investigation were taken from the Wainiha River on Kauai. The male measured 343 mm in total length and weighed 484 grams while the female measured 279 mm and weighed 340 grams. Unconfirmed reports have been received of larger fish being taken in previous years; however, any male fish measuring more than 275 mm and any female fish measuring more than 225 mm in total length can be considered large.

PRINCIPAL FISHING AREA

With the exception of the islands of Lanai, Niihau and Kahoolawe where there are no permanently flowing streams, o'opu nakea are found in streams on all of the major islands of the Territory, in varying degrees of population density and on each of these islands the o'opu is being fished to a lesser or greater degree depending on the abundance.

Due to the encroachment of industrial progress and the deleterious consequences which such advancements almost inevitably effectuate on existing fish and wildlife, the population of o'opu nakea on the island of Oahu has been diminished considerably. This depletion has progressed to the point where the o'opu is becoming somewhat of a rarity and whatever fishing is done for the species on Oahu can be considered inconsequential.

The impact of industrial growth on the population of gobies, though not as severe as on Oahu, is being felt on other islands also and is particularly noticeable where waters have been diverted from streams in increasing amounts for domestic, industrial and irrigation purposes. On Maui and Hawaii a few of the streams still support a fair population of fresh water gobies, and although the numbers found there cannot be considered plentiful, some of the people residing near those streams are fishing regularly for the species.

The steams in the uninhabited windward valleys on the island of Molokai possibly contain the highest concentration of o'opu today; however, the rate of goby fishing there is very slight. This is not only in part due to the isolation of the area occasioned by the rugged terrain which renders these valleys accessible only by boat from the sea but also in part due to the low fishing pressure exerted by the comparatively small number of people residing on that island. Also, marine fishes, which are relatively abundant and easily available along the Molokai coastline, readily absorb the fishing pressure exerted by both the sport and commercial elements thereby greatly reducing or eliminating altogether the pressure on the goby.

It is on the island of Kauai that the most intensive rate of goby fishing is being carried on. Here, a large portion of the island's inhabitants participate in this form of fishing, and the consequent interest generated results in most, if not all, of the legislation dealing with the goby originating from Kauai. It is the consensus among the older residents of the island that the abundance of o'opu nakea is decreasing from year to year and, observations conducted along this line appear to bear out such a contention; however, it is still possible to obtain good o'opu fishing on several of the streams on Kauai. It is particularly during the spawning season, when the o'opu descend downstream and concentrate in large numbers in the lower portion of the streams near the river mouth, that fishing for this species becomes most popular.

On Kauai as on the other islands, irrigation and domestic water is also being diverted from many of the o'opu bearing streams, and although this appears to have contributed the most toward the reduction of the o'opu population, the effect has not been as markedly adverse as on the other islands. This is due to the fact that the streams on Kauai being larger, have a greater flow of water than those found on the other islands and, in consequence, the drawing off of similar volumes of water has a proportionately smaller impact on the total physical environment. In addition, the major streams on Kauai, unlike streams on the other islands, are less affected by drought conditions, since the headwaters all originate at Mount Waialeale reputedly the wettest spot on earth. The rainclouds milked throughout the year by this mountain and the strategic location of the Alakai Swamp, which lies immediately below the summit and which serves as a vast spongy reservoir, make possible the maintenance of fairly constant stream flows which do not fluctuate too excessively below the normal level.

The streams which are heavily fished on Kauai are the Hanalei, Waimea, Hanapepe, Wailua, Wainiha, Lumahai and the Kalihiwai. In terms of number of people utilizing the stream, the Hanalei River receives the heaviest fishing pressure followed by the Waimea and the Hanapepe Rivers. The Wainiha, the Kalihiwai and particularly the Lumahai Streams have high goby populations; however, since access is controlled by private interests the number of people fishing these streams are limited.

THE GOBY HABITAT

The o'opu nakea, being specialized for life in fast flowing waters, is ideally suited for the torrential type of streams found in the Territory. Except for the colder streams located at higher elevations, almost any unpolluted stream in the islands is capable of sustaining goby life. However, since the reproductive cycle of the o'opu involves a downstream spawning migration followed by a marine existence for the early larval stage and the subsequent re-entry and upstream migration of the fry, it is essential that the stream should have a continuous flow throughout the year which is uninterrupted and which empties directly into the sea.

Since most of the salient characteristics typifying the better o'opu streams are embodied in the Wainiha Stream and since this stream, in addition to having a good o'opu population is readily accessible by vehicle for several miles along the lower reaches, the Wainiha was selected for intensive study and is presented here as a typical goby habitat.

Physical Features of the Wainiha River

The river located in the Wainiha Valley on the island of Kauai has headwaters originating near the north summit of Mount Waialeale, the elevation of which is 5,080 feet. For a distance of about 8 miles the river flows initially in a general northwesterly direction, then at an elevation of 500 feet it curves to the east and flows in a northeasterly direction for another 4 miles before emptying into the sea at Wainiha Bay. On the east the river is bordered by the Laau Ridge and on the west by the Wainiha Pali, the total drainage area so formed comprising about 16 square miles. In addition to the runoff water received from the drainage area, a substantial amount of seepage is received from the Alakai Swamp. This swamp originates near the summit of Mount Waialeale and extends for a distance of about 9 miles along the flats bordered by the Wainiha Pali. During extended periods of dry weather, it appears that seepage from the Alakai Swamp offers the principal source of water supply to the Wainiha River.

A recently reactivated water gauging station maintained by the United States Geological Survey is located about 6 miles above the river mouth at an elevation of 850 feet. Records at this station were kept from July, 1914 to June, 1916 and discontinued until recently when the station was again put into operation. The flow records of the earlier 1914 - 1916 period show a minimum daily discharge of 59 M.G.D., a maximum daily discharge of 1,800 M.G.D., a maximum floodpeak discharge of 7,000 M.G.D., and an average daily discharge of 153 M.G.D. Incomplete records of recent calibrations available only for the July, 1953 to June, 1954 period show a minimum daily discharge of 23 M.G.D. having occurred one day each in the month of September, October, February and March and a maximum daily discharge of 653 M.G.D. having occurred in April. Figures for the maximum flood peak and average discharge are not available. The above figures show that from a minimum discharge to the maximum flood peak discharge the volume of flow may change by more than a hundredfold. This greatly fluctuating flow rate is characteristic of Hawaiian streams and in many cases occur to a more pronounced degree in many of the streams on the other islands.

A hydroelectric plant is located near the bank of the Wainiha about 1½ miles above the river mouth. The water for the turbines is drawn from the Wainiha by a diversion dam and a system of ditches and tunnels dug along the west slope of the valley. The concrete diversion dam which extends across the stream at a height of 3½ to 4 feet above the river bed is located 5 miles above the river mouth at an elevation of 700 feet. Where the power ditch crosses tributaries, water from these minor streams are also diverted into the ditch. Normally, the flow of the Wainiha exceeds the ditch capacity and the excess spills over the diversion dam. Only at infrequent intervals during extended periods of low rainfall is the flow completely diverted into the ditch. Three weeks was the longest period that no spillage over the dam was observed. At such times, seepage water emerging from below the base of the dam, augmented by water flowing from untapped tributaries along the east slope, provide a sufficient flow below the dam to maintain fish life.

In addition to the diversion of water for generating power, a very minor portion is drawn for the irrigation of taro paddies cultivated along the banks near the mouth of the Wainiha River.

Temperature and pH readings of the Wainiha River which were taken whenever the opportunity presented itself are listed in Table 1. The water temperature for the most part remained below 70° F and showed a range of 63° to 76° F. Every pH determination made at the stream gave an alkaline reaction ranging from pH 7.10 to pH 8.73. A definite relationship existed between rainfall and pH. During extended periods of dry weather the alkalinity increased and during periods of heavy rainfall the pH reading decreased to near neutrality.

Along its entire length, the bed of the river is composed of smoothly ground basaltic rocks ranging from pebbles to boulders weighing several tons. Below the layer of rock a deposition of alluvium is found and from the surface occasional patches of silt and gravel can be seen deposited between the rocks and along the banks and bottom of the deeper pools. Near the river mouth, beach sand deposited by tidal and wave action line the bottom and banks of the stream.

From the mouth to nearly ½ mile inland the river flows in a comparatively deep, broad and quiet channel. Beyond this point the slope of the river increases progressively and for the next 2 miles an average gradient of 19 per 1000 is maintained. The average gradient then increases to 36 per 1000 until the stream rises sharply to drain the slopes of Mount Waialeale.

The valley walls of the Wainiha are extremely steep for almost the entire length of the river. Slope measurements of the wall give gradients of 340 to 660 per 1000 and at places the walls form sheer cliffs to the very edge of the river. Along the entire length of the valley walls, numberous tributaries, both intermittent and permanent, cascade into the Wainiha.

Due to the character of the bottom and the steepness of the gradient, the Wainiha has a broken and irregular flow which may best be described as rapids and cascades. For the most part the flow is fast over broken, shallow water not much more than knee deep and oftentimes over and around rocks large in proportion to the size of the river. The average width of the river measures about 30 feet. Pools are found at intervals and usuall where one side of the river bank forms sheer cliffs cut into solid bedrock.

Biological Features of the Wainiha River

The slopes of the Wainiha Valley are densely covered by what may be best described as a rain forest. The most commonly observed plants composing this rain forest flora are the false stag-horn fern, tree fern, bamboo, wild yam, wild taro, bananas, kukui, guava, ohia lehua, ohia ai, koa, and hau bush. Along the banks at the lower section of the river, hau bushes predominate the overhang while further upstream the guava are more common. The grasses covering the forest floor of the lower valley slopes and the banks of the stream are the Hilo grass, panicum and the honohono.

In the water itself, small patches of water hyacinths are found only near the river mouth and except for filamentous green algae found throughout the length of the stream other aquatic plants are not present.

The dominant aquatic fauna, other than fishes, commonly seen in the Wainiha are the larval forms of various species of midges belonging to the family Chironomidae, dragonfly and damselfly nymphs, aquatic angle worms, the black opae belonging to the family Atyidae and Neritina granulosa, a univalve mollusc belonging to the family Neritidae.

The fishes found in the stream are the o'opu nakea (Awaous guamensis), o'opu nopili (Sicyopterus stimpsoni), o'opu anihaniha (Stenogobius genivittatus), o'opu akupa (Eleotris fusca), gold fish (Carassius auratus), aholehole (Kuhlia sandvicensis) and mullet (Mugil cephalus).

The aholehole and the mullet are only transient stream inhabitants, their normal habitat being the sea. The mullet have never been observed above the lower channel-like area, while the aholehole have been observed 2½ miles above the river mouth. The aholehole are found in greater numbers than the mullet; however, the total number of both species occurring in the Wainiha is very small. The mullet, feeding primarily on diatomaceous slime, does not enter into any feeding competition with the gobies; however, the aholehole, being carnivorous, have been observed preying on the young of the o'opus.

The goldfish which is an exotic to the Hawaiian Islands has been seen only occasionally in the lower section to a point about 3/4 miles inland from the river mouth. Being somewhat omniverous in its feeding habits, it may prey on the young of the goby but the few goldfish present in the Wainiha would make such predations unimportant.

The o'opu akupa and the o'opu anihaniha, occurring in about equal abundance, are the dominant fish life found in the quiet channel-like portion near the river mouth. Both species will enter the faster flowing sections of a stream, and although on occasions the anihanihas have been taken 2½ miles and the akupa, 3 miles above the river mouth, their abundance decreases progressively upstream and their normal range in the Wainiha appears to be from the river mouth to about one mile inland. The feeding habits of the anihanihas are not known; however, the akupa is a carnivore and has been observed feeding very voraciously on the o'opu fry.

By far, the o'opu nakea and the o'opu nopili compose the most numerous species of fish found in the Wainiha. The range of both species overlaps considerably with the lower range of the nakea beginning at the river mouth while the nopili is first found in the rapids immediately above the quiet waters of the channel area. The nakea are usually seen concentrated in greater numbers in the quieter pools and backwater areas formed by sheltering boulders, while the nopili seem to prefer the faster flowing waters of the rapids.

To determine the distributional pattern and relative population density of both the nakea and the nopili in the Wainiha River, a method was developed which made possible the direct enumeration of the fish in the stream. Equipped with diving goggles and "snorkel" breathing devices, two divers conducted the census by recording on plastic pads the number of fish seen in the water. The counts were made at eight different stations which were located at 3/4 mile intervals, and numbered consecutively upstream from 1 to 8 with station #1 located in the channel just within the river mouth and station #8 located about 5½ miles inland. The stations were all measured off so that the results obtained could be reduced to numbers of fish enumerated per 1000 square feet.

The results obtained, presented in Table 2, should not be considered as absolute values of the goby population but as an index for comparing the relative abundanc of the fish in various portions of the stream. The census indicates that the principal range of the o'opu nakea in the Wainiha extends from the rapids portion located just above the channel area up to a point 5½ miles inland. From an initial low of 1.8 fish per 1000 square feet counted at the channel area, the density of o'opu nakea increased sharply to a maximum of 68.3 fish per 1000 square feet at station #4 located about 2½ miles above the river mouth. Beyond station #4 the density of o'opu nakea again fell sharply to 8.2 fish per 1000 square feet at station #8 located 5½ miles above the river mouth.

On the other hand, the population of o'opu nopili remained at a low level up to station #4 before any significant increase in density occurred. After the increase to 22.7 fish per 1000 square feet at station #5, the density remained rather constant up through station #8 indicating that the principal range of the o'opu nopili begins 2½ miles above the river mouth and extends for more than 3 miles beyond that point.

Although the enumeration method was not employed above station #8, to determine the upper distributional limits of both the nakea and nopili, surface and underwater observations were conducted up to the base of the Hinalele Falls located 10½ miles above the river mouth at an elevation of 2,200 feet. Up to the base of the falls no physical barrier which could interfere with the upstream movement of the gobies was encountered; however, progressively upstream, the density of o'opu nakea showed a continued decrease and the last o'opu nakea was observed about 8 miles above the river mouth at an elevation of about 1,500 feet. At this point the o'opu nakea was extremely scarce. The last observe fish being the only one seen in about a half a mile stretch of that portion of the river.

A marked decrease in the number of o'opu nopili was also noticed above station #8. At a point about 6 miles above the river mouth, the density of this species appeared to number half that observed at station #8. The last nopili was seen about 9 mile: above the river mouth.

The temperature of the water which was decidedly colder in the upper reaches of the stream may be the principal factor limiting the upper distribution of both the nakea and nopili for the other physical environmental characteristics as well as the food available for both species near the head end of the stream did not seem to be substantially different from those of the lower section.

REPRODUCTION OF THE O'OPU NAKEA

Ovaries in the very early stages of ripening, distinguishable from immature or green ovaries by the slight tinge of yellow imparted by the developing yolk granules, are usually first noticed early in April and may continue to occur up to the end of July. Observations made on developing ovaries show that the ova become fully ripe in a period of about four months after first showing signs of ripening. The occurrence from April through

July of ovaries in various degrees of maturity from the very early to the advanced stages of ripening indicates that the spawning season of the o'opu nakea is prolonged and extends for several months.

Studies on ova diameter show that a ripe ovary consists of two modal groups of ova. The first group with the mode at 0.04 mm consists of seed eggs, which have the appearance and size of ova found in immature ovaries, and the second group with the mode falling at 0.45 mm consists of ripe eggs. Using the gravimetric method, estimates were made of the number of ripe eggs produced by fish of various sizes. Results showed that the fecundity of the o'opu nakea in terms of quantity of eggs produced was extremely high. It was found that a gravid female four inches in total length is capable of producing an estimated 125,000 ripe eggs; a female seven inches in total length, an estimated 750,000 ripe eggs and a female eleven inches in total length, an estimated 1,500,000 ripe eggs.

The first downstream spawning migration of the goby usually takes place in early August and continues at irregular intervals through November and may occasionally extend into December. Heavy freshets or flash floods of sufficient strength to cause considerable roiling of the water preceded all of the mass downstream spawning migrations of the o'opu nakea witnessed at various rivers on Kauai. This substantiates the observations of the old timers of the islands who report that every mass migration must be preceded by high water. The possibility exists that some of the gobies may spawn in the upper reaches of the stream without descending downstream but evidence showing such occurrences has not been uncovered.

In order to locate spawned eggs and to determine the principal spawning sites, intensive underwater observations were conducted from the mouth of the Wainiha River to about 6 miles inland. During these diving operations, eggs were never found in the upper reaches of the stream. All the spawning sites located thus far were found far downstream in the lowest portion of the stream within the channel itself or in the rapids just at the head of the channel. In this limited area just within the river mouth the most numerous batches of spawned eggs were found, and it appears that this area is the major spawning site of the o'opu nakea. Across the river mouth a sand bar built by the wave action of the sea and the opposing river current formed an effective dam. Within the dammed area in waters ranging from four to eight feet deep, eggs were found on almost all the rocks examined. In spite of its proximity to the sea,hdyrometer readings taken during high tide from the surface to the bottom did not indicate any measurable salinity in this area where the eggs were found.

Though it may be possible that gobies descend to the lower portion of the river to spawn in the absence of freshet condition, particularly should an extended period of dry weather occur during the spawning season, there has been no evidence to indicate this. Thus far, all occurrences of spawned eggs were noted two to four days subsequent to a freshet condition. This also indicates that spawning occurs very soon after the downstream descent.

The eggs were found attached to the sides and upper surfaces of rocks and boulders by means of an adhesive foot or organ present on the egg. Each batch of eggs appeared to occupy from about 30 to 60 square inches on the rock surface with the eggs pressing against each other and occurring in a single layer. When different batches of eggs were brought back to the laboratory for examination, the eggs were all found in the late embryological stages of development and all viable eggs hatched within 24 hours.

By gill netting near the mouth of the Wainiha River immediately after a spawning run had occurred, 12 female and 6 male gobies were taken in excellent condition. Of these fish, six females and three males were placed in a glass aquarium and the remaining six females and three males were placed in a holding tank constructed of redwood. In addition, three males, each of which had been caught by angling and which had been kept in captivity in a tank for a period of one to six months, were also placed in each of the two containers together with the gill netted fish. To provide suitable spawning surface, rocks were placed in both the aquarium and the tank. Within 14 to 48 hours after capture two of the females in the aquarium and three of the females in the tank spawned. Fortunately one of the fish laid its eggs against the glass wall of the aquarium making possible direct observation of the entire spawning behavior.

The courtship phase of the spawning act was initiated by the male, which with its mouth agape and dorsal fins erect rushed aggressively at the female, nudging and nipping her on the body, especially around the region of the belly. The female ignored the male initially; but after several nips, the female responded by also rushing at the male with jaws distended and dorsal fins erect. Following this, both fishes commenced chasing each other round and round in a tight pinwheel fashion while still keeping their mouths widely open and holding dorsal fins erect. At times, with the lips of one fish in tight osculatic with the lips of the other fish and while the mouths of both fish were still held agape, the fish appeared to be shoving and wrestling with each other. Between periods of active courtship, the pair frequently rested quietly for brief moments on the bottom, and whenever any other fish ventured too close, the male very belligerently attacked and chased off the intruder. The entire courtship play was concluded in a relatively short period of about 10 minutes when the female abruptly moved to the glass wall of the aquarium and began laying her eggs.

By utilizing the ventral fins which are modified into a single sucking disc, the female clung to the vertical wall of the aquarium with her belly and genital papilla pressed tightly against the glass wall of the aquarium. The eggs were seen emerging from the genital pore located at the base of the papilla and directed toward the fringed margin of the papilla by the forward as well as the lateral undulating movements of the fish. The slow rhythmic swaying from side to side of the papilla and the lateral motion of the posterior half of the body distributed the eggs evenly in single layer over the glass wall. As the spawning fish approached the top of the aquarium she invariably swam to the bottom and always commenced spawning while facing and moving in an upward direction laying the next strip of eggs alongside those that were previously spawned.

After a strip of eggs was laid or while the female appeared to be resting, the male fish swam over the eggs and commenced to fertilize them. Rather than eject his sperm in a cloud, the milt, which appeared whitish in color, was seen emerging from the tip of the genital papilla in a fine forceful stream which adhered for several seconds to the eggs in a clearly discernible streak before dispersing gradually over the adjacent eggs. The modified ventral fin was also used by the male fish to cling against the side of the aquarium wall, and as in the case of the female, by swaying the posterior half of the body as well as the genital papilla, the milt was distributed over the eggs.

The spawning act appeared to be very exhaustive to both the male and female fish as evidenced by the abnormally rapid respiratory movements of the opercula as well as the continuously opened mouth. Except for brief intervals of rest, the female continued to spawn for seven hours. The male which took part in the courtship play and initial fertilization of the eggs was one of the fish caught the day before by gill netting. After an hour of spawning, this male was chased away in an exhausted state by one of the male fish which had previously been held in captivity in a redwood tank for more than six months. The second male which took over the act of fertilizing the eggs continued to do so for the remaining six hours during which the female spawned. While the eggs were being spawned this male fish chased away all fish venturing too close to the spawning site. Subsequent to spawning and up to the time of hatching, both fish guarded the eggs; however, of the two, the female appeared to be more attentive and aggressive.

Observations made on fish held in captivity in a tank for a period of more than six months showed that the gonads of these fish ripened concurrent with those observed in the field. The belly became distended and dissection performed on a few fish revealed that they were gravid; however, spawning did not occur during the first year of captivity. Later, the distended abdomen of these fish began shrinking back to normal and dissection showed that the ripe ova were being reabsorbed. However, during the second year of captivity a few of the fish spawned in the tank suggesting that although it appears that the down-stream migration is required to provide the stimulus needed to trigger off reproduction in the natural habitat, such a stimulus need not occur in an artificial environment if the fish are held captive for a sufficiently long period of time.

The incubation period of the eggs is of very short duration, hatching occurring within 24 to 28 hours after spawning. Immediately after hatching several hundred larvae were removed from the aquarium and transferred into beakers containing only fresh water and also into beakers containing sea water of about 34 o/oo salinity. Both the fresh and sea water were changed daily in the beakers by pipetting the larvae out and transferring them into newly obtained fresh and sea water. All the larvae placed in fresh water died four days after hatching while those placed in sea water lived for a period of eight days. At the time of death, the larvae which had been kept in the fresh water medium, had not completely absorbed their yolk sacs, and death appeared to be due to causes other than starvation. On the other hand, the yolk sacs of those placed in the salt water medium were completely absorbed by the fifth and sixth day and observations were made of the larvae attempting to ingest fine particulate matter suspended in the water. Were it possible to supply the larvae with suitable food it is believed that they could have been reared for an indefinite period in the salt water medium.

Although no positive proof has been found indicating that the early larval stages of the o'opu nakea cannot be spent in a totally fresh water medium, all evidence uncovered thus far seems to indicate that salt water is needed for the development of the early larval stages. Some of the evidences substantiating this belief are as follows:

(1) A few hours after hatching, the larvae upon being transferred abruptly from fresh to sea water were able to make the necessary physiological adjustments without any mortality ensuing,

(2) The newly hatched larvae when placed in sea water lived twice as long (8 days) in comparison to those placed in fresh water.

(3) Observations made of the early swimming behavior of the larvae show that their negative geotropic reaction is highly conducive to their being swept out to sea by the river current rather than their being retained in the stream environment. Immediately after hatching and for a period of four days, the larvae when placed in a container for observation, displayed a purely vertical movement swimming perpendicularly upwards very actively and upon reaching the surface passively sinking downwards. When a current was generated in the container the larvae allowed themselves to be passively carried with it and made no effort to resist it in any way.

Field observations made of o'opu nakea larvae re-entering the river mouths from the sea show that the upstream migration of the young first occurs in limited quantities in December and continues through July with the peak occurring in March and April. From the beginning of the spawning period (August) to the time when the larvae first re-enter the stream (December), there is a time lag of four to five months. From the end of the spawning period (December) to the end of the upstream migrational period (July), there is a time lag of six to seven months. Between spawning peaks (August and September) and peak upstream migration of the larvae (March and April), another time lag of six to seven months occurs. Assuming that the above time lag represents intervals between the spawning and the re-entry of the larvae into fresh water, it seems reasonable to surmise that the larval o'opu nakea spend from four to seven months of their early life in a marine habitat. While in the marine habitat, the growth rate as well as the embryological development of the larvae is very slow, for the fry are still in the transparent stage and measure only 15 to 20 mm in total length when they first re-enter freshwater.

All field observations made of larval o'opu entering the fresh water were of schools involving a dozen or so individuals to several thousand fish. While migrating upstream, the larval fish display remarkable ability in negotiating obstacles such as vertical falls and swift rapids found in the stream. In one instance where undercutting had produced a deep concavity in the face of a fall, o'opu larvae were seen upside down, somewhat analogous to a housefly on a ceiling, making their way over a portion of the concavity where a barely discernable film of water flowed over the rocks. In order to test the fishes' capabilities in negotiating vertical falls, a few of the larvae were brought back to the laboratory and placed in a container. When a smooth piece of board was held upright over the container with the bottom of the board touching the surface of the water and when a thin film of water was trickled down the board, the larvae immediately began climbing the board. Timing tests showed that the fish were able to climb 18 inches in 20 seconds.

A batch of larval gobies found entering the river mouth from the sea were captured by seining and placed in a tank for rearing. These larval fish were taken in July and after rearing for 12 months an examination was made of the gonads of two female gobies measuring 115 and 119 mm in total length. This examination revealed that the ovaries of both fish were ripening showing that the gobies can attain sexual maturity a year after re-entering a fresh water habitat.

During the spawning season the smallest female with ripening ovaries taken from the Wainiha measured 87 mm in total length, while during the same period the largest female taken with immature ovaries measured 197 mm in total length. Sampling conducted at 3/4 mile intervals along the Wainiha in July and August showed a progressive decrease in size of mature fish as samples were taken further downstream, and conversely, progressively larger immature fish were found in the upper section of the river. Scarcity of fish in the upper reaches prevented adequate sampling; however, of the 12 female gobies taken six miles above the river mouth, six of them ranging in total length from 214 to 279 mm were found with mature ovaries, while the remaining six fish ranging from 108 to 197 mm were immature. In contrast, of the 89 female fish taken 1½ miles above the river mouth, 87 of them ranging in total length from 87 to 186 mm were found with mature ovaries, while the remaining two fish measuring 84 and 117 mm were immature. Although it is not definitely known why fish in the lower sections of the stream should attain sexual maturity at a smaller size than those found in the upper reaches, a reasonable conjecture would be the retardation of sexual maturity in the upper sections of the stream due to the prevalence of colder water temperatur

The process of migrating downstream and the act of spawning itself appear to be extremely debilitating to the fish, for several weeks after a downstream migration, a large number of dead o'opu nakea of both sexes can be found in the lower section of the stream. The number of dead fish seen during this period leads many of the local residents to believe that death invariably follows after the fish spawns. Although a greater percentage o fish may succumb rather than recover from the reproductive process, death after spawning does not seem to be a physiological necessity, for observations were made of the recovery o a few of the fish, both males and females, which spawned in aquaria conditions.

FOOD AND FEEDING HABITS OF THE O'OPU NAKEA

Field observations made of feeding o'opu nakea indicate that the fish is primarily a browser and a bottom feeder. It is often seen rasping the filamentous algae together with the larval aquatic insects off of rocks and boulders. When feeding in the rapid section of a stream, the fish remains stationary by clinging to the substrate with its ventral fins which are modified to form a sucking disc. As morsels of food are washed by, the fish darts out to grab them. When angling for the fish and using earthworms for bait, it is noted that the fish almost invariably waits until the bait settles to the bottom before taking it and only infrequently will it rise to take the bait in midwater. At no time were observations made of the o'opu nakea rising to the surface to take aquatic insects hovering over the water.

To determine the food habits of the o'opu nakea, food studies based on contents of the digestive tract were conducted. Since the goby does not have a definitive stomach, the contents of the entire digestive tract from the esophagus to the vent were examined. Prior to examination the viscera were preserved for at least 24 hours in 10% formalin in order to harden the ingested food matter. For this study, both volumetric and numerical counts were made of the food contents of 320 digestive tracts taken from fish ranging in size from 150 to 215 mm in total length.

Of the fish examined, volumes of food found per digestive tract ranged from less than 0.1 to a maximum of 4.4 cc with 1.2 cc being the average volume found in a fish. Filamentous green algae, forming the greatest bulk, were found in 97% of the fish and by volume formed 84% of the total food ingested. In 20% of the fish, filamentous algae were the only food matter found in the digestive tract.

The remaining 16% by volume of ingested matter found in the digestive tract consisted of animal matter such as chironomid larvae, earthworms, atyid shrimps, snails, damsel fly nymphs, adult chironomids and other adult dipthera. A summary of the organisms consumed by the o'opu nakea is presented in Table 3. An examination of the table reveals that the chironomid larvae constitute the most important animal matter eaten by the o'opu. Numerical counts made of chironomid larvae found in the digestive tracts showed an average incidence of 20 larvae per fish with the maximum of 800 larvae found within a single fish. The larval chironomids, being tiny organisms, make up only 30.7% by volume of the total food animals ingested; however, this percentage still constituted the largest volume within the animal group.

While few earthworms were found in the digestive tracts, the numerical incidence being less than 1%, the size of the worms made them the second most important food animal by raising the volumetric percentage to 24.2%. This also was the case with the atyid shrimps which constituted 21.5% by volume, although in numbers forming only 1.3% of the ingested food animals. In the areas where the gobies were collected for the food studies, the atyid shrimps, occurring in abundance and in close association with the o'opu nakea, appeared to be the most readily available food animal. However, the low numerical incidence of shrimps found in the digestive tract indicate that the o'opu were not actively feeding on the shrimp. In addition, atyids occurring in the digestive tracts consisted entirely of bits and remnants of the shrimp exoskeleton, further indicating that the o'opu was apparently feeding only on the molted shell of the shrimp rather than on the live animal.

FRESH WATER GOBY TAGGING PROGRAM

Marking of Larval Fish By Fin Clipping

As previously mentioned, the larval o'opus called hinanas and ranging in size from 15 to 20 mm in total length are found re-entering the stream from the sea from December to July, which covers a period of about eight months. Since this changeover from a marine to a freshwater habitat occurs over such an extended period of time, growth stud: based on length frequencies of fish captured periodically cannot be relied upon, nor can : rate of upstream movement of the fish be determined adequately.

Since quantities of larval o'opus are easily obtainable in season, attempts were made to mark the hinana. The size of the fish precluded the use of tags; therefor, fin clipping experiments were tried. It was hoped that after studies on regeneration of excis fin had been made, a large number of hinana of uniform size could be marked by clipping of different combination of fins and released in the main as well as minor tributaries of the Wainiha. The periodic recapture of the marked fish would then offer clues to the growth rate and migrational pattern of the fish. However, all attempts made to mark the fish by clipping off the pectoral or dorsal fins resulted in 100% mortality which necessitated the termination of the experiment. The larval fish being very small and delicate could not be handled without causing excessive injury. All fin clipped fish placed in well aerated aquaria died within an hour after handling while unclipped control fish placed in similar aquaria lived for an indefinite period.

Tagging of O'opu Nakea

The o'opu nakea being a demersal species is frequently found hiding in narr cracks and crevices between or under rocks and oftentimes may be found burrowed completely under silt, gravel and other bottom detritus with only its eyes exposed. This secretive behavior of the o'opu requires that any tag used on the fish must offer the least likelihood of snagging or promoting other frictional effects which would contribute to the loss of the tag. Considering their close association with the substrate, an internal type of tag would probably offer the best result; however, the difficulty of detecting and recovering internal tags without the use of elaborate and costly electronic devices made the use of such tags impractical for this project and only the external type of tags were considere

The commonly used external types of fish tags are affixed to the jaw, the opercle or pierced through various portions of the body of the fish. Of these three general types, only the opercular and the body tags appeared suitable for o'opu tagging. The jaw tag was not considered for it was felt that the presence of such a tag would interfere too greatly with the feeding habits of the fish as the goby feeds primarily by rasping algae and chironomid larvae off of rocks.

The opercular tags tested were of the strap type and were fabricated out of very thin strips of either aluminum or stainless steel. When clinched on the opercle, the tags measured ¼ inch in width by 3/4 inch in length. For identification purposes, numerals were engraved or stamped on the metal.

For body tags, modified ring and streamer type tags were fabricated. The ring tags were made of 1-3/4 inch lengths of flexible No. 20 fibron extruded plastic tubing through which a 28 pound test stainless steel wire leader was passed. On the plastic portion of the tag, identification numerals were inscribed using plastic vinyl ink. The plastic tubing, together with the stainless steel wire already inserted through the tubing, were forced through the back of the fish from the right to the left side just above the vertebrae and below the junction of the first and second dorsal fins. Both ends of the stainless steel wire were then passed through a No. 5 seven strand leader sleeve which was butted against the ends of the plastic tubing and crimped with a plier to hold the wire ends in place. Instead of twisting the ends of the wire together, leader sleeves were used as this permitted a much quicker means of fastening the tags and also resulted in less injury to the fish.

The basic design of the streamer type tag was somewhat similar to the ring tag. Flexible No. 20 fibron extruded plastic tubing on which identification numerals were inscribed with vinyl plastic ink was used again as the basic component of the tag. However, the plastic tubing measured only 5/16 inch in length and rather than stainless steel wire, nylon fishing line was used to hold the tag in place. The tag was attached to the fish by passing a surgical needle threaded with 18 pound test soft monofilament nylon line through the back of the fish in the same area where the ring tag was attached. With the line through the fish and the ends held over the back of the fish, first the plastic tubing then a No. 5 wire leader sleeve were slipped over both ends of the nylon line. By crimping the sleeve, the ends of the nylon line were kept from pulling apart and the sleeve also acted as a keeper for the plastic tubing.

Using the three types of tags mentioned above, experimental tagging was conducted on fish kept in captivity in a 500 gallon tank. To simulate the o'opu's natural habitat rocks as well as gravel and silt were placed in the tank. Eight o'opus each were tagged with the aluminum opercular strap tag, the stainless steel opercular strap tag, and the ring tag. Twenty fish were tagged with the streamer type tags. During the course of the experiment no tagging mortality resulted. Within the first month of tagging all of the stainless steel opercular tags dropped off, half of the aluminum opercular tags were lost while all of the ring and streamer type tags remained attached in place. Three months after tagging one aluminum opercular tag, two ring tags and 10 streamer tags remained in place.

The bony structure of the o'opu's operculum, being very fragile, was not strong enough to support a tag for any length of time. Apparently, the stainless steel tags dropped off before the aluminum tags because of its greater weight and the consequently heavier strain it placed on the opercle. In every instance, whether the tag was made of aluminum or stainless steel, loss of the tags resulted from the tearing of the opercle. Frictional effects and the constant motion of the tags from the respiratory movements of the gill covers all combined to prevent healing of the tagging wound. Eventually, the gradual enlargement of the wound resulted in the loss of the tag.

Initially, the ring tags appeared very promising. However, this tag was also subjected to excessive rubbing against obstructions since the basic design of the tag necessitated that a somewhat bulky, stiff and unyielding portion of the tag protrude from the fish. In addition to frictional effects, the onset of bacterial infection also contributed to some of the ring tag losses.

The streamer tag, due to its compactness and high degree of flexibility, reduced considerably the frictional difficulties which made the other types of tags objectionable for use on the o'opu. Also, the cleaner tagging wound made by the surgical needle promoted faster healing thus assuring better retention of the tag. On the basis of the results obtained from the comparative tests made of the different types of tags, the streamer tag was selected for field use.

By trapping, 105 fish taken from the Wainiha Stream were tagged and released. The fish tagged ranged in size from 113 to 243 mm in total length. In order to recover the tagged fish, periodic diving and spearing operations were conducted which resulted in the recovery of only three of the tagged fish. The three fish recovered were all males and originally had been tagged and released about four miles above the river mouth. At the time of recapture, they were all retaken in the channel area near the river mouth during spawning season.

Two of the fish, which were retaken 7 months after tagging, had grown in total length from 221 to 234 mm and from 243 to 257 mm showing an increase in growth of 13 and 14 mm for the 7 months period. The third fish, which was retaken 8 months after tagging, had grown from 220 to 245 mm showing an increase of 25 mm for the 8 months period.

With the recovery of only three tagged fish definite conclusions can not be drawn regarding the growth rate of the o'opu. It appears, however, that the growth rate of this species is very slow, possibly in the neighborhood of only one to two inches per year for a fish in the 9 to 10 inch size class. In view of the small number of fish which were obtainable for tagging purposes, studies on migrational patterns and population abundance could not be made.

FRESH WATER GOBY TRAPPING PROGRAM

To efficiently capture the o'opu in the Wainiha Stream, particularly for the tagging program and also to obtain a more representative sample of the goby population than that procurable through angling, spearing, or seining, an experimental trap was designed for use in the stream. Since most of the approaches to the river banks of the Wainiha are over steep and brushy terrain, it was necessary that the trap be relatively small and light so as to be easily portable but still strong enough to withstand the strain of severe freshets. These limitations greatly restricted the type of impoundment which could be utilized, and the trap eventually selected consisted of a single box-like crib or pot with a single constricted throat. The crib, with frames made of ¼ inch galvanized fencing wire, was covered with ½ inch square galvanized wire cloth and measured 16 inches in depth by 28 inches in width and 34 inches in length. Detachable wings 16 inches deep and 6 feet long made also of the ½ inch square galvanized wire cloth were located on either side of the funnel-like opening.

Since one of the primary trapping objectives was to sample the spawning stock of gobies descending the river during the seasonal spawning migration, the trap was first tested for this purpose at various sites along the Wainiha as well as in the powerhouse ditch just below the intake. To trap downstream migrants, of necessity, the trap had to be set in the direct path of the river current with the funnel facing upstream. Even during periods of low to moderate water flow the blockage of the trap opening by twigs, branches and leaves swept down with the current rendered the trap ineffective within a very short time. In consequence, the trap could not be used effectively for sampling downstream migrants in the upper reaches of the river. However, in the quieter flow of the channel-like area near the river mouth where the river both broadens and deepens, the trap proved effective for sampling fish which had completed their downstream migration.

For random sampling in the upper reaches of the river and to obtain fish for tagging purposes, three traps similar in construction to the one described above were used. The traps proved effective when set with the funnel facing downstream; however, unexpected freshets very frequently tore the traps off the mooring and crumpled them against the rocks even when set in protected areas behind large boulders. This frequent occurrence of high water, in addition to damaging the traps, oftentimes made water conditions too

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Recommendation:

For the completion of the reproductive and recruitment phases in the life history of the o'opu nakea, it is imperative that a continuous flow of water be maintained from the upper reaches of the stream to the sea. With increased divergence of water for irrigational, industrial and domestic use, not only is the linkage with the sea being interrupted to a greater extent, but also the total habitable area for the o'opu is being reduced in many of the streams. Since curtailing the present water consumption can not be instituted without adversely affecting the well-being and economy of the Territory and since indications point to an even greater divergence of water in the future, it does not seem possible that the restoration of the o'opu nakea population to its former level of abundance can be effectuated by the simple expedient of employing management measures which are presently available. This, however, does not imply that corrective measures can not be undertaken to protect the existing stock of fish.

For streams where the restoration of a fishable stock of o'opu nakea appear futile, it is recommended that a species of fish which does not require access to the sea during any of its life history be established. Such an introduction will increase the total productivity and will make possible better utilization of that portion of the streams located above the diversion dams. The fish recommended for introduction is the South American catfish, Astroblepus grixalvii. This species should prove adaptable to Hawaiian streams since it is found in the Andes in torrential streams somewhat similar to ours.

During the downstream spawning descent, appreciable quantities of gobies are being funneled into irrigation ditches and reservoirs. The reproductive potential of these fishes are destroyed, and in many cases, the diverted fish are made unavailable to the fishing public. To eliminate such waste, it is recommended that self cleaning fish screens be installed at intakes wherever it is feasible to do so.

To prevent excessive mass removal of the o'opu particularly during the spawning season when the fish are highly susceptible to illegal trapping, it is recommended that the commercial fishing for this species be prohibited. Such a prohibition should not cause undue hardship to any individual since the commercial o'opu fishery as it exists today is highly seasonal and is conducted only on a very limited part-time basis. Furthermore, since it is suspected that the bulk of the o'opu appearing in the market are being captured by poaching with illegal traps, the prohibited sale of the fish will discourage if not eliminate this illegal activity.

Prepared by ______________________ Approved by ______________________
VERNON E. BROCK, Director
Division of Fish and Game

Date ______________________

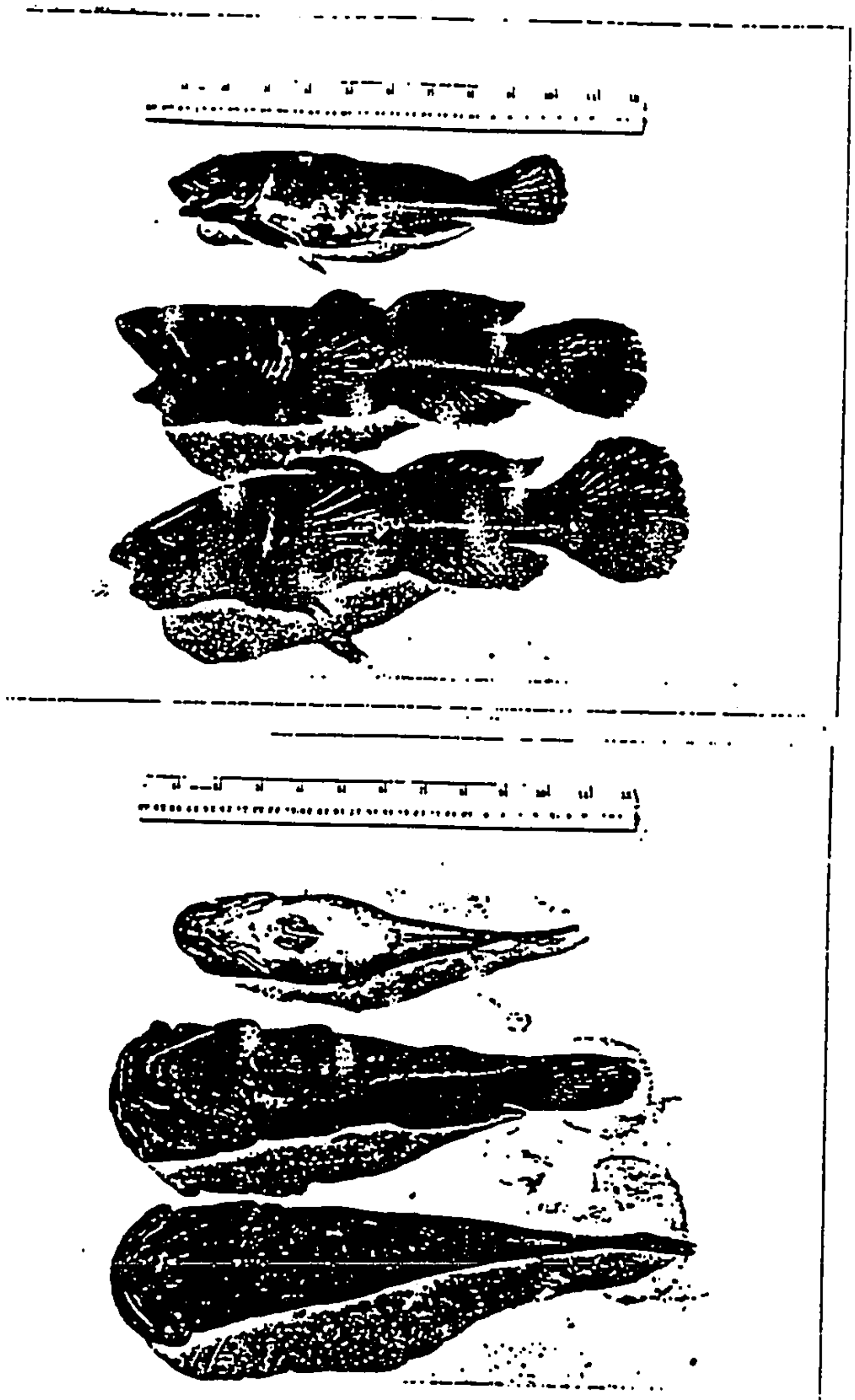

Figure 1 Lateral and Ventral View of O'opu Nakea

The top specimen is a female while the two lower fishes are males. Note the difference in general appearance between sexes and especially the distinct difference in the shape of the anal papillae. The fishes portrayed above are exceptionally large specimens.

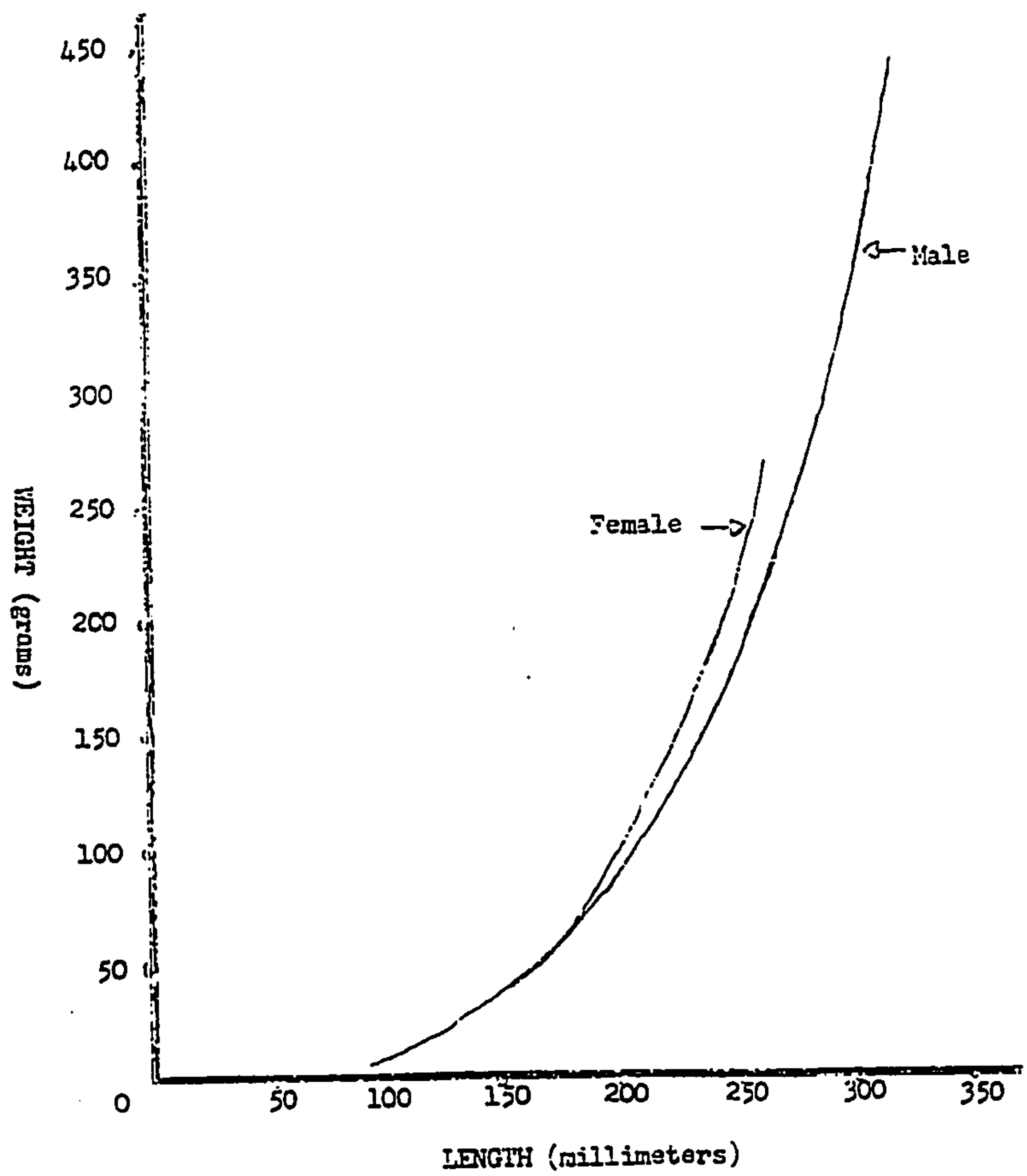

Figure 2 Midline Drawings of Length - Weight Relationship of 910 Female and 977 Male O'opu Nakea

Date	Time	Station	Air Temp. (° F)	Water Temp. (° F)	pH
4/ 1/52	1545	5	69	66	7.95
4/ 7/52	1500	1	73	68	-
4/ 8/52	1400	5	70	66	7.80
5/ 7/52	1100	5	70	63	7.72
5/14/52	1505	6	72	69	8.38
5/21/52	1305	6	70	66	7.57
6/ 9/52	1600	8	70	65	7.45
7/ 1/52	1625	7	75	70	8.01
7/16/52	1415	5	78	72	7.53
7/18/52	1625	7	75	69	7.10
7/24/52	1300	7	69	66	7.80
9/11/52	1200	1	80	69	-
9/18/52	1300	6	78	70	-
9/25/52	1430	6	74	69	-
10/ 2/52	1530	2	74	72	8.69
10/ 3/52	1145	5	73	70	8.22
10/ 3/52	1300	7	78	70	8.41
10/ 3/52	1435	2	79	76	8.73
10/ 3/52	1630	1	76	72	8.32
10/10/52	1130	1	77	69	7.61
4/27/53	1100	2	77	71	-
6/ 4/53	0945	2	79	70	7.79
6/ 4/53	1030	5	77	69	8.00
6/ 4/53	1120	7	79	68	8.33
7/23/53	0930	4	75	70	-
7/23/53	1800	7	76	68	7.30
7/24/53	1200	2	80	73	-
7/24/53	1430	1	82	76	-
8/11/53	1100	8	75	66	-
8/12/53	0930	6	70	66	-
8/12/53	1330	4	75	70	-
8/12/53	1600	7	72	69	-
8/21/53	1050	3	82	73	8.40
8/21/53	1600	7	81	71	8.60
8/24/53	0900	7	75	68	7.20

Table 1 Temperature and pH Readings Taken of Wainiha River

The stations numbered consecutively from 1 to 8 were selected at 3/4 mile interval with station #1 located just within the river mouth and station #8 located 5½ miles inland at an elevation of 800 feet.

Station Number	Distance Above River Mouth In Miles	Elevation Above Sea In Feet	Number O'opu Nakea Counted Per 1000 Sq. Ft.	Number O'opu Nopili Counted Per 1000 Sq. Ft.
1	0	2	1.8	0
2	3/4	25	25.1	2.4
3	1-1/2	75	54.6	4.5
4	2-1/4	150	68.3	5.0
5	3	300	31.3	22.7
6	3-3/4	550	23.3	17.0
7	4-1/2	700	9.6	20.0
8	5-1/4	850	8.2	22.3

Table 2 Results of Enumeration

Census Showing Relative Abundance of O'opu Nakea and O'opu Nopili in Different Sections in the Wainiha Stream.

FOOD GROUP	Total Number Ingested By Sample of 320 Fish	Total Volume Ingested By Sample of 320 Fish	Average Number Ingested Per Fish	Average Volume (cc) Ingested Per Fish	o/o of Total Number of Food Animals Ingested Per Fish	o/o of Total Volume of Food Animals Ingested Per Fish
hironomid Larvae	6409	16.0	20.0	0.05	88.4	30.7
thworms	47	12.6	0.1	0.04	0.6	24.2
dult Chironomids	160	1.8	0.5	less than 0.01	2.2	3.5
tyid Shrimps	95	11.2	0.3	0.04	1.3	21.5
nails	456	5.8	1.4	0.02	6.3	11.1
mselfly Nymphs	14	1.6	less than 0.1	less than 0.01	0.2	3.0
iscellaneous Organisms*	68	3.1	0.2	0.01	0.9	6.0
TALS	7249	52.1	22.7	0.16	-	-

*Miscellaneous organisms include ants, beetles, honeybees, mosquitoes, grasshoppers, amphipods, millipeds, beetle larvae, and earwigs

Table 3 Summary of Animal Food Matter Eaten By The O'opu Nakea

The summary is based only on ingested material of animal origin. Filamentous green algae, which actually constituted 84% by volume of the total food eaten, was not included in the table. The fish examined ranged in size from 150 to 215 mm in total length.

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2844-02
October 18, 1990

Dr. Bruce Anderson, Acting Director
Office of Environmental Quality Control
Honolulu, Hawaii

Subject: Environmental Assessment for Hanalei Excursion Boat Staging Operations, Hanalei, Kauai

Dear Dr. Anderson:

This is in response to Dr. Marvin Muira's May 16, 1989 comments on the subject environmental assessment. On June 26, 1989, the County of Kauai Planning Director issued a determination that an environmental impact statement would be required in conjunction with a Special Management Area permit application for the proposed boat staging operations.

Currently, we are preparing the Draft EIS for the proposed action. Your comments and this response shall be incorporated in the Draft EIS as documentation of the consultation process initiated by the County.

The following responses are in the respective order of your comments.

1. The excerpt from Ego's 1956 report on the Wainiha River, which indicated finding the predominant location of goby egg clusters near the mouth of the river cannot be directly applied to the situation at Hanalei River. There is no true estuary at Wainiha River (also according to Ego), so egg-clusters were actually located within a totally freshwater environment completely dissimilar to the situation near the proposed boat-loading area. Goby eggs will not be exposed to any petrochemical pollution released from the proposed excursion boat staging operations.

2. Spawning does appear to occur during the later part of the peak season for excursion boating operations. Spawning initiates with the onset of the first heavy rains of the fall-winter season. The vulnerability of gobi larvae to petrochemicals following hatching is not established but it is probably greater than at later stages of life. It can be argued that because hatching will occur so soon after deposition (24-28 hours, according to Ego), stream flow will be high and dilution-dispersion of the petrochemicals released downstream (in the estuary) will be greater, thus minimizing concentration levels and exposure time of the larvae to those chemicals. Heavy rainfall also marks the beginning of the non-peak season and decreased excursion boating activity and maximum boating activity is less likely to be achieved. Further, if deemed necessary, boating operations could be regulated during days

following the first heavy rains to restrict the total number of boats running engines in the estuary.

3. The relatively swift streamflow observed will prevent petrochemical from settling to the sediment. Moreover, the sandy bottom of the river mouth where the proposed boating activities will be staged is in dynamic exchange with the beaches offshore. Thus, long-term accumulation of less soluble fractions of petrochemicals that may be released during boat staging operations is impeded. If deemed necessary, periodic testing of sediments could be conducted to determine the potential for accumulation of petrochemicals.

4. No formal evaluation on the entrainment of the larvae of native species through outboard motor intake systems, or the impact of propeller blades was conducted, nor are such impacts conducive to evaluation. It would appear reasonable, however, that high-flow conditions which coincide with larvae migration would minimize this impact. The volume of water entrained in outboard motors or thrusted by propellers is extremely small in relation to streamflow volume.

We hope that we have satisfactorily responded to your comments. If you have any questions please call me.

Sincerely,

Earl K. Matsukawa, Project Manager

cc: North Shore Charter Boat Association
Mr. Martin Wolff
County of Kauai Planning Department

2344-1

University of Hawaii at Manoa

Environmental Center
Crawford 317 • 2550 Campus Road
Honolulu, Hawaii 96822
Telephone (808) 948-7361

May 30, 1989
RN:0220

Mr. Tom H. Shigemoto, Director
Planning Department
County of Kauai
4280 Rice Street
Lihue, Kauai, Hawaii 96766

Dear Mr. Shigemoto:

Environmental Assessment
Hanalei Excursion Boat Staging Operations
Hanalei, Kauai

The above referenced document proposes staging of excursion boat operations along the southern bank of the Hanalei River estuary on the north shore of Kauai. This Environmental Assessment (EA) was prepared in conjunction with the Shoreline Management Area (SMA) permit application seeking to establish commercial boating as a development activity originating from the Hanalei River County boat ramp and the Hanalei Excursion Boat Base Yard.

This review was conducted with the assistance of Frederick Collison, Travel Industry Management; Edward Laws, Oceanography; James Parrish, Hawaii Cooperative Fisheries Research Unit; and C. Anna Ulaszewski, Environmental Center.

<u>Alternatives</u> (p. 19)

No Action

According to this alternative, "all commercial tour boat staging activities [would] be located outside of the County SMA", at Black Pot Park. Our reviewers concur with the Charter Boat Association that moving the Hanalei River staging operations to Black Pot Beach Park would be environmentally and economically inadvisable.

Alternative Site

Although the Ocean Recreation Management Rules and Areas (ORMRA, Title 19 Chapter 86, Hawaii Administrative Rules) restricts the location of commercial tour boat activities, the Rules are subject to amendment. Thus, if other locations in the area are environmentally and economically suitable for staging commercial boat tour operations, the EA should identify them as an initial step to proposing appropriate changes to ORMRA.

The EA fails to consider sites outside of the Hanalei Bay region which might serve as alternate staging areas. Most available areas (e.g., Port Allen) present logistic difficulties to operators due to excessive transit distances to the Na Pali coast. However, other possibilities might be considered, such as negotiating an agreement with the U.S. Federal Government for use of an appropriate area of the Barking Sands Military Reservation. Although such an option may not be feasible presently, it should be considered as a long term alternative.

<u>Water Quality</u> (p. 16 and Appendix)

Our reviewers expressed the following concerns regarding the assessment methodology:

Because all surveys were conducted within a single day, the assessment is limited as to its representation. Thus, diurnal and seasonal variations in environmental and biological characteristics are not accounted for.

Under the circumstances, we realize that samples could not be taken during normal operations. In view of the chosen method of assessment (analysis of chemical residues in the water column), it is not clear how representative the artificial protocol is of normal operations.

The assessment was conducted during "moderate" flow, "on the rising tide". This does not assess the "worst case", which would occur during a low flow and a steep incoming tide.

According to the Appendix, page 10, "naphthalene was selected for a standard because it is probably the predominant fluorescent material" in the petroleum products under consideration. While the fluorescent properties of naphthalene and its analogs render them amenable to this type of analysis, other major hydrocarbon constituents of petroleum are significantly more toxic to aquatic organisms (e.g., benzene and toluene). In view of the environmental concerns motivating this assessment, specific analyses for these more toxic soluble compounds might have been warranted.

No assessment of surface or sediment contamination was made.

Page 16 of the Appendix states that "the potential for chronic impacts cannot be entirely dismissed". Certainly, a major shortcoming of the present assessment is the lack of consideration of cumulative impacts of hydrocarbon contamination in the estuary. We are aware of the limitations imposed by the circumstances surrounding the survey. However, we generally felt that this was not a particularly thorough study of the problem, and that at the very least, some biological sampling should have been included. The objectives of such testing would be to determine the amount of bioaccumulation of petroleum residues and to assess the extent of acute or chronic toxic effects caused by exposure to the petroleum contamination.

Other Concerns

With respect to base yard operations, we have concerns about the storage, disposal, and spillage of fuels, lubricants, and waste oils. The runoff from the base yard is a potential source of petroleum contamination in the estuary.

We also note that any significant level of human activity in the estuary would disrupt the natural environment and result in harassment of wildlife. However, in view of the history of activities in the area, such disruptions are already prevalent.

Recommendations

While precautions will be taken during refueling operations, accidents will happen. According to page 7 of this document, some boats will be fueled in the water. Even with a boom in place, it is possible that contamination will occur. We recommend that NO fueling be done while the boats are in the water.

The consensus of our reviewers was that a more elaborate and extensive survey could have been performed to address environmental concerns raised by the proposed action. The present EA does not demonstrate any substantive problems caused by the operations, and perhaps the impacts are subtle enough to warrant continued operations. However, there are inevitable cumulative effects which will result from these activities, and we clearly don't know very much about the biology of the estuary. In view of this, it would appear judicious to permit continued operations on a temporary basis while more thorough studies are conducted. At the same time, consideration of alternate sites for the staging of commercial tour boat activities should be encouraged.

Thank you for the opportunity to comment on this issue. We hope that our comments will be taken in to consideration.

Yours truly,

John T. Harrison, Ph.D.
Environmental Coordinator

cc: OEQC
North Shore Charter Boat Association
Wilson Okamoto & Associates, Inc.
L. Stephen Lau
Edward Laws
James Parrish
Frederick Collison
C. Anna Ulaszewski

2844-02
October 18, 1990

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Dr. John T. Harrison, Ph.D.,
Environmental Coordinator
Environmental Center
University of Hawaii at Manoa
Crawford 317, 2550 Campus Road
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Subject: Environmental Assessment for Hanalei Excursion Boat Staging Operations, Hanalei, Kauai (RN:0220)

Dear Dr. Harrison:

This is in response to your May 30, 1989 comments on the subject environmental assessment. On June 26, 1989, the County of Kauai Planning Director issued a determination that an environmental impact statement would be required in conjunction with a Special Management Area permit application for the proposed boat staging operations.

Currently, we are preparing the Draft EIS for the proposed action. Your comments and this response shall be incorporated in the Draft EIS as documentation of the consultation process initiated by the County.

The following responses are in the respective order of your comments.

1. Alternatives - Alternative excursion boat staging sites in the Hanalei area were considered in the preparation of the ORMA. The only other site receiving serious consideration was Poa Puu Marsh on the north bank of the Hanalei River mouth. Due to the wetland environment and private ownership, this alternative was not pursued. With regard to sites outside of the Hanalei Bay region, a site in the Barking Sands Military Reservation could overcome the problem of distance which precludes the Port Allen alternative. Such an alternative was not pursued primarily since the Hanalei Excursion Boat Base Yard presently offers the most readily available site that has been approved by both State and County agencies. Providing that they are permitted to operate from the Hanalei Excursion Boat Base Yard in the interim, the North Shore Charter Boat Association is willing to participate in discussion with County, State and Federal agencies in locating a site in the Barking Sands to Polihale area which would provide comparable advantages available at the existing boat yard.

2. Water Quality - We recognize the limitations regarding assessment of seasonal fluctuations in stream flow. As is the case in any environmental impact study, some reasonable balance must be struck between the magnitude of effort devoted to a particular concern and the potential environmental risk it

poses. In view of the findings of the AECOS study, we would concur with your recommendation that the proposed operations be allowed to proceed, if only on a temporary basis, while additional studies are conducted. We would suggest a periodic water quality monitoring program which would target low streamflow conditions.

Napthalene was selected as an indicator of petrochemical introduction in the stream water column due to its detectability at extremely low levels of concentration. Petrochemicals such as benzene and toluene are much more difficult to detect, and would probably not be detectable at the low levels indicated by the naphthalene tests. With respect to toxicity, literature cited in the study indicates that benzene and toluene are less toxic to aquatic organisms than heavier products such as naphthalene.

No water surface assessment was conducted due to the difficulty of quantifying concentrations of surface contaminants. Such contaminants tend to stay together and any random sample may or may not capture them, and it would be difficult to determine at what levels they are present.

No sediment samples were collected since observation of stream flow suggested that any settling of petrochemicals would be prevented by the relatively swift stream flow. According to available literature, sediment contamination is a problem in lakes where the current is insufficient to wash-out petrochemicals from the water. If sediment collection were to be done, if would only be appropriate during summer months when stream flow is extremely low and there may be a potential for petrochemicals to settle on the bottom and become trapped in the sediments. Even if petrochemicals settle on the bottom, long-term accumulation is further inhibited since the river mouth area is sandy-bottomed and subject to accretion and erosion by wave action as well as stream flow.

We hope that we have satisfactorily responded to your comments. If you have any questions please call me.

Sincerely,

Earl K. Matsukawa, Project Manager

cc: North Shore Charter Boat Association
Mr. Martin Wolff
County of Kauai Planning Department

Michael H. Kido
PO BOX 352
Kilauea, Kaua'i, Hi. 96754

May 2, 1989

Tom Shigemoto
Planning Director Kaua'i County
4280 Rice Street
Lihue, Kaua'i 96766

Dear Tom,

To begin, I would like to commend you and the County for taking a "hardline" posture in enforcing the Shoreline Management Area (SMA) Rules with regard to commercial tour boating in the Hanalei River. Concerned North Shore residents have, for years, been calling for an assessment of the impacts of this intensifying use of the river and it is indeed unfortunate that it took a court injunction to get the tour boat industry to deal with the many problems it has created.

My main purpose here is to comment on the Environmental Assessment for the "Hanalei Excursion Boat Staging Operations" from the perspective of an aquatic biologist currently studying Hawaiian stream ecosystems. I strongly disagree with the consultants conclusion that there is no "significant impact" on the "environmental resources" of Hanalei. I will confine my discussion to the fresh-water component of the ecosystem although we should also be concerned about nearshore areas as well as the impacted Napali Coast.

The native component of Hawaiian streamlife includes five endemic fish, an endemic mollusk (hihiwai), and two endemic shrimp (opae). All are believed to be diadromous, indicating that they are incompletely adapted to freshwater and must complete their larval phase of development in the ocean. The 'o'opu-nakea and 'o'opu- nopili descend into the upper area of the estuary to lay and fertilize their eggs while the 'o'opu-alamo'o apparently uses the entire stream length for reproduction. Estuarine areas are therefore critical to these species since they must pass in and out of these areas to complete their life cycle.

Populations of native stream animals, in particular 'o'opu and hihiwai, have been declining statewide for years. The 'o'opu-nakea (*Awous stamineus*), 'o'opu-nopili (*Sicyopterus stimpsoni*), and the 'o'opu-alamo'o (*Lentipes concolor*) were listed as threatened by the American Fisheries Society (Dodd et al. 1985). The 'o'opu-alamo'o is currently the rarest, listed as Category 1, Endangered Species Candidate by the U.S. Fish and Wildlife Service (Federal Register vol.54 no.4) and has been found in the upper reaches of the Hanalei River.

In regards to the EA in question, it was apparent that the consultants are not familiar with native Hawaiian stream ecosystems and do not recognize the critical importance of the estuarine component to native fauna. I found the AECOS boat staging simulation quite revealing and have interpreted the data in the light of our current work with the 'o'opu-nakea (A. stamineus).

Using the data and conversions provided in the AECOS report the detectable petrochemical from the staging simulation was plotted in figure 1. It is readily seen that the level of soluble petrochemical in the estuary rises especially in the area near the boat baseyard. This apparently is the area where the boats were launched and the charter boat "Kahanu" operated during the test. It was interesting that detectable soluble petrochemical also rose a short distance both above and below the baseyard which may indicate a limited dispersion of the pollutant in the upstream amd downstream direction (perhaps induced by the movement of the boats in the end phase of the test).

Although very little information exists on the effects of petrochemical pollution on lotic (flowing-water) ecosystems in Hawaii, it seems clear from mainland and international studies on pesticides, that although the effects may be transitory, they should not be dismissed as being insignificant (Muirhead-Thomson 1987).

My preliminary tests on the effects of gasoline on adult and juvenile 'o'opu-nakea seem to indicate a high sensitivity to this pollutant. Although these tests need to be redone using larger sample sizes, a concentration of approximately 13ppm as gasoline was lethal to the species in these preliminary static tests (test concentrations were made comparable by using the AECOS formulas provided in the report). Hinana (juvenile 'o'opu approximately 12 mm in length) seem to be more sensitive than adults (approximately 9cm individuals were tested) and presumably post-hatch stages (less than 5mm) would be even more sensitive because of increased size/volume ratios. Adult alien fresh water species however, such as the swordtail (Xiphophorous helleri) and the mosquitofish (Gambusa affinis) interestingly seem to be quite tolerant to these levels of gasoline. This may be one factor explaining the increasing predominance of alien species in our fresh water habitats.

Our studies on the spawning behavior of the 'o'opu-nakea indicate that perhaps 80% - 90% of their reproduction occurs during their first spawning run which begins in late summer. The run in 1988 began with the first rains on August 9 (the peak of the tour boating season in Hanalei). The major portion of the production of 'o'opu-nakea larvae therefore occured within two weeks of the first heavy rains of late summer.

Another interesting observation made this past summer was the marked tendency for hatching 'o'opu larvae to persistently swim for the surface of the river. This behavior presumably would have adaptive value for the species in ensuring that the hatchlings would catch the main flow of the stream out into the ocean. The majority of 'o'opu-nakea larvae after hatching

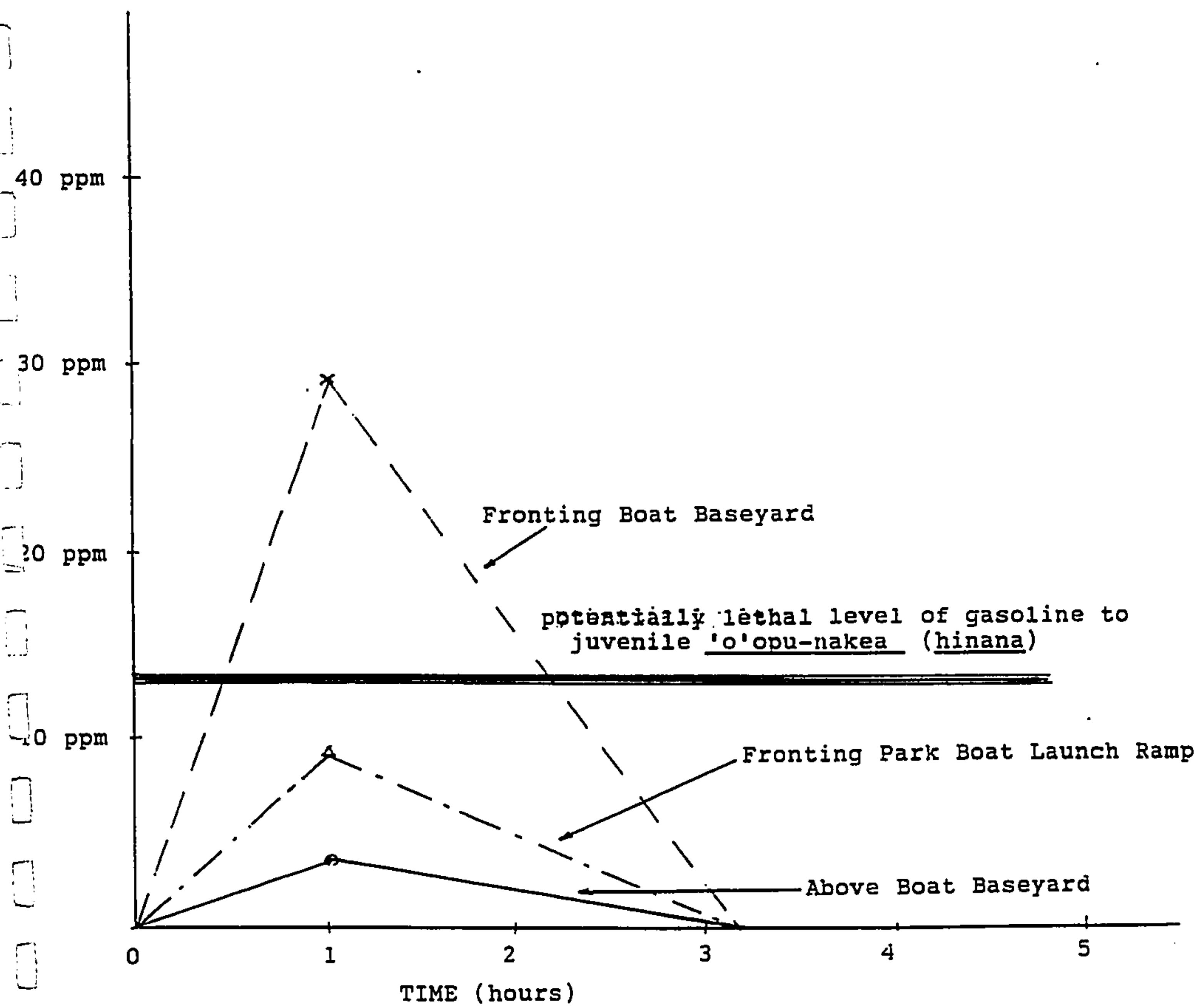

Figure 1: Increase in detectable petrochemical during AECOS boat operation simulation/ Hanalei River estuary April 1989 (data converted to ppm as gasoline)

therefore, probably remain in the upper foot of water on their trip out to the ocean.

Putting all of this information together in light of the AECOS study points to a potentially devastating impact of commercial tour boat activity on populations of 'o'opu-nakea in Hanalei River. Even if the maximum level of petrochemical pollution was reached in the AECOS simulation (as the EA claims and which I doubt with 50 boats potentially operating per day), a large "kill off" of 'o'opu-nakea larvae could potentially occur during the spawning/hatching period as these tiny fish make their way out into the ocean (see figure 1).

High quality rivers like Hanalei are becoming increasingly important natural resources as native fresh water components dwindle throughout the State and I continue to feel that these areas are not appropriate for intensive commercial activities. I believe that you are legally and morally correct in upholding the SMA Rules which were intended to protect these important natural areas. If the boaters refuse to relocate their operations, I hope that you will exercise your authority to require that an in-depth EIS be performed before any consideration of permits begins.

Respectfully yours,

Michael H. Kido

Michael H. Kido

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cc Mayor Joann Yukimura
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2844-02
September 28, 1990

Mr. Michael Kido
P.O. Box 325
Kilauea, Kauai, Hawaii 96754

Subject: Environmental Assessment for Hanalei Excursion Boat Staging Operations, Hanalei, Kauai

Dear Mr. Kido:

This is in response to your May 2, 1990 comments on the subject environmental assessment. On June 26, 1989, the County of Kauai Planning Director issued a determination that an environmental impact statement would be required in conjunction with a Special Management Area permit application for the proposed boat staging operations.

Currently, we are preparing the Draft EIS for the proposed action. Your comments and this response shall be incorporated in the Draft EIS as documentation of the consultation process initiated by the County.

The following responses are in the respective order of your comments.

1. Your comments regarding the subject environmental assessment and the proposed action suggest a strong personal bias as to the intent, purpose, and desired outcome of your experiment. We are concerned as to how this bias has affected your findings. We find several key misinterpretations and misrepresentations which cast the proposed action in a negative light, as discussed below.

2. Your comparison of numerical values obtained from field measurements conducted by AECOS to those of other studies is understandably tempting; however, the AECOS report cautions against doing so (see Discussion, page 14). The "conversions" are qualitative, not quantitative.

3. The soluble petrochemicals were detected only in samples downstream of the outboard motor operations. Sample 12 was taken from within a cluster of several boats which were stationary with motors running.

4. Based on the results of the AECOS field measurements and the literature reviewed concerning effects of outboard motor operations on aquatic biota, a significant negative impact of excursion boats on the Hanalei River biota is not demonstrated. While this does not preclude the possibility of any negative impact, existing information would indicate that this possibility is remote. We have indicated that this is an unresolved issue in the Draft EIS.

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5. It is misleading to graphically present the AECOS field results with a value purported to represent the "lethal level of gasoline to juvenile 'o'opu-nakea" as if the concentrations shown in the ordinate were equivalent. Moreover, even if the AECOS instrument response were comparable to the 13 ppm of gasoline, the toxic component of gasoline may be radically different from the petrochemical component detected in the AECOS study, which is assumed to be condensation from outboard motor operations. Certainly, we acknowledge that your study indicates a potential concern regarding significant gasoline spillage in the estuary.

   We concur that native species may be less tolerant of petrochemical pollution than exotic species, and that larval and juvenile forms of these native species may be even less tolerant than adult forms. However, several factors must be considered regarding exposure of such native species to detectable levels of petrochemicals in the estuary, including the rarity of maximum boating operations as simulated in the AECOS study, the rapid evaporation, dispersion, and dilution of petrochemical components, greater dilution and dispersion of petrochemical components during freshet conditions generally associated with the migration of native species through the estuary, and the onset of heavy rains in late summer which reduce boating operations.

   You provide no support for suggesting that the simulation conducted by AECOS is less than representative of actual boating operations. In fact, the simulation went well beyond that which would occur under actual operating conditions in an attempt to produce a detectable level of contamination. With the reduction in proposed boating operations in the Draft EIS (41 boats instead of 51 boats), the maximum operation level is even less than the AECOS simulation. In addition, if deemed necessary, mitigation measures such as the reduction of engine operating time and limitations on the total number of boats with running engines in the estuary at any given time can further reduce introduction of petrochemical condensation.

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& ASSOCIATES

We hope that we have satisfactorily responded to your comments. If you have any questions please call me.

Sincerely,

Earl K. Matsukawa, Project Manager

cc: North Shore Charter Boat Association
Mr. Martin Wolff
County of Kauai Planning Department

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APPENDICES

APPENDIX A

SOLUBLE PETROCHEMICAL MEASUREMENTS IN THE LOWER REACH OF THE HANALEI RIVER, HANALEI, KAUAI, HAWAII

by AECOS, Inc.

AECCS No. 567

**SOLUBLE PETROCHEMICAL MEASUREMENTS
IN THE LOWER REACH OF THE HANALEI RIVER,
HANALEI, KAUAI, HAWAII**

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April 1989

Introduction

Concern has been expressed at various hearings and in the media that operation of the small boats (the Hanalei/Anini permittees) conducting commercial tours along the Na Pali coast, Kauai may be having a negative impact on the ecology of the Hanalei River estuary. The majority of the craft involved in this trade launch at or near a public boat ramp on the Hanalei River close to the river mouth, and approximately 80% of these boats proceed a short distance (tens of meters) upstream to a sandbar along the west shore where passenger loading is affected. Thereafter, the boats proceed out into Hanalei Bay and northwestward along the Na Pali coast. Passenger transfers for those craft not using the sandbar area in the estuary presently occur elsewhere along the north Kauai coast.

The numbers of boats involved varies with the season (i.e., demand) and the time of day. At maximum utilization, during the months of May to September, as many as 45 to 50 craft might be launched each day. Most of the activity occurs between 8 and 10 AM which is the usual departure window for tour trips along the coastline. Returning craft enter the river at times which are spread over the afternoon, with many operators accomplishing two trips in a day during the peak season. Actual running time of engines within the estuary are brief. To prevent fouling of spark plugs, motors are run only as necessary to move the craft from the launch point to the loading area and then, after loading/unloading of passengers, to depart the estuary.

The kinds of impacts these operations might have on the Hanalei River have been vaguely stated. A general "sensitivity" of estuarine environments is frequently alluded to, and pollution from motorized craft, specifically the introduction of fuels, oils, and exhaust condensates to the aquatic environment, is suggested as a potential threat to resident and transient organisms in the estuary. This study has been designed to measure one aspect of motorized craft operations on the estuary: that of enhancing the concentration of soluble petrochemicals in the water column.

Both the degree of risk represented by petrochemical additions to the river system and the portion of this risk assessed by the measurements reported herein must first be put into some perspective. Soluble petrochemicals represent only a small part of the complex mix of organic compounds that make-up a crude oil or an oil product such as a fuel or lubricating oil. By definition, soluble petrochemicals are the hydrocarbons in a mineral oil (or refined derivative) that can dissolve in the water. Most of the components of fuels are not soluble in water, and those that are soluble are only sparingly so. Despite the low solubility of petrochemicals as a group, the toxicity of the soluble fraction is relatively high, and therefore concern about their presence in natural aquatic environments is justified.

<u>Fate of Petroleum Hydrocarbons in Aquatic Environments</u>

Fuel and oil products may be introduced to an aquatic environment by several means. Perhaps the most common is run-off from the watershed where the operation and fueling of motorized vehicles results in small spillage along roadways and at facilities (e.g., gas stations) associated with vehicle operation and maintenance. Atmospheric condensation of exhaust products and fuel evaporates is another common source. Motorized boats may also contribute petrochemicals to natural waters and the processes are the same, although some perhaps more direct, as those involving vehicles. However, outboard motors usually exhaust below the water surface, so that some or much of the exhaust emission becomes homoginized into the water column by the propeller during in-gear operation. Improvements in outboard motor design and use of unleaded fuels have, in recent years, reduced the pollution impacts associated with exhaust and crankcase condensates from outboard motors.

Spills of crude oil and/or product (refined fuels and oils) directly into aquatic environments represent the most visible source of petrochemical pollution and produce the most damaging immediate impacts on aquatic life. However, much of this impact is caused by the smothering effect of heavy oils, particularly on intertidal life, rather than specific chemical or toxic properties of the oil. Spills also demonstrate most readily the fate and sequence of changes that petrochemicals undergo with time, and have been the most studied of all the potential aquatic phenomenon arising from man's use of petrochemicals. Further, most spills are the result of human accidents, and are therefore regarded as a pollution source amenable to prevention and intervention.

The eventual fate of a petrochemical spill will depend greatly upon the initial composition of the material: whether it is a crude oil or some type of refined product such as gasoline. Products differ in the relative proportions of different hydrocarbons: the molecules with few carbon atoms (say $n\text{-}C_{14}$ or less) have low boiling points and evaporate readily; the molecules with more than 28 carbon atoms are prone to sinking and are degraded only very slowly. The discussion here will consider mostly gasoline (or gasoline/oil mixtures) in a fresh or estuarine environment such as the lower Hanalei River. Gasoline is a mixture of mostly saturated $n\text{-}C_4$ to $n\text{-}C_{12}$ hydrocarbons, containing substantial amounts of paraffins, olefins, naphthenes, and aromatics (The Merck Index, 1968). These are compounds in the boiling range of 0^{o} to $200^{o}C$. Outboard engines utilize a fuel/oil mixture on the order of 50:1 (2% oil). The oil or lubricant is typically composed of 20% kerosene, 20% dispersant, and 60% lubricating oil (hydrocarbons in the $n-C_{20}$ to $n-C_{40}$ range) with 0.5% of other additives (Dicks and Bayley, 1983). Inefficiencies (known as scavenging losses) in outboard motors result in between 15 and 40% of the fuel passing through the engine cylinder unburned and exhausted with combustion products.

When a fuel is introduced to a body of water, it spreads over the surface as a thin film (forms a slick) because the fuel is essentially immiscible (does not mix) and insoluble (does not dissolve in) with the water and is of an average density less (that is, it is lighter) than water. Although dependent upon temperature and wind conditions, evaporation of volatile fractions from the surface film results in the greatest bulk loss from the aquatic environment; more than 75% of a refined fuel such as gasoline will be lost to the atmosphere within 24 hours (RCEP, 1981) and most is lost within minutes or hours depending upon temperature and wind conditions (Dicks and Bayley, 1983). Evaporation increases the viscosity of the remaining slick, which slows or stops its tendency to spread. The average density also increases, so the residue may eventually become dense, tarry globules that sink to the bottom. However, because the non-volatile fraction (the larger molecules) found in an outboard motor fuel is a small proportion of the total (less than 2% of the fuel mixture consists of fractions greater than $n-C_{20}$), most (70 to 98%) of this kind of product would be removed by evaporation within 24 hours (Dicks and Bayley, 1983).

Other degradative processes also occur: photochemical oxidation (the breakdown of complex organic compounds by sunlight), microbial degradation (activity of bacteria and fungi which utilize the hydrocarbons as a food source), and dilution/dispersion/emulsification (physical processes which spread the fuel, and promote either its movement into the water column as an oil-water mixture or its physical removal from the area). The latter processes are dependent upon wind and wave conditions and, of particular significance in the Hanalei River system, currents.

Of course the slick might be moved onto shore. Degradative processes will continue, but only in cases where the accumulation is great (such as from an accidental spill) and the product heavy (say bunker oil as opposed to high octane gasoline), will serious environmental damage to shore and intertidal organisms be clearly evident.

As should be clear from the foregoing discussion, only a relatively small portion of the fuel involved in a spill or otherwise introduced to an aquatic ecosystem, will actually enter the water column in relatively quiet waters. The compounds which dissolve in water are mostly in a class called aromatics or polynuclear aromatic hydrocarbons (PAH). Crude oil and particularly refined petroleum products contain large amounts of aromatic hydrocarbons which do not naturally occur in aquatic environments. Gruenfeld (1973) reported aromatics comprising between 12 and 47% of eight different crude and refined oils tested. These compounds include benzene and heavier polycyclic and heterocyclic hydrocarbons with two or more benzene (six carbon) rings: examples are acenaphthene (n-C_{12}), anthracene (n-C_{14}), fluorene (n-C_{13}), naphthalene (n-C_{10}), phenanthrene (n-C_{14}), pyrene (n-C_{16}), and chrysene (n-C_{18}). Most are insoluble or only slightly soluble in water. On the other hand, benzene is one of the most soluble of hydrocarbons in water (1780 ppm according to McAuliffe, 1963, 1966). The solubility of naphthalene in fresh water is between 30 and 40 ppm at 25°C (Mitchell, 1926; Josephy and Radt, 1948). In seawater, the solubility is around 3 ppm (Gordon and Thorne, 1967). Compare this with the concentration of various inorganic salts (mostly sodium chloride) in sea water, which is far from a saturated solution, at around 34,000 ppm.

Methods

A total of twenty samples were collected from the lower portion of the Hanalei River on April 10, 1989 for the analysis of soluble petrochemicals. Sample bottles were prepared by prerinsing with freon. Water samples were obtained by lowering the bottle to a depth of between 8 and 15 cm below the water surface, opening the cap until the bottle filled, then replacing the cap before lifting from the water. This procedure was followed to intentionally avoid collecting water from the surface and possibly contaminating the sample with surface film petrochemicals. In the laboratory, petrochemicals were removed from the water by solvent (freon) extraction, a procedure which would not differentiate between petrochemicals actually dissolved in (or at least mixed with) the water, and any fuels or oils floating on the sample surface or coating the inside walls of the sample bottle.

A sampling protocol was established as follows. First, a series of five water samples (group 1) was collected between 1220 and 1245 hours from the Hanalei estuary between the mouth and the boatyard. A total of six boats representative of the kinds of craft which utilize the site for customer loading and off-loading were then operated on the river for more than a one hour period. Launching of these boats started at 1245, and all six craft were in the water with motors running by 1320. Between 1320 and 1415, five of the boats remained stationary along a sandbar (where loading usually takes place) with motors running, while a sixth boat, the "Kahanu" (a charter boat), was similarly operated stationary near the shore opposite the boat yard where this craft traditionally loads passengers. At around 1415, the five boats at the sandbar "launched", moving around the lower river for an additional 10 to 15 minutes. The "test" operation of all six craft was finished by 1431 hours. Four water samples (group 3) were collected from the lower river between the boatyard and the public launch ramp between 1415 and 1430 hours.

During the period when the boats were operating, a series of six water samples (group 2) was collected from the Hanalei River and two tributaries upstream of the test area. Sample locations are shown in Figure 1. Finally, starting one hour after cessation of the operating test (i.e., between 1530 and 1610 hours), a series of five samples (group 4) was collected from the estuary between the mouth and a point 370 m upstream of the mouth. Sample collection data are tabulated in Table 1.

Samples were placed on blue ice in a cooler as they were collected. These were transferred to a storage refrigerator maintained at between 1 and 3 ^{o}C on the evening of April 10. Unfortunately, two samples (No.s 2 and 4) burst from the cold in

Table 1. Field log of water samples collected in the Hanalei River and tributaries on April 10, 1989.

SAMPLE	TIME	LOCATION	UPSTREAM (1)	FLOW (2)	DEPTH (3)	SAL (4)
		Group 1				
1	1224	slough opp. boat yard; canoe area	250	still	45	0
2	1227	off sandbar,west shore	140	out	75	0
3	1231	off sandbar,west shore	120	still	20	0
4	1233	off public boat ramp	80	out	90	0
5	1243	middle river mouth	0	out	90	0
		Group 2				
6	1300	tributary drainage, Hanalei just below Hwy 56	1850	strong	50	0
7	1314	above Hwy 56 bridge	4600	out	100	0
8	1320	just below Hwy 56 bridge east bank	3800	still	80	0
9	1325	west bank, midway btwn Hwy 56 bridge and #10	3000	still	60	0
10	1331	just dwnstr of Dolphin restuarant, west bank	1800	out	80	0
11	1336	tributary stream just west of #10, below Hwy 56	1900	slow	60	0
		Group 3				
12	1415	sandbar, west bank from between operating boats	140	out	75	0
13	1421	slough (same as # 1)	250	still	25	0
14	1425	just dwnstr of sandbar	110	out	75	0
15	1430	opp public boat ramp	80	out	100	0
		Group 4				
16	1529	mid-river at mouth	0	out	115	0
17	1533	opp public boat ramp	70	out	100	0
18	1538	off west bank sandbar	140	out	75	0
19	1543	slough (same as # 1)	250	still	60	0
20	1610	west bank opp hau forest	370	still	60	0

footnotes:

(1) - approximate distance in meters upstream from stream mouth

(2) - observable flow characteristics at point where sample was collected

(3) - approximate depth in centimeters at sample location

(4) - sample salinity in ppt measured by refractometer

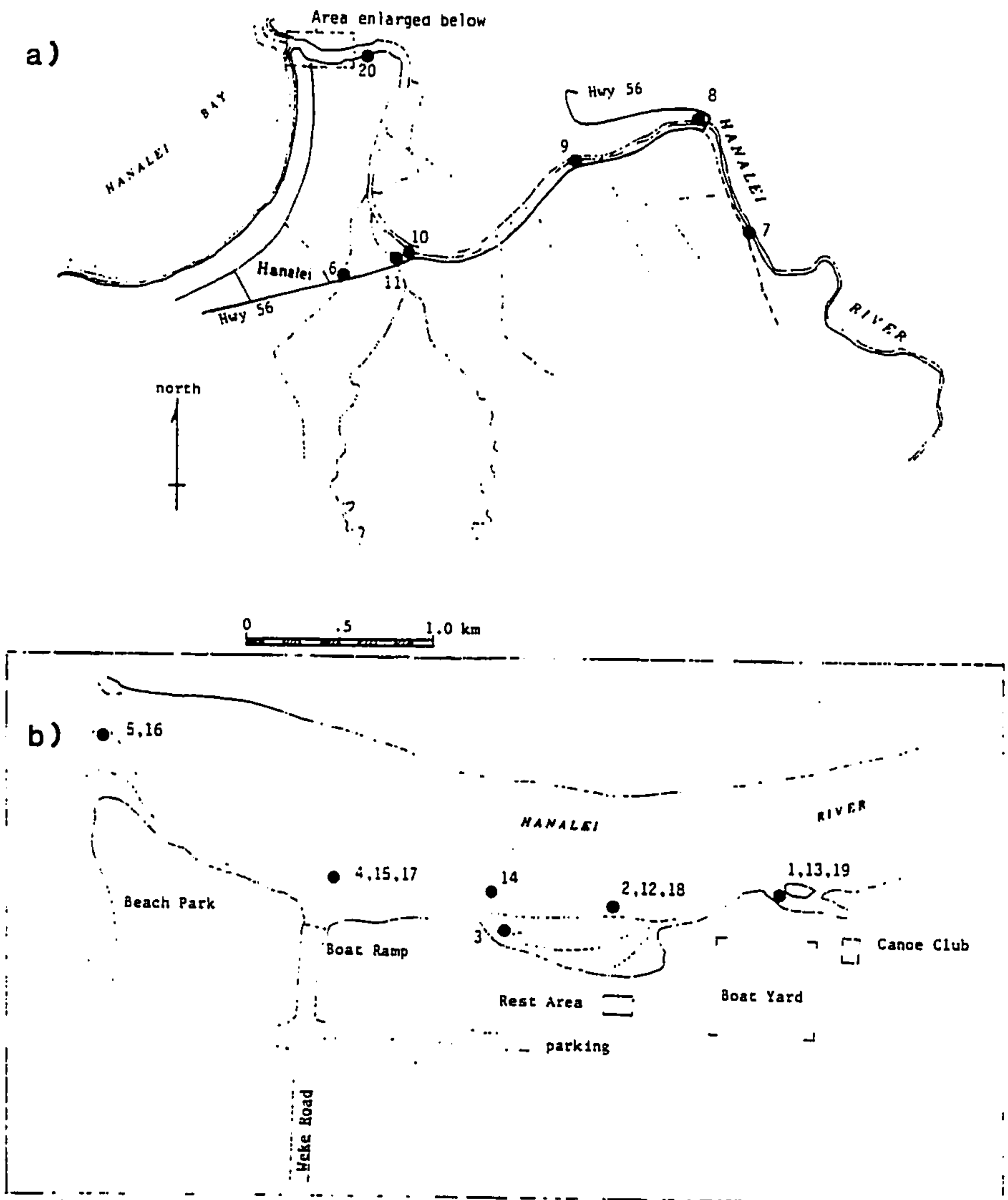

Figure 1. a) Map of the lower Hanalei River showing sample locations upstream from mouth. b) Sketch map of the river mouth with sample locations.

storage and could not be analyzed. Extractions were undertaken on April 15 following the procedure (503 E.) outlined in APHA (1985) which uses freon (trichlorotrifluoroethane) as the extracting solvent. This method incorporates a silica gel clean-up procedure to remove polar materials such as fatty acids. Some complex aromatics might also be removed by the silica gel, so all samples were analyzed for florescence before and after clean-up. Because some loss of florescence (between 5 and 20%) did result, only the pre-cleanup values are reported.

The extracts were analyzed for fluorescence on a Turner Associates Model 111 fluorometer fitted with a #110-851 U.V. lamp, a narrow bandpass, primary filter (providing an excitation wavelength of 254 nm), and a secondary filter set combining sharp-cut and narrow bandpass types (280 to 340 nm emission wavelength) as described in AECOS (1978) following methods from Gordon, et al. (1974, 1976). Fluorometric analysis is dependent upon the property of some compounds which absorb light energy at one wavelength to emit the energy at a higher wavelength (that is, they fluoresce). By tailoring the exciting and detecting wavelengths with colored filters, some specificity of detection of compounds can be achieved with the fluorometer. For example, each PAH group has a characteristic emission spectra: benzene has an emission peak at 280 nm; the two ring compound, naphthalene, has an emission peak at 320 nm; the three and four ring compounds emit at 350 nm, while the five and more ring compounds emit at 400 plus nm (Gordon, et al., 1974, 1976; Schwarz and Wasik, 1976). Thus, the selection of filters narrows the number of different chemical compounds that will be detected, but the method is not specific for any one. In this case, the filter combination was selected for greatest sensitivity to the lighter, more soluble aromatics believed to be most abundant in the fuel and exhaust from outboard motors.

The mouth of the Hanalei River is a physically dynamic environment. The river is the largest on the north coast of Kauai and originates in the high-rainfall interior of the island. The Hanalei River is reportedly tidal for a distance of three miles upstream (Cox and Gordon, 1970). For comparison, the (Route 56) highway bridge is located 3.86 km (2.4 miles) upstream from the mouth (USGS, 1985). The natural flow of the Hanalei River averages about 75 mgd (Davis, 1960), but some 25 mgd is presently diverted from the headwaters to the Wailua River. Volume at minimum flow is estimated at around 10 mgd (Cox and Gordon, 1970). At the time the water samples were collected, flow in the river was judged moderate, probably fairly typical for wet season, non-flood conditions. The predicted low tide (LLW) in Hanalei Bay on April 10 was at 1024 hours, although because the previous high water (LHW) was only several inches above the low tide (HLW) at 0128 hrs, relatively low water characterized the entire 12 hour period prior to the start of water sampling. All samples were collected on the rising tide, which peaked (HHW) at around 1800 hours. The steady increase in water level during the sampling period could be clearly observed along the shore. Winds were very light from the north or northeast (blowing into the estuary). A light rain fell in the late afternoon, mostly after completion of the sampling.

Water samples were not collected during normal commercial operations (launching and passenger loading) because a court injunction had been imposed prohibiting such operations as of April 6, 1989. Various constraints including weather conditions delayed the study past this date, so a time was selected which would present conditions providing the greatest opportunity for detecting a measurable effect; that is, conditions tending to maximize the residence time of the water in the river mouth. This condition was achieved with the exception that greater residence times can be expected to occur during the dry season when the river discharge is at a minimum.

Although commercial operations by the Hanalei/Anini permittees had not occurred for a period of several days prior to the sampling, other boating activities did take place: some 6 to 9 fishing boats and 6 commercial cruise zodiacs (which loaded passengers elsewhere along the north Kauai coast) had been launched during the morning hours. At least two other motorboats were observed operating on the lower river.

The running of six boats simultaneously in the loading area for over a one hour period was not typical of normal operations as described above, but was intended to be representative of at least 12 engine operating hours (12 motors x 60 minutes) within the lower estuary. It is estimated that twenty departing and returning tours (40 engines x 2 trips; maximum that could be reasonably accommodated over a one hour period in the area) is equivalent to between 6 and 12 hours of single motor operation within the river mouth, assuming actual operating (motor running) times of between 5 and 10 minutes for each boat while in the estuary. This estimate is somewhat conservative, so the test conditions fairly produced conditions worse than those experienced by the environment during peak commercial operations.

Results

Quantitative analysis of petroleum in the environment presents a somewhat difficult problem because the crude petroleum and most of the commonly used products such as gasoline and motor oil are complex mixtures of chemicals, each compound having a unique set of physical and chemical properties. The fluorometric method to detect petroleum constituents in the water column takes advantage of the property of aromatic hydrocarbons to fluoresce in the presence of ultraviolet (UV) light. The response of the fluorometer to the Hanalei River extracts was calibrated against four naphthalene standards in the range between 0.125 and 1 ppm. These were made by dilution from EPA Standard = 1219 (5000 mg/l naphthalene in MeOH).

Naphthalene was selected for a standard because it is probably the predominant fluorescent material in light oils and in the truly water soluble fraction of heavy oils (Turner Designs. undated). Although benzene is far more soluble and, with the closely related chemical toluene, a significant component of motor fuel and engine exhaust, the quantum yield (amount of energy fluoresced per unit of energy applied) of benzene in water is only 3% that of naphthalene (John and Soutar, 1976). Thus, the results in Tables 2 and 3 are expressed in mg/l (ppm) as naphthalene. Expressing the results this way does not mean that all of the substance or substances detected were in fact naphthalene, nor that any naphthalene was necessarily present in the Hanalei River samples. The results should be read as the concentration of unknown aromatic hydrocarbons that give the same instrument response as the given concentration of naphthalene.

Table 2. Results of fluorometric measurement of freon extracts of river water from the lower reaches of the Hanalei River and two tributary drainages (mg/l as naphthalene).

Group 2		Group 2	
SAMPLE	CONC.	SAMPLE	CONC.
20	<0.003	10	<0.003
6*	<0.003	9	<0.003
11*	<0.003	8	<0.003
		7	<0.003

* Smaller streams tributary to the Hanalei River measured immediately downstream of Hwy 56 culverts.

Table 2 gives the results from all samples collected upstream of the area utilized by the Hanalei/Anini permittees boats. These data have been arranged in order of increasing distance upstream from the river mouth. Sample 20 was included in this set (group 2) although collected later in the day (post-test period). Soluble petrochemicals were not detected anywhere in the lower 4.6 km (2.9 miles) portion of the river at a concentration at or above the limit of 3 ppb established by the analyst as the level or concentration below which there can be no confidence in the values obtained.

Table 3 gives the results from samples collected in the area where boat launching and passenger loading occurs. These are arranged vertically in the table in "downstream" order (see Figure 1b). The three groups represent pre-, during, and one-hour post-test sample sets. Within each group, samples collected at corresponding locations are on the same horizontal line.

Table 3. Results of fluorometric measurement of freon extracts of river water from the mouth of the Hanalei River (mg/l as naphthalene).

Group 1		Group 3		Group 4	
SAMPLE	CONC.	SAMPLE	CONC.	SAMPLE	CONC.
1	<0.003	13	<0.003	19	<0.003
2	lost	12	0.0203	18	<0.003
3	<0.003	14	0.172		
4	lost	15	0.0544	17	<0.003
5	<0.003			16	<0.003

The group 1 results show, for the vicinity of the public boat ramp, that soluble petrochemical levels do not increase (over values upstream) in the river mouth where boating activity has traditionally concentrated. Neither the morning launchings on April 10 nor some unspecified accumulation of oil products in the river are contributing measurable aromatic hydrocarbons to the lower estuary.

The group 3 results demonstrate that aromatic hydrocarbons are contributed by outboard motor operations at a density as great as or greater than peak season operating levels. These levels are low, but clearly detectable. The data indicate that no measurable "upstream" movement of hydrocarbons occurs on a rising tide (undetectable concentrations in samples 13, 19, and 20).

The group 4 samples demonstrate that the aromatics contributed by the test outboard motor operations were removed from the estuary in less than one hour. The modes of removal of these aromatics were not assessed by this study but very likely were dispersion (water flow), dilution, and evaporation (listed in probable order of importance). All of the samples were measured by refractometer and found to be fresh water. Thus, although the lowermost segment of the Hanalei River is an estuary, brackish water was evidently present as a distinct layer beneath the fresh water and, if present, was deeper in all locations than the depth at which samples were collected. When sample 16 was being collected, a warmer layer could be detected along the bottom and was estimated to represent only the lowermost 20 to 25 cm of the 115 cm water column.

Another approach to instrument calibration is to utilize a known concentration of the petroleum or petroleum product of interest. In cases where a spill of known composition is involved, samples of the material spilled could be used to make standards. Our instrument response to a gasoline solution of 37.5 ppm unleaded gasoline in freon was determined to be equivalent to 0.22 ppm naphthalene. Thus, the results in Tables 2 and 3 could be converted to ppm as gasoline by multiplying the given concentrations (as naphthalene) times 170. The quantity obtained might be misleading, even if all of the aromatic hydrocarbons measured came directly from gasoline, because the river samples presumably represent a water extract of gasoline and exhaust products only some of which may be directly mixed into the water column by the mechanical action of the outboard engines.

In order to relate the sample values qualitatively to gasoline spilled on water and taking into account the low solubility of gasoline as a whole, a water extract was prepared by adding 1 ml of commercial unleaded fuel to 1000 mls of tap water and rotating for 30 minutes in a rotary extractor. The mixture was then allowed to stand for 3 hours before 500 mls were removed from the lower part of the sample (the surface film was excluded). Hydrocarbons were then extracted from this 500 mls with freon as described for the river water samples. This procedure resulted in a "solution" which measured 0.61 ppm as naphthalene (or 103.7 ppm as gasoline). This concentration represents a 13.9% recovery of the initial spike of 1 ml in one liter. Recovery is low in this instance because it was made dependent upon the solubility of the various fractions that make-up a gasoline.

Discussion

The toxicity of some components of petroleum to aquatic organisms has long been known. Establishing lethal and sublethal concentrations has been difficult. Although a considerable literature relating to crude oil and product toxicities exists, most studies can not identify the specific toxic components responsible for observed effects. Sublethal or chronic effects seem likely, but are even more difficult to establish. In general, the acute toxicity of a petroleum or petroleum product is related to the proportion of light aromatics and alkenes present. Acute toxicity decreases as weathering occurs and the volatile fractions are lost by evaporation, dispersion, and dilution. The most notable toxic, non-volatile hydrocarbons found in oils and spent (burned) fuels are the PAH's, some of which are mutagenic. Current information supports the generalization that the majority of acute toxic effects, including that of active water-soluble fractions containing aromatics, occur when concentrations are greater than 0.1 ppm and usually greater than 1.0 ppm. Sub-Lethal effects commonly occur between 0.1 ppm and 1.0 ppm (Dicks and Bayley, 1983). These authors point out, however, that "... sub-ppm levels of oil which produce sub-lethal effects in the laboratory, do not result in significant environmental damage overall", a conclusion shared by a Royal Commission report (RCEP, 1981). EPA has promulgated criteria for naphthalene in aquatic environments based on the lowest observed effect level (USEPA, 1980). Acute and chronic toxicity of naphthalene to freshwater aquatic life occur at concentrations of 2.300 ppm and 0.620 ppm, respectively. Acute toxicity to saltwater aquatic life occurs at concentrations as low as 2.350 ppm.

The accumulation of hydrocarbons as a result of outboard motor operations has been studied in both natural systems and controlled situations. The most thorough investigation to date (Schenk et al., 1975) used 0.5-acre ponds for comparisons over a three year period between heavily stressed and control ponds in a study under the direction of the United States Environmental Protection Agency. For the stressed ponds, one liter of fuel was burned in various outboard motors per day per million liters of water; representing approximately three times the maximum outboard motor usage that could be reasonably undertaken in a given area assuming an average depth of 3.7 m. The control ponds saw no outboard motor use during the study. A number of different aspects of the biology and chemistry of the test ponds were studied. No acute biological effects were observed in either field or laboratory tests in this study, which looked at phytoplankton, zooplankton, periphyton, benthos, and fishes. Increases in total hydrocarbons in the water column (1 to 5 ppm after 2.5 years) and sediments (100 to 200 ppm) were observed in the test ponds as compared with the control ponds, but aromatic hydrocarbons were rapidly removed from the water by evaporation. Increased lead levels in both the water column and sediments were observed in the leaded fuel test pond.

The toxic properties of outboard motor exhaust can be demonstrated under laboratory conditions. Environmental Engineering, Inc. (197?) found a lethal effect from outboard motor exhaust water in fish bioassays, but concluded that "...the concentration necessary to produce a fish kill or damage to the ecological balance would require extremes far beyond the normal use of marine engines on rivers and lakes." In order to produce a solution lethal to juvenile bluegills, a 4 HP motor had to be run at 1000 rpm for 8 hours in a 50 gallon drum of water. A 15% dilution of this water produced some deaths, while 20% and 30% dilutions proved fatal to all of the test animals within 8 hours. A solution produced by 4 hours of operation in the 50 gallon drum had no observable effect on bluegills at dilutions of 30%.

The present report is an attempt to address only one aspect of the operation of commercial motorized craft in the mouth of the Hanalei River: whether these craft produce measurable increases in the concentration of aromatic hydrocarbons in the river mouth during commercial passenger loading and unloading operations. The introduction of aromatic hydrocarbons to an aquatic environment does not a priori establish that environmental damage will occur. Even in cases of large oil or product spills, links between damage to biota and toxicity of the oil have proven difficult to establish (Dicks and Bayley, 1983). The several studies designed to assess impacts of outboard motor operations on small, natural systems have concluded that few if any ecological effects occur (English et al., 1963; Schenk et al., 1975, Environmental Engineering, 197?). These studies have utilized levels of motor density and fuel consumption per unit lake volume well in excess of what natural lakes would reasonably support on space considerations alone. Aquatic systems such as the Hanalei River which include a significant linear water flow component, would be even less likely to show ecological damage from such activities because of the rapid removal of water subjected to inputs of aromatic and other hydrocarbons from outboard motor exhausts and minor spills.

We realize that the reader will be tempted to assess the potential for environmental harm in this situation by comparing the concentrations presented in Table 3 with the USEPA (1980) aquatic criteria for naphthalene, or perhaps other studies which report toxic concentrations of gasoline or specific aromatic hydrocarbons. We caution against such direct comparisons. The fluorometric method used here has several advantages, including high sensitivity to aromatics, relatively rapid processing of samples, and reasonable analytical costs; and these advantages make fluorometry particularly suited to detecting patterns in the distribution of petroleum products in aquatic environments. But the results from field samples, although quantitative, must be regarded as significant only in a relative sense. That is, their greatest value is in making comparisons from one place to another or over time within the same study.

The concentrations presented in Table 3 are very much dependent upon the standard selected to calibrate the fluorometer. For example, had benzene been used the concentration values reported would be much higher (comparable perhaps to the gasoline response factor of 170) because, as noted above, benzene is only weakly fluorescent. Thus, the calibration curve would require higher concentrations of benzene for the range of instrument response obtained in the river during motor operations.

The difficulty relates directly to our uncertainty of the composition of the aromatics measured in the river during heavy outboard motor operations. If the aromatics generated in the water column are mostly weakly fluorescent compounds such as benzene and toluene, then their absolute concentrations in the river water during the test period is substantially higher than the reported concentrations as naphthalene. This thought need not result in undue additional concern because the toxicities of benzene and toluene (see NAS, 1975) are lower than many of the polycyclic aromatics, and their rate of removal from the environment would be high by comparison to the larger aromatic molecules.

The significance of our results can be summarized as follows. During conditions of moderate flow, contributions of soluble petrochemicals from the watershed of the Hanalei River are not detectable at ppb levels. This result follows from the prolonged rainy period preceding the sampling and the non-urban setting of northern Kauai. The operation of outboard motors at the density experienced during maximum use of the lowermost portion of the Hanalei River estuary does contribute aromatic hydrocarbons at sub-ppm levels, at least to the upper water layer. The most likely source of these compounds is condensation from outboard motor exhausts. Under the conditions of moderate flow and an incoming tide, the concentrations appear insufficient to produce acute toxic effects on resident or transient biota. Dissipative losses of aromatics is rapid, and the principal mechanism at the time of the study was presumed to be outflow from the estuary. Further dilution, evaporation, and biochemical degradation would mitigate against damage to the ecology of Hanalei Bay solely from this source. Chronic effects on the ecology of the estuary from the levels of petrochemicals observed in this study are also deemed unlikely. However, the potential for chronic impacts cannot be entirely dismissed. Circumstances which result in a greater contribution of petrochemicals to the estuary from any source and/or conditions which substantially reduce the factors responsible for the rapid dissipation observed, if obtaining over a prolonged period of time, might result in chronic impacts to the estuarine ecology.

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APPENDIX B

COMMENTS ON NATIVE STREAM AND ESTUARINE FAUNA IN RELATION TO THE PROPOSED HANALEI EXCURSION BOAT STAGING OPERATIONS, HANALEI, KAUAI

by Kelly M. Archer

COMMENTS ON NATIVE STREAM AND ESTUARINE FAUNA IN RELATION TO THE PROPOSED HANALEI EXCURSION BOAT STAGING OPERATIONS, HANALEI, KAUAI

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INTRODUCTION

Recently, an Environmental Assessment was completed to determine the effects on the local environment of the proposed Hanalei Excursion Boat Staging Operations near the mouth of the Hanalei River, North Shore of the island of Kauai. These proposed operations would involve passenger loading and unloading into commercial tour boats from the river bank at the existing Excursion Boat Yard, some 200 meters from where the river enters Hanalei Bay. The Assessment included a study (AECOS No. 567) evaluating the quantity of soluble petrochemicals expected to be introduced to the estuary due to commercial boats traveling to and from the loading area (Ref. 1).

This report is a discussion of the information that is available on the native fauna commonly found in Hawaiian estuaries and streams and on the acute and chronic effects of petrochemicals on aquatic organisms in general. A computer literature search of biological abstracts over the last 8 years generated 33 citations relating to petroleum and aquatic fauna. These citations were evaluated for applicability and available studies were then included in this report.

NATIVE STREAM SPECIES

Stream fauna in Hawaii are commonly discussed in terms of their origin. Native fauna are organisms which are found naturally in the state, while alien species are ones present due to introduction by man. This study will focus on native species.

Ten species of conspicuous invertebrates and fishes commonly found in streams throughout Hawaii are considered native (Table 1). Of these ten species seven are known to be diadromous and require passage to the ocean and back to insure reproductive success. These species live and spawn in freshwater and hatchlings from their eggs must spend a period of development in the ocean before migrating upstream. Two of the other fish species, *Eleotris sandwicensis* (o'opu okuhe) and *Kuhlia sandvicensis* (aholehole) are principally found near the mouths of streams in estuarine environments and could be impacted by the proposed activity. The following is a summary of each of these nine species with regard to lifestyle and distribution (Ref. 2).

1. *Atyoida bisulcata*: o'pae kala'ole.

A small (2-4 cm) endemic shrimp, common to abundant in perennial Hawaiian streams to 1,000 m elevation. The opae is primarily a detrital filter feeder and is diadromous, although there is still some question as to whether the diadromy is obligatory.

2. *Macrobrachium grandimanus*: o'pae o'eha'a.

This endemic, diadromous, palaemonid prawn inhabits lower reaches of streams and mixohaline shoreline ponds throughout the State and ranges in size from 2 to 9 cm in total length (distance from the tip of the rostrum to the tip of the telson). This o'pae is an omnivore that ingests mostly detritus, although adults appear to prey on other benthic animals.

3. *Neritina granosa*: hihiwai.

This endemic, diadromous mollusc is common in remote streams on the Neighbor Islands but occurs in very few O'ahu streams. Reaching a size of over 5 cm, this mollusc feeds on algae and is usually found in riffle areas having high flow velocities.

4. *Stenogobius genivittatus*: o'opu naniha.

One of the smaller (5-6 cm in length) disdromus native stream gobies, the naniha is widely distributed in Hawaii in mixohaline waters and lower stream reaches. This o'opu is also found in other areas in the tropical Pacific. Omnivorous, naniha eat plant material, plankton, and small invertebrates.

5. *Awaous stamineus*: o'opu nakea.

This endemic, diadromous o'opu is the largest of the native gobies, reaching a maximum length of 30 cm. A small fishery is supported by nakea on the island of Kauai. The nakea is widely distributed on all islands but is found in small numbers on O'ahu. This o'opu is omnivorous, feeding on filamentous algae and benthic animals.

6. *Eleotris sandwicensis*: o'opu okuhe.

This diadromous eleotrid lacks the ventral sucking disk of the true gobies but is similar in appearance and is an ubiquitous endemic with a distribution similar to that of the o'opu naniha. Okuhe may reach a size of 25 cm and is sometimes caught as a food fish. This o'opu is a carnivore, ingesting fish, insects and benthic animals.

7. *Lentipes concolor*: o'opu alamo'o.

Endemic, diadromous and comparatively rare, this Hawaiian goby is currently listed as "Category 1" in the Federal Register, which states that Lentipes "is a comparison taxa for which the Service (USFWS) currently has sufficient information on hand to support the biological appropriateness of proposing to list as endangered or threatened" (Ref. 3). Lentipes are found in only 15% of all Hawaiian streams, and its abundance is frequently low with distribution limited to upstream areas. Although omnivorous, larger Lentipes (to 14 cm) eat more animal material (primarily atyid shrimp and insect larvae), while smaller fishes appear to consume more algal material. Lentipes have not been recently identified in Hanalei Stream.

8. *Kuhlia sandvicensis*: aholehole.

This kuhliid bass is an endemic mixohaline fish that is widely distributed throughout the State. Aholehole may reach 20 cm and, being mostly marine, are a principal predator in stream mouths and estuaries in Hawaii.

9. *Sicyopterus stimpsoni*: o'opu nopili.

The nopili is an endemic, diadromous goby and is the only member of the genus Sicoypterus in Hawaii. Ranging in size up to 13 cm, the nopili is found on all islands in varying abundances. On O'ahu, the nopili has been found only in Kaluanui and Koloa streams in very small numbers. It is adapted for feeding on the epilithic community, primarily algae with microzoan associates.

ESTUARINE SPECIES

Although Hanalei Estuary has not been specifically studied Maciolek and Timbol (Ref. 4) identified 35 species and crustaceans and fish in Kahana Estuary (Table 2). Eleven native species (seven species of fish and four species of crustaceans) were regarded as representative members of the community (Table 3). Five of these species have been previously described in this report as common stream species, demonstrating both the euryphaline nature of these fauna and the importance of the estuarine environment to their diadromous lifestyle. Based on their collections and environmental variations among Hawaiian estuaries, there may be as many as 50 native fish alone which inhabit or visit estuarine environments in the State (Ref. 4). Since only juvenile individuals were collected of the marine species, it is apparent that estuaries serve as an important nursery for marine species and as a critical "acclimation" zone for the diadromous native stream fauna.

PETROCHEMICALS AND AQUATIC ORGANISMS

The terminal 5.5 km of Hanalei River is considered estuarine with a tidally influenced saltwater "wedge" that extends upstream beyond the Route 56 highway bridge (Ref. 5). Depending on stream flow conditions, a layer of freshwater over a meter thick rides on top of this saltwater "wedge" and flows into Hanalei Bay.

The study completed by AECOS (Ref. 1) in April, 1989, determined the expected levels of soluble petrochemicals to be introduced by the proposed excursion boat staging operation. During moderate flow, a number of samples were collected under test conditions believed by the authors to be worse than those expected to be experienced by the environment during peak commercial operations. The following summarizes the results of this study: 1) from undetectable levels prior to the test, the highest concentration of soluble petrochemicals found during the test was 0.172 ppm; 2) one hour following the test, nondetectable soluble petrochemicals were found; and 30 there was no movement of soluble petrochemicals upstream from the test site.

As mentioned in the AECOS report considerable attention has been paid to the toxic effects of crude oil on aquatic species with very little attention paid to determining the actual component responsible for the toxic effect. The results of a number of studies relating the accumulation of hydrocarbons and outboard motors were included in their report (see Discussion, pp. 13-16). A recent study (Ref. 6) determined that a freshwater carp, *Puntius sophore*, experienced an immediate decrease in respiration rate and metabolism following exposure to a concentration of 200 ppm of crude oil. Interestingly, respiration increased after a five day period had elapsed. The author inferred that a formation of coagulated mucus film over the gills and body surface caused by the action of crude oil was the cause of fish mortality when exposed to concentration levels greater than 1,000 ppm. The author also states that his results differed from previous studies which determined an increase of metabolism due to petroleum hydrocarbons (Ref. 7,8). M.S. Prased then offered the explanation that crude oil consists of many components besides hydrocarbons which may demonstrate individual effects and explain the differences in results.

Montagne, et. al., 1987 (Ref. 9), reported on the productivity of marine communities as a function of proximity to a natural coastal petroleum seep. Their findings demonstrated a marked increase in productivity the closer the community was to the petroleum seep. The crude oil served as a source of carbon available to sediment bacteria which then provided microbial carbon for benthic invertebrates and thus other macrofauna.

There are many contradictory studies relating the effects of crude oil on aquatic fauna. Because of this, it is important to determine the active toxic agents for adverse acute or chronic effects on aquatic fauna when dealing with petroleum products.

Although, as a group, petrochemicals are not very soluble in water, the small percentages of soluble petrochemicals are considered relatively toxic (Ref. 1). Dange and Masureka (Ref. 10), determined the acute toxicity levels (LC_{50}) of 6 soluble petrochemical hydrocarbons, namely cyclohexane, benzene, toluene, phenol, xylene and napthalene, for the crescent perch, *Therapon janbua* and the inflated clam, *Katelysia opina* (Gmelin), both estuarine animals. These researchers found napthalene to be the most toxic hydrocarbon component, producing 50% mortality in the fish at concentrations of 22.5 ppm. The clam proved to be less affected, as its LC_{50} value for napthalene was 77 ppm. Following napthalene, the toxicities of the other hydrocarbons (in decreasing order of toxicity) are phenol, benzene, xylene, toluene and cyclohexene. The fish was found to be significantly more sensitive to the presence of hydrocarbons than the clam.

One study was identified which researched the chronic effect of crude oil on a marine fish, the Atlantic cod, *Gadus morhua* (Ref. 11). Fish were exposed for periods of 3 to 21 weeks, to concentrations ranging from 12 to 500 ppm. No mortality occurred but food consumption was reduced in oil treated cod. Enlarged gall bladders and a reduced rate of gametogenesis in male cod were also found. Feeding, growth and reproduction in male cod are biologically important variables affected by chronic exposure to petroleum. However, again there was no indication of the active, toxic component in the crude oil used.

COMMENTS

The soluble hydrocarbons found in petroleum is the principal concern of this project, both from the standpoint of what will be introduced to the estuary from boat exhaust and the associated toxicity levels. These components are also the most quickly lost from the aquatic environment through evaporation, photochemical oxidation, microbial degradation and dilution, dispersion, and emulsification (Ref. 1). Stream flow in particular would play a dominant role of dispersing any petrochemicals introduced near the mouth of the Hanalei River that were not quickly evaporated. Although the residence time of freshwater in the terminal reaches of the estuary have not been determined, it is probable that even during low flow and high tide conditions the residence time would be less that 1 hour. This suggestion is supported by the lack of detectable concentrations of petrochemicals found one hour following the AECOS study test.

Chronic effects of the soluble petrochemicals are probably not a major concern in this situation. Long-term, repeated exposure of native aquatic fauna to petrochemicals is doubtful, even following an extended period of scheduled boat operation. At least three principal arguments support this view; the motile native species tend to avoid areas of stream disturbance (motor running and boat loading activities, for instance), the location of benthic species in the underlying saline water level will probably not be exposed to the soluble petrochemicals because of their density and low solubility of these petrochemicals in sea water, and, finally, the relatively short residence time in the lower estuary of many of the diadromous native stream fauna.

Currently, no information is available on the sensitivity to petrochemicals of Hawaii's native stream and estuarine species. It is reasonable to believe that they are at least as sensitive as the estuarine species used in the Dange and Masureka study (Ref. 9). To reach concentrations nearing the acute toxicity level reported by these authors would require an increase of over two orders of magnitude from the concentrations recorded in Hanalei Estuary during the AECOS test. Baring a severe change in the residence time of freshwater in the estuary or the occurrence of a major petrochemical spill, this seems an unlikely possibility.

From an environmental standpoint, two suggestions regarding the proposed boat operations appear reasonable. First, no refueling of tour boats should occur within the estuary itself. The boats should be refueled on land in the base yard (or elsewhere) to insure that appropriate safety precautions can be used to prevent the accidental introduction of petrochemicals to the estuary. Secondly, it would be ideal to institute a program of periodic collection of estuarine fauna in Hanalei for bioassay to monitor any change in uptake of petrochemicals. This would provide important information to improve our understanding of the effects of boating activity on native species in the Hawaiian estuarine environment.

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TABLE 1

List of conspicuous native invertebrates and fishes commonly found in streams in the Hawaiian Islands.

Scientific Name	Local Name	Origin[1]
Crustaceans		
Atydoida bisulcata *	o'pae kala'ole	endemic
Macrobrachium grandimanus *	o'pae o'eha'a	endemic
Molluscs		
Melanoides sp.	pond snail	indigenous
Neritina granosa *	hihiwai	endemic
Fishes		
Awaous stamineus *	o'opu nakea	endemic
Eleotris sandwicensis	o'opu okuhe	endemic
Kuhlia sandvicensis	aholehole	endemic
Lentipes concolor *	o'opu alamo'o	endemic
Sicyopterus stimpsoni *	o'opu nopili	endemic
Stenogobius genivittatus *	o'opu naniha	indigenous

1 endemic - found naturally in Hawaii only
indigenous - found naturally in Hawaii and elsewhere

* diadromous species

TABLE 2

List of species identified from Kahana Estuary, Windward O'ahu (Ref. 3).

SCIENTIFIC NAME

CRUSTACEANS

Grapsidae
Metopograpsus thukuhar

Portunidae
Portunus sanguinolentus
Scylla serrata
Thalamita crenata

Palaemonidae
Macrobrachium grandimus
Macrobrachium lar
Macrobrachium rosenbergii
Palaemon debilis
Palaemon pacificus
Palaemon sp.

Penaeidae
Penaeus marginatus

FISHES

Acanthuridae
Acanthurus triostegus

Albulidae
Albula vulpes

Apogonidae
Apogon brachygrammus

Bothidae
Bothus Pathernus

Carangidae
Caranx sp.
Seriola dumerill (?)

Diodontidae
Diodon holocanthus

FISHES cont.

Eleotride
Eleotris sandwicensis

Fistulariidae
Fistularia commeersoni

Goblidae
Awaous stamineus
Bathygobius fuscus
Oxyurichthys lonchotus
Stenogobius fuscus
Vitraria clarescens

Kuhlidae
Kuhlia sanvicensis

Muglidae
Chelon engeli (?)
Mugil cephalus

Poeciliidae
Poecilia reticulata
Xiphophorous helleri

Serranidae
Ephinephelus sp.

Sphyraenidae
Sphyraena barracuda

Synodontidae
Saurida gracilis

Tetraodontidae
Aronthron hispisdus

TABLE 3

Species of conspicuous invertebrates and fishes found to be representative of the Kahana Estuary community (Ref. 3).

SCIENTIFIC NAME	
CRUSTACEANS	FISH
Grapsidae	*Eleotridae*
Metopograpsus thukukar	*Elotris sandwicensis*
Portunidae	*Gobiidae*
Scylla serrata	*Stenogobius genivittatus*
Thalamita crenata	*Oxyurichthys lonchotus*
Palaemonidae	*Kuhliidae*
Macrobrachium grandimanus	*Kuhlia sandvicensis*
Palaemon debilis	
	Mugilidae
	Chelon engeli (?)
	Mugil cephalus
	Sphyraenidae
	Syphraena barracuda
	Synodontidae
	Saurida gracilis