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Technical Report 74

Resources of the Marine waters of Kaloko-Honokohau National Historical Park

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Abstract

Marine resources of Kaloko-Honokohau National Historical Park in the North Kona District of west Hawaii Island were qualitatively surveyed from the high intertidal to a depth of about 200 ft. The survey extended from Wawahiwaa Point ("Pine Trees") at the north to Noio Point at the south. Intertidal habitat types included exposed basalt bench, exposed low cliff, rock and rubble shore, and sandy beach. Distribution and abundance of intertidal invertebrate macrofauna throughout these habitats are described from walking surveys along the intertidal area of the park. Visual underwater surveys continued subtidally by snorkel and SCUBA diving. Nine major subtidal habitat zones were defined. Of these the most extensive were: an expansive boulder-strewn basalt pavement area (25-45 ft. deep), a coral-covered slope (60-100 ft. deep), a basalt cliff (45-90 ft. deep), and an abrupt underwater cliff of 5-25 ft. along much of the shoreline. Descriptions of the fish communities and the invertebrate fauna are presented. Management alternatives for marine resource preservation and visitor use of the park are discussed. These include comments on threatened and endangered species, boat traffic, visitor water recreation and fishing.

Introduction

Kaloko-Honokohau National Historical Park is currently being established on the coast of West Hawaii. The primary objectives of park management are to preserve the cultural and anthropological resources within the park and to preserve and enhance the other natural resources that fall within park jurisdiction (National Park Service 1988a). A narrow strip of coastal waters is included within the park boundaries. This report describes the physical and biological components of that offshore region, based primarily on field surveys by scientists of the Hawaii Cooperative Fishery Research Unit. This information has been accumulated and presented as an aid to park planning and decision making (National Park Service 1988b). Elements of special interest to management are described, and management implications and recommendations are discussed.

There is little scientific literature or other written source of information on the biology and marine environment of park waters specifically. However, a reasonable literature on other West Hawaii marine coastal environments exists. General descriptions and maps of the physiography, marine fauna and resource utilization of the west Hawaii Island coast are found in Cheney (1981) and Nolan and Cheney (1981). Brock and Brock (1974) inventoried fish and invertebrate communtities of the Kona shoreline. The ecology of nearshore marine communities of west Hawaii Island is addressed in Doty (1968, 1969), Kimmerer and Durban (1975), Cheney *et al.* (1977), and Kay *et al.* (1977). Quantitative reef fish census data are available for 2 areas within several kilometers of the KAHO park boundaries: the Old Kona Airport area (Division of Aquatic Resources 1978) and the "Pine Trees" or Wawahiwaa Point area (Nolan 1978).

The Puako region of the South Kohala district has been the focus of several marine resource surveys (Kay *et al.* 1977; Division of Aquatic Resources 1978). Puako has been considered for a marine conservation district site (Kimmerer and Durban 1975). In addition, the nearshore reef environments, fishery and fish ecology of Puako were described in Hayes *et al.* (1982). These reports include quantitative surveys of fish and invertebrates as well as general habitat descriptions.

The fish fauna, invertebrate community, nutrient regime and hydrographic features of Honokohau boat harbor have received long-term attention (Bienfang 1980; Bienfang and Johnson 1980; Brock 1980; U. S. Army Corps of Engineers 1983). The harbor is adjacent to but not within the geographic boundaries of this study (see below). Recently, there has been much commercial development along the West Hawaii shoreline. Often environmental studies which accompany developments address potential impacts to nearby marine resources, and in some cases mitigation measures are proposed (e.g., Belt, Collins, Ltd. 1975; AECOS, Inc. 1980; U. S. Army Corps of Engineers 1988).

At present the park consists of 2 disjunct parcels separated by private land. Although the current northernmost and southernmost boundaries of the fast land of the total (2-part) park seem well established on shore, it seems that lands south of Honohokau Harbor may eventually become part of the park or fall under some form of park jurisdiction. Some arrangement is being negotiated with State authorities regarding management of waters (including the intertidal) along a strip of shoreline north and south of the present extreme boundaries of the park.

Foresight requires a survey of the greater potential park waters. For purposes of this study, the area surveyed and referred to as "park waters" was bordered on the landward side roughly by the high tide mark between the tip of Wawahiwaa Point and a point about half way out on the north side of Noio Point; it was bounded on the seaward side by a straight line connecting these locations on these 2 geographic features (Wawahiwaa Point and Noio Point)(see Fig. 1). No areas within these boundaries were excluded from survey, regardless of current jurisdiction, except that (1) the intertidal in the short length of shoreline from Maliu Point southward across the harbor channel was not examined in detail, (2) Honokohau boat harbor was not surveyed at all, and (3) the subtidal area directly in the harbor channel approach was not viewed carefully in the water because of hazards from boat traffic. As convenient points of geographic reference in this report, (1) the northern "shore boundary of the park" is used (currently marked by a blue paint mark on supratidal lavas); (2) the southern "shore boundary of the park" is the location referred to above on Noio Point (Fig. 1).

Methods

The area surveyed in this assessment is described in the Introduction. Depths encountered within the park ranged from 0 to 150 ft. All surveys were conducted by field teams of 2 to 4 marine biologists during field trips of 2 to 5 days duration. A total of 6 such efforts were made from 1 October 1988 through 4 December 1988. All work was conducted during daylight hours during a variety of tide states. Intertidal work was conducted mostly during the hours of lower tides.

A reconnaissance of shoreline features was conducted on foot along the entire park shoreline. Major landmarks were noted, as well as prominent terrestrial vegetation and substrates. Distances between some landmarks were measured in order to provide ground truth measurements for map construction. Several "permanent" features on shore were used consistently as compass bearing markers from offshore locations to help pinpoint marine habitats and boundaries on the map. Although an inventory of avifauna was not an objective of this study, when endangered Hawaiian stilt were observed at the shoreline, their approximate numbers and location were noted.

During the shoreline reconnaissance, the intertidal zone was surveyed for major biota and substrate types. The general distribution and some indication of abundance of dominant animals were noted, and some specimens were collected to confirm identifications. Although not a major focus of this study - the marine flora is dealt with fully in a separate study for NPS - dominant algae were noted and collected and their general abundance recorded to facilitate matching habitats between the two studies.

The bulk of the survey work presented in this report was conducted in the subtidal zone within the park boundary, offshore to a depth of approximately 150 ft. All surveys were conducted using either snorkel or SCUBA gear. Shallow habitats close to shore were accessed from shore (mostly snorkeling), and deeper, offshore habitats were accessed from a small (13-ft.) Boston Whaler using SCUBA. Characteristics used to describe habitats were depth, general topography, substrate type, and major surface structural features, as well as dominant sessile (e.g., coral) communities present. Habitat boundaries were established visually by viewing from the surface, either swimming free or towed by boat.

In order to adequately characterize the large areas of complex subtidal habitats at KAHO, long tracks were swum within each habitat throughout the entire park. Inventories of all subtidal algae and animals were made visually underwater (recording on waterproof paper), with enough surveys conducted within each habitat to insure a high degree of coverage. This method provides less quantitative results than sampling with small, well defined transects, however the greater areal coverage provided by our semi-quantitative methods made it preferable for the requirements of this study.

Rough, semiquantitative estimates of relative abundance for fishes and mobile macroinvertebrates were made and noted in the field using descriptive terms as follows: (1) "abundant" indicates species that dominated a particular habitat, and were usually several times more numerous than most other species present. The number of individuals of "abundant" species seen in a survey was typically greater than 30. In some surveys, the total numbers for certain species were reported. Absolute numbers, however provide only a general guide in these estimates, since areas covered and time spent during different surveys varied greatly. "Common" species were those that were somewhat fewer in numbers than abundant species, however they were consistently conspicuous within a habitat (usually from 10 to 30 individuals per survey). "Few" indicates taxa that typically numbered less than 10 throughout an entire survey. "Present" refers to animals that were seen within a habitat, however no estimate of relative abundance was made. (Usually only a few individuals occurred per survey).

Divers visually assessed the relative abundance of sessile invertebrates and benthic macroalgae, roughly estimating the total coverage of each taxon as a percentage of the entire area surveyed. In some instances, the descriptive terms used above for fishes and mobile macroinvertebrates were applied to these taxa.

Animals are identified in this report by scientific name, traditional Hawaiian names, and/or other common names. Appendix C contains a glossary for these 3 naming systems, together with some major sources for the nomenclature.

Since all census work was conducted using visual methods, cryptic species are undoubtedly underrepresented. These groups were especially difficult to observe during snorkel surveys. The length of all surveys varied greatly, however an attempt was made to cover each habitat equally, spending more time in larger habitats, and less time in smaller zones. Observations made in this study represent conditions during a relatively short period of time. Extensive, long-term studies elsewhere on the West Hawaii coast (e.g., Hayes *et al.* 1982), however, suggest that seasonal differences in the major resources we surveyed are not sufficiently large to require long-term sampling for the purposes of this assessment.

During the study, it became apparent that the threatened green sea turtle was a conspicuous component of the subtidal marine environment in the park. Special effort was made to record all sightings of these animals and determine the extent of their major resting habitat. Further discussion of census methods for turtles is presented in the Green Sea Turtles section.

Since the anthropology of the area that the park encompasses is of great interest, special effort was also made to identify any underwater structures or articles that might in any way be construed as being of human origin (e.g., fishpond walls, fishing artifacts).

The ancient Hawaiians used a wide range of marine animals extensively for survival and for cultural purposes. Major uses included food, bait, tools, ornaments, and medical remedies. Certain marine animals were of religious and other cultural significance, and were sometimes used in religious ceremonies and sorcery, or were believed to bring good or bad luck. Sea creatures appeared prominently in ancient songs, prayers, chants and legends. A good many marine animals have significant use for the modern population of Hawaii. For the fauna observed in park waters, we used major literature sources and personal knowledge to produce a brief summary of their modern and traditional uses and significance (Appendix C).

Results & Discussion

Shoreline And Intertidal Environment

General Geographic Description

Most of the park shoreline consists of a bench of pahoehoe lava, ranging in width from a few feet to about 200 ft., bordered on the seaward edge by a fairly steep cliff or step, ranging in height from about 1 ft. to nearly 20 ft. (Figure 1). The tidal excursion is small, and the water level typically ranges 1-2 ft. above or below the edge of the cliff. In several places, particularly where the cliff is missing, a jumble of basalt boulders or large cobbles marks the water line, and in a few places (Beaches A, B, C and D, Figure 2), the basalt surface slopes rather smoothly and a sand berm extends into the intertidal. Elsewhere the berm often continues alongshore, landward of the exposed basalt bench or boulders. Along much of the shore, where sufficient sand has accumulated in this supratidal zone, a narrow band of high bushes or

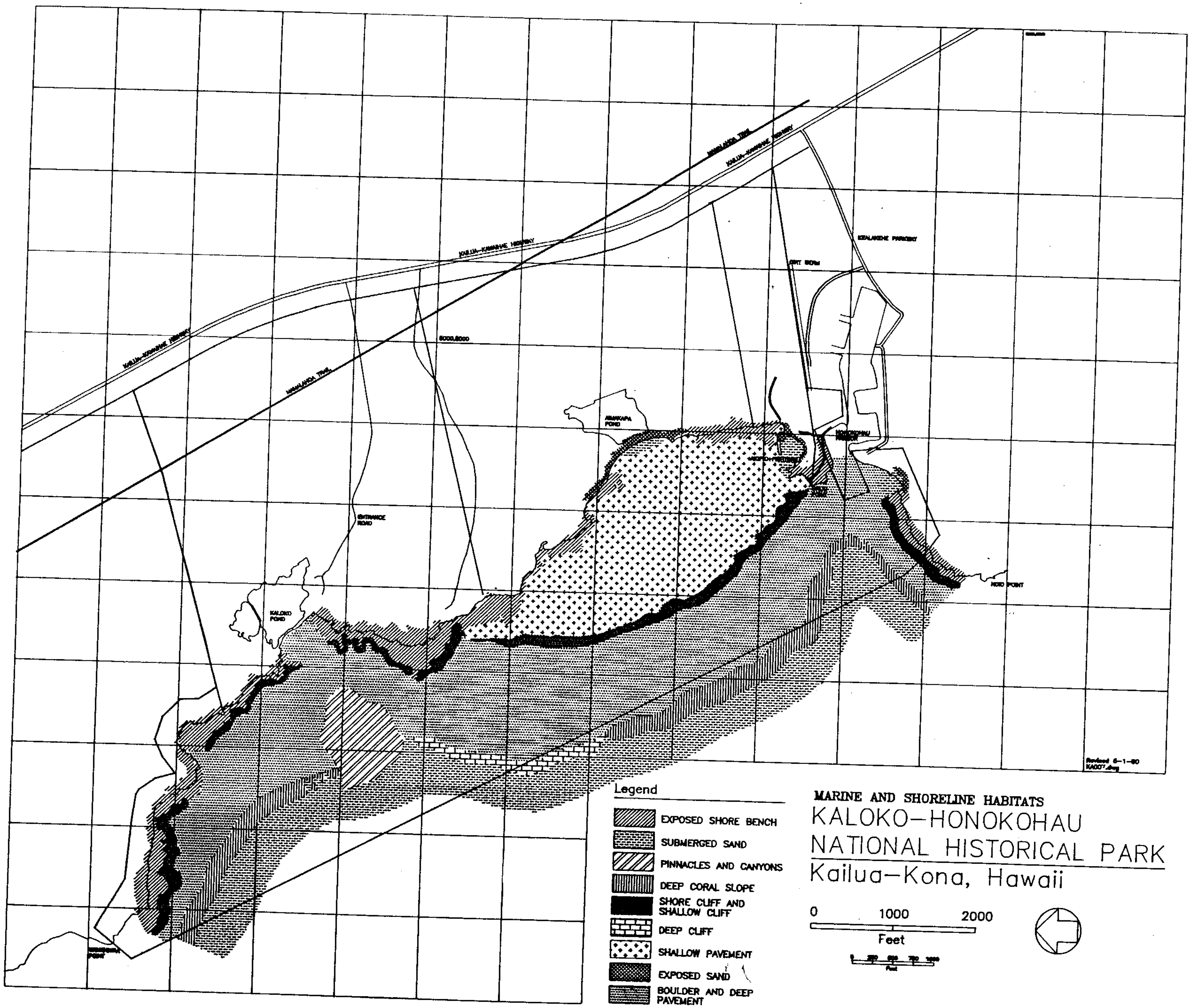
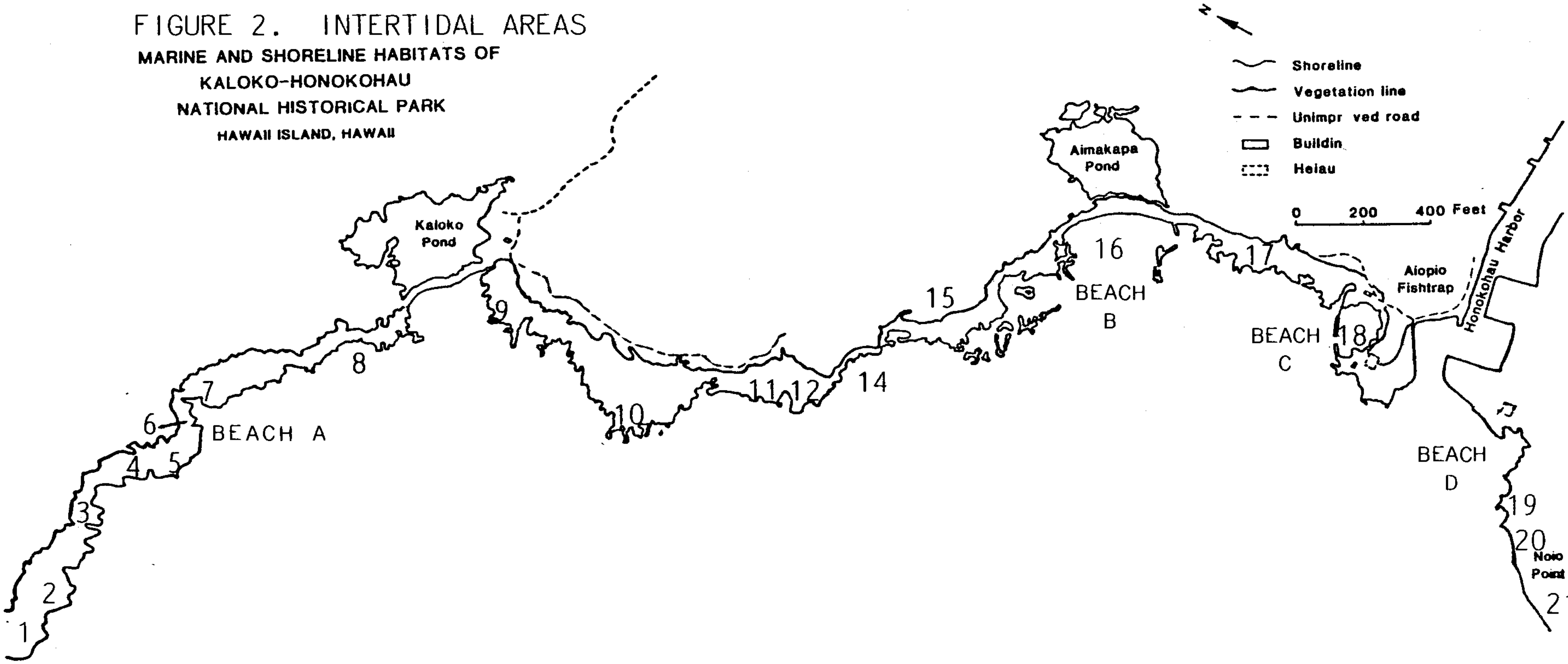

ENTRANCE ROAD
KALOKO POND
Legend
EXPOSED SHORE BENCH
SUBMERGED SAND
PINNACLES AND CANYONS
DEEP CORAL SLOPE
SHORE CLIFF AND SHALLOW CLIFF
DEEP CLIFF
SHALLOW PAVEMENT
EXPOSED SAND
BOULDER AND DEEP PAVEMENT
MARINE AND SHORELINE HABITATS
KALOKO–HONOKOHAU
NATIONAL HISTORICAL PARK
Kailua–Kona, Hawaii
0
1000
2000
Feet

FIGURE 2. INTERTIDAL AREAS

MARINE AND SHORELINE HABITATS OF
KALOKO-HONOKOHAU
NATIONAL HISTORICAL PARK
HAWAII ISLAND, HAWAII



low trees such as naupaka (*Scaevola taccada*) provides a screen between the immediate shoreline and the lava flows that extend inland. Small, localized stands of mangroves occur primarily in 2 shore locations: (1) surrounding Kaloko Pond, and (2) along a portion of the boulder shore north of Honokohau Beach (Figure 3, M1 and M2 respectively).

General Physical Characteristics

Except for small, scattered areas of semipermanent tide pools, much of the width of the lava bench is exposed along most of the shoreline during a good part of most days. The area of active water exchange and prime "tide pool" habitat for many organisms is restricted to a narrow band along the immediate outer fringe of the bench. Because of the steepness and wave exposure of the bench at its seaward margin, the environment and biota seaward of the margin rapidly assume a subtidal character. That zone is best studied from underwater and is reported with subtidal results (below).

Where the shore bench is wide and well developed, the basic substrate usually consists of a rather solid and continuous lava flow, although some loose boulders lie on the surface of the bench. The surface often has rough topography, particularly on the high bench in the north and the high sea cliffs in the far south, but it has little general slope seaward until the extreme edge. For about the northern half of the park shoreline (to the southern extent of Kaloko Bay), this high bench is almost continuous except for (1) a short length at Beach A and immediately north and south of it where the intertidal bench step is lower and covered by a jumble of boulders, and (2) the Kaloko Pond boulder wall and its immediate surroundings (see Figure 1, "shore cliff"). Along its full length, the northern, high bench ends at the seaward edge in a steep (often near vertical) drop of at least several feet.

In the transition area between Kaloko and Honokohau bays, the geological cliff feature appears to move gradually offshore and become submerged, roughly marking the seaward margin of Honokohau Bay (Figure 1, "shallow cliff"). From this point southward until it disappears under the sand beach at Aimakapa Pond, the exposed shore bench has a lower step seaward and typically is boulder covered in the intertidal.

The bench width varies greatly, especially south of Kaloko Pond. At some points in the northern portion of Honokohau Bay it is reduced to a narrow slope of large boulders fringing the shore. Smaller cobbles often extend profusely out over the subtidal shallow pavement. A little north of Aimakapa Pond, the boulders end, and a substrate of sand, cobble and pavement mixed in varying proportions extends across the length of Honokohau Beach at or just below the water line (see Beaches section). A little south of Aimakapa Pond, the lava bench resumes. It is wide, well developed, and nearly flat, with its upper surface representing a level near mid tide. The step at its seaward edge is abrupt but low, typically 1 - 3 ft.

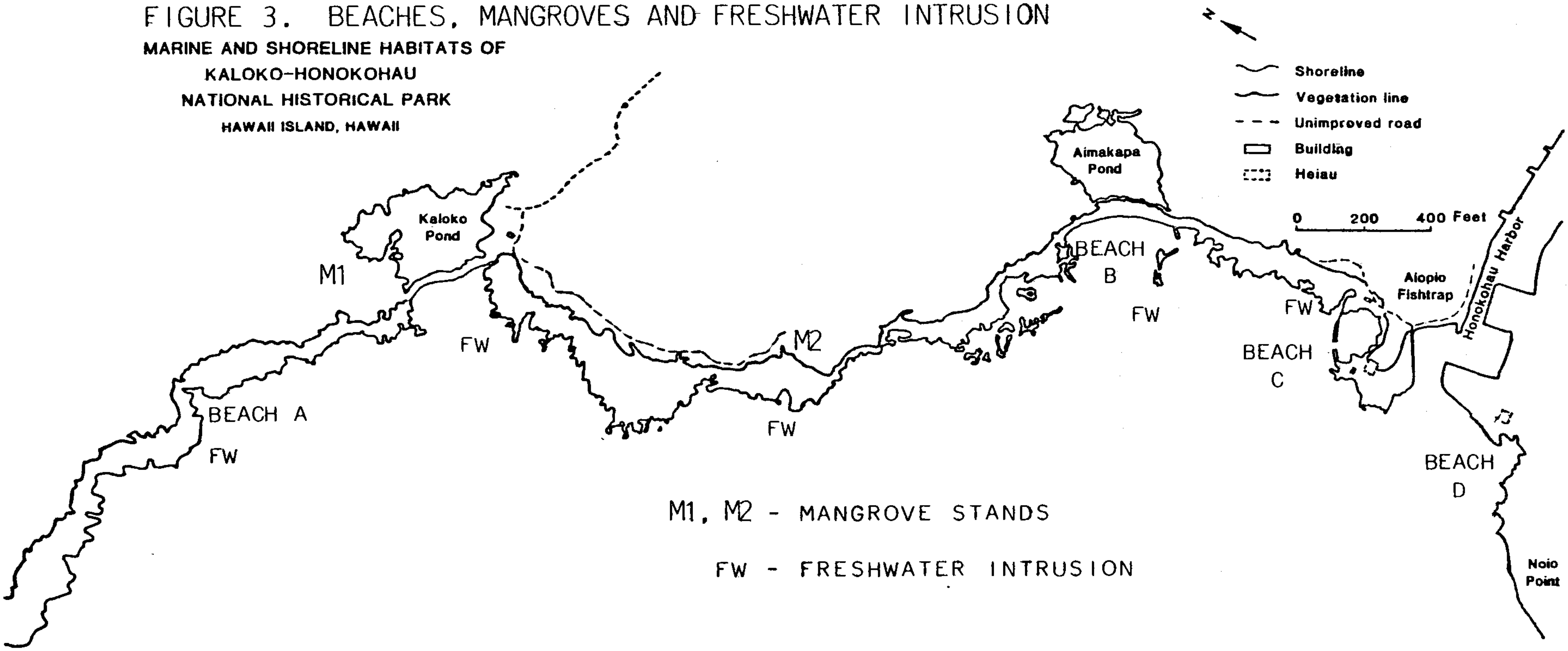
The northern wall of Aiopio fishtrap effectively marks the southern extent of the low bench. A sand slope interrupted by scattered, small protrusions of lava (see Beaches section) extends southward and westward to the rather high, exposed lava ridge at the south end of the trap (Maliu Point). The ridge continues roughly as a lava sea cliff rising several feet above sea level, extending southward (except where cut by the artificial harbor channel), and then moves inland slightly just south of the channel, behind the sand slope of the most southerly beach (Beach D, see Beaches section).

Immediately south of this beach, the bare lava sea cliff rises steeply again and continues along Noio Point to the southern boundary of park waters as a rough, broken, steep-walled, deeply indented cliff, reaching several feet or more above and below sea level. On this highest length of sea cliff, especially the portion on Noio Point, the horizontal extent of the intertidal is extremely compressed (nonexistent in places), and it was often difficult to approach, collect specimens, or even observe portions of it well. Therefore, our data are more limited in these areas. Opportunities for visitors to enjoy the biota of this portion of the shoreline at close range are similarly limited, and hazards to personal safety are somewhat greater. However, the steep, deeply indented shoreline cliffs near the southern park shore boundary are scenically attractive, including a few natural arches or bridges and blowholes.

Exposure to wave and swell action is great along most of the park shoreline under most conditions. The waters inside Aiopio fishtrap are rather well protected by the remnants of the pond's boulder

FIGURE 3. BEACHES, MANGROVES AND FRESHWATER INTRUSION

MARINE AND SHORELINE HABITATS OF
KALOKO-HONOKOHAU
NATIONAL HISTORICAL PARK
HAWAII ISLAND, HAWAII



walls and some natural coastal morphology. Beach D south of the harbor channel receives considerable protection against weather from most quarters. Beach A south of Wawahiwaa Point apparently receives some protection from some quarters, especially from more northerly weather. The inner portion of Honokohau Bay near Aimakapa Pond probably receives somewhat less wave energy than most of the park shoreline. The wide expanse of shallow pavement in the bay causes large swells to begin breaking rather far from shore, and much of the energy may be dissipated by the time the shoreline is reached. The entire coastline lies in the lee of very high mountains, providing protection from prevailing trade winds. However, "kona" weather can produce sizable waves and large swell from exposed western quarters. Despite the occurrence of mangroves in a few places, from the perspective of the marine biota, the entire park shoreline and intertidal must be considered a habitat of high energy.

Most of the consolidated substrate available to intertidal biota is bare lava. Patches of calcareous material are common in the intertidal, usually rather limited in area and widely scattered. Few places were seen with much thickness of accumulated calcareous material; most patches consisted of thin veneers of coralline algae. Their associated fauna was distinctive; the most conspicuous macroanimal, the shingle urchin *Colobocentrotus atratus* rarely occurred elsewhere. Little if any evidence was seen of any thickness of reef structure formed by accumulation of layers of successive scleractinian coral colonies.

There are no perennial surface streams in the park or adjacent coasts, but subsurface freshwater intrusion in the intertidal and shallow subtidal is widespread and (in some locations) massive in West Hawaii (Kay *et al.* 1977, Bienfang 1980). We made few salinity measurements, but the presence of large freshwater outflows could often be seen as separate water masses or detected by lower temperature. No particular effort was made to map the complete distribution of low temperature/salinity areas, but some of the more conspicuous locations are noted on Figure 3 and in the text. In most cases we could only guess at the potential effects of freshwater flow on the intertidal biota. Where observations suggested a specific likely effect, comments appear (below) along with the report of the biota affected.

Distribution of Tide Pools and Other Intertidal Habitats

One of the largest groups of large tide pools along this shoreline is found near the tip of Wawahiwaa Point (Area 1, Figure 2). The bench is wide, rather flat, and not high above sea level. There are tide pools at various distances shoreward. Some extend for rather long distances roughly parallel to shore. Several are interconnected at various heights of tide. Many are fairly directly connected to the open sea; some are more protected from direct exchange. Most of the lava surfaces with more seaward exposure have a coralline algal cover. The southern exposure of the point has a particularly large complex of interconnected pools (Area 2, Figure 2). At the base of the point (Area 3, Figure 2), a stretch of large boulders lines the edge of the bench. Toward the next small point southward, 2 rather large and well defined pools are fairly isolated at mid tide (Area 4, Figure 2) and well stocked with coral and other marine life. The topography of the exposed bench surface is rougher in this area. Near the tip of the small point (Area 5, Figure 2), a natural arch or bridge of some scenic interest occurs in the bench lava, surrounded by an unusually large biomass of long algae growing thickly on the lava. In the corner just at the south end of this point (Area 6, Figure 2) and just north of Beach A, a large white arrow has been painted on the shore bench. Near that point pools on the narrow bench contain sensibly colder water that is nearly fresh to the taste. Obviously much fresh water enters the sea here.

At Beach A, the substrate consists of a sand berm supratidally and a fairly continuous, smooth surface of sloping lava subtidally. Very little sand and very few large boulders are present subtidally. South of the beach, the exposed bench begins again, first fringed by a boulder slope, and farther south, by a steep cliff. This moderately wide, cliff-edged, rough basalt bench continues southward, past the northern shore boundary of the park, to the northern end of the boulder wall of Kaloko Pond. Along most of this length, particularly the northern portion, tide pools are fairly common and mostly small. Most are located close to the shelf edge and directly surface connected to the open sea, although the local topography gives good protection to some. Some smaller pools occur high on the bench, but the intertidal aquatic life zone tends to be generally compressed into a fringe near the edge. In the southern portion of this stretch, larger tide pools occur close to the edge. Several tens of yards north of the final point above the Kaloko Pond wall (Area 8, Figure 2), 2 large linked pools at different elevations occur, both with rich intertidal communities. The wall of Kaloko Pond is a boulder slope that provides intertidal habitat. It is distinctive primarily for the large amount of freshwater outflow and for the large, artificial "tide pool" (Kaloko Pond) which it impounds. Sea water in the tiny cove just outside the wall at the southeast end of the pond is especially cold (fresh). Since the pond is the subject of a separate study, the present project deals only with integration into the intertidal data base of observations on the seaward slope of the wall. The temperature distribution within the inner-to-middle portions of Kaloko Bay suggests that the salinity is greatly lowered by fresh water along all the shore waters opposite Kaloko Pond and for at least a short distance around the point to the north.

In the inner portion of Kaloko Bay, (Area 9, Fig 2), the lava shore bench is topographically generally similar to that just north of the bay, but it has somewhat lower surface relief and some boulders. The intertidal fauna is much reduced compared to the adjacent bench farther south except for abundant neritid gastropods. There appears to be a major freshwater intrusion intertidally about where the bench bends sharply southward. Over the next few hundred yards southward, the bench widens greatly but is otherwise generally similar in form. In this stretch of shoreline, just north and south of the greatest width of bench at Kaloko Point (Area 10, Figure 2), the shore cliff is cut with some of its most spectacular canyons and channels and contains arches and other impressive scenery for underwater viewing. The immediate area of the point seems to receive especially high surge energy. For a stretch of about 150 ft., the outer, exposed edge of the bench supports a strikingly large biomass and diversity of algae. Tide pools are common and often large, especially near the edge of the cliff, but some are found 10 - 30 yards shoreward. Especially large pools occur near the tip of Kaloko Point and some 200 yd. south (near where the shore cliff moves seaward and an intertidal boulder slope develops at the edge of the bench, Area 12, Figure 2). Between these areas the lava bench is moderately wide, relatively flat, and has few boulders (Area 11, Figure 2). One particularly large tide pool occurs. Near where the boulder slope begins, there appears to be a noticeable freshwater intrusion. Continuing southward, the bench narrows further and finally disappears, becoming simply an intertidal boulder slope, with a sand berm shoreward and cobble-strewn pavement subtidally (Area 14, Figure 2). Considerable patchy algal growth occurs on the intertidal boulders as well as on bench lava.

South of the sand berm/subtidal pavement and cobble (Area 15) and the intertidal area of Beach B (Area 16), the long, low bench (Area 17) appears to be covered and exposed by most tides. Its nearly smooth surface and drainage result in relatively few and mostly shallow tide pools. It supports a thick growth of short (broken and grazed) algae over much of its surface. Many sizable broken fragments, apparently from these algal stands, are commonly seen in the adjacent semiprotected waters and on the sand berm. Just subtidally below this low bench, and in Areas 15 and 16, there are sizable areas where fairly large, soft, thin, filamentous algae covers hard substrate, including cobbles. There is significant freshwater intrusion in Area 17 (measured salinity was 15 ppt. in a large pool on the bench); the intrusion apparently decreases to the north in Area 16.

South of Beach C (Area 18), the elevated sea cliff topography is less conducive to tide pools. Very much of the intertidal habitat occurs on near-vertical surfaces subjected to heavy surge action. Even these difficult habitats have considerable patchy areal coverage of calcareous algal veneer (inhabited by *C. atratus*) and some short, erect macroalgae. Within 100 yd. south of Beach D on Noio Point, a small lava shelf occurs near sea level at the base of the sea cliff (Area 19). This shelf contains some of the larger tide pools formed on these southern sea cliffs. Another low elevation, exposed pool occurs in a similar situation a little farther south (Area 20). Still farther south, the sea cliffs are especially steep, rugged and deeply indented, with very few, small tide pools and very limited human access. The most southerly tide pool examined (Area 21) probably lies outside the park shore boundary. It is situated high above sea level near the edge of the cliff. It is fed by high surge from a wave-cut channel more or less perpendicular to the main shoreline and flanked by 2 generally similar channels. It is perhaps the richest area of intertidal biota we were able to observe on Noio Point.

Beaches and their Uses

The park shoreline contains few locations with easy access for swimmers and waders over conventional sandy beach. The only 4 locations with any such amenities are shown in Figure 3. Of these, Beach D near Noio Point is a short walk from a parking area at the south side of Honokohau Harbor entrance. It receives good protection from waves from most quarters. Although small, its boundaries are conspicuous, and it has good water quality and a desirable depth profile. There is a large sandy berm in the supra- and intertidal; subtidally, a rather small area has a fair sand coverage. Depths for more serious swimming are close at hand (but caution is required because of heavy boat traffic through the harbor channel). These characteristics, together with its ease of accessibility, make it a popular family beach for conventional swimming, wading and water play.

Beach C at the old Aiopio fishtrap has considerable sand above and below water and good protection from wave action. However, the beach slope is very gentle, and the restricted circulation and presence of finer sediments leads to usually very poor visibility (often measurable in inches). These characteristics, combined with enough scattered exposed hard bottom to provide a hazard to bare feet, greatly reduce the recreational value of the area. The close proximity to the occupied residences there may also be a disincentive. Despite convenient parking, swimmers and waders are seen there only occasionally.

Beach B at Aimakapa Pond has by far the largest sand berm above water of the 4 park beaches. However, only the small portion of the coast shown in Figure 1 as submerged sand has any significant amount of sandy substrate below water, and only a small portion of that area is uninterrupted by outcroppings of hard substrate hazardous to bare feet. The intertidal and supratidal beach profile is fairly steep, and the small lens of continuous sand gives fairly easy access to a limited water area of swimming depth. However, the area is surrounded by much shallow, hard bottom, and it is not a high quality area for swimming, wading or water play. At present, the extensive supratidal sand berm is rather heavily used for sunbathing. The long walk from the closest parking reduces the potential for use, particularly by families.

Beach A is not shown in Figure 1 as an area of exposed or submerged sand. The area is small and there is in fact little sand accumulation at any level. (A small berm occurs supratidally.) However, the low, exposed shore bench is discontinuous at that point. Instead, the intertidal and immediate subtidal area is a gently sloping pavement of relatively smooth, hard substrate nearly free of large boulders, with some thin sand scattered discontinuously subtidally and more continuously supratidally. The shoreline configuration gives some protection from waves from some quarters. Entry to the water is easy, but the substrate is somewhat hazardous to bare feet, and some width of it must be crossed to reach water of swimming depth. It is a poor beach for most water recreation. It lies beyond the northern boundary of park land, and is reached only by a rather long and difficult walk from Kaloko Pond or a much longer drive by 4-wheel drive vehicle from Keahole Point. Nevertheless, the beach seems to receive some light recreational use.

Intertidal Biological Communities

Sandy Substrates

On submerged beach sand characterized by fairly high wave energy and unstable substrate, suitable habitat for benthic organisms is minimal. Few epibenthic macroorganisms would be expected, and few were seen. We did not sift the sand for burrowing forms. Our results do not allow characterizing the macrofauna there except that diversity and abundance are low. Beaches B and C are surrounded by extensive areas of shallow pavement of rather low animal resource value. Beaches A and D abut stretches of low and high exposed shore bench, respectively, which support relatively rich invertebrate and fish fauna. However, because of the logistics of water access (especially at Beach D), effects of activities at the beaches are likely to be restricted closely to the beaches proper. Recreational wading/swimming/water play at the beaches seems unlikely to produce much environmental impact.

The Intertidal Fauna

Table 1 lists all intertidal and subtidal invertebrate taxa seen and visually identified in the field or collected and identified in the laboratory. Scientific and common names are given (as best the animals could be identified under sometimes difficult conditions), and those that occurred in the intertidal are indicated. Many of these also use a subtidal habitat. The distinction is somewhat arbitrary and is mostly an artifact of methodology. Although we approached the land/water interface as closely as possible from below (diving, snorkeling) and from above (wading), the transition region is difficult to characterize accurately. A number of taxa are therefore shown as both intertidal and subtidal, where both habitats seem to be used significantly. The list is certainly not exhaustive, even for the macrofauna visible for visual census. Some animals are extremely cryptic, active only nocturnally, or rare. However, the list agrees rather well with the fauna expected (see Brock and Brock 1974), and is probably fairly complete for the common macroanimals and adequate to characterize the hard bottom intertidal communities.

There are few, if any, strictly intertidal fish species in Hawaii. However, many subtidal species venture close to the shoreline in shallow water (see subtidal results section) and range up and down the shore profile with the tide. They are easiest to observe when found in tide pools and their connecting, shallow channels.

Tide pools appear to represent major habitat for a number of fishes, including juveniles of subtidal adult species. At KAHO, the following fishes were commonly observed in this habitat: several unidentified gobies (Gobiidae); some blennies (including *Istiblennius zebra*); 3 damselfishes, kupipi (*Abudefduf sordidus*), mamo (*Abudefduf abdominalis*) and the brighteye damselfish (*Plectroglyphidodon imparipennis*); one surgeonfish, the manini (*Acanthurus triostegus*), and the aholehole (*Kuhlia sandvicensis*). Other fishes occasionally seen in tide pools included 3 wrasses (*Thalassoma trilobatum, Halichoeres ornatissimus* and *Stethojulis balteata*), one butterflyfish (*Chaetodon quadrimaculatus*), as well as juvenile u'u or menpachi (squirrelfishes of the genus *Myripristis*), alaihi (squirrelfishes of the subfamily Holocentrinae), and a puhi (muraenid eel). This list is certainly not exhaustive, but it likely characterizes the dominant fish fauna of these limited habitats. Seasonal changes in this fauna corresponding to recruitment pulses of nearby subtidal species are to be expected. Most of these taxa are covered more fully in the section on subtidal results (below).

Distribution, Abundance and Importance

The onshore-offshore distribution of animals in this habitat is discussed in the habitat description above. Table 2 summarizes the overall distribution and abundance of intertidal invertebrate macrofauna within park waters, and indicates how the various taxa were distributed along the shoreline. Where appropriate, it indicates the specific areas where they were found. Figures 1 and 2 are helpful for locating referenced areas.

In many cases relative abundance is presented in broad terms such as "few", "common", or "abundant". The accuracy and precision of the survey methods and the small sample size preclude the use of more quantitative estimates. Where only a few total individuals were seen, there is no reason to believe the taxon does not occur in other areas. A large sample size would likely detect all the taxa more widely; for taxa uncommon in this survey, the specific areas where they were observed may tell little about the actual spatial distribution of their numbers.

Clearly, substrate is an important controlling factor in the distribution of intertidal benthos. For example, few macroinvertebrates occurred in Beaches A, B, C or D (Figure 2 and 3). A few taxa, including a toothed pearl shell (*Isognomon californicum*) and a sea cucumber or loli (*Actinopyga mauritiana*), were abundant at least on Beach A, where sand cover and scour are minimized and more hard substrate is available. Many taxa were restricted primarily to intertidal areas of solid lava bench and were absent or uncommon on boulder slopes predominant in Area 12 and particularly Area 14. Area 15 provides a great length of shoreline with primarily supratidal sand and cobble. There, the lava pavement (cobble covered) is primarily subtidal and is without a steep step or boulder slope. Few intertidal macroinvertebrates are adapted to this less stable habitat with fewer protective cracks, holes and crevices. A number of species were common or abundant on the high lava bench but rare or absent on the low bench of Area 17. For these reasons, notes on distribution of the intertidal fauna (Table 2) often define the distribution in terms of the occurrence of bench or bench surface.

The largest and most conspicuous intertidal animals at KAHO are sea urchins (echinoids), sea cucumbers or loli (holothurians), and sea stars or peapea (asteroids). The last group (all *Linckia* spp.) were few and scattered in the intertidal, and appear to play a minor ecological role and to represent a minor resource for sightseers or collectors. *Linckia* species were more abundant in subtidal areas (see below).

Several species of sea urchins occurred in considerable numbers in the intertidal zone and probably contributed significantly to the intertidal animal biomass. The most abundant species were the shingle urchin or haukeuke kaupali (*Colobocentrotus atratus*) and the pale rock boring urchin or ina kea (*Echinometra mathaei*). The black rock boring urchin or ina eleele (*Echinometra oblonga*), the short-spined urchin or hawae (*Tripneustes gratilla*), and the slate pencil urchin or haukeuke ula ula (*Heterocentrotus mammillatus*) were all common. All these species contribute importantly to the natural scenery of the intertidal, along with the other, less abundant urchins and the holothurians.

The striking red color and appearance of the slate pencil urchin provides some ornamental value for amateur collectors; other sea urchins might also be easily removed from exposed tide pools as curios by visitors. Holothurians are similarly vulnerable to collection, but they are much more abundant than slate pencil urchins and the long spined urchin species, and are much less likely to be desired as curios. There is some present use (and a long tradition of use) of sea urchin eggs and reproductive tissue as food, causing urchin mortality. In most places, the demand is light and the species fished are abundant. Tourists are unlikely to harvest sea urchins for food.

Echinoids have important effects on the ecology of the intertidal community. Rock borers (*E. mathaei* and *E. oblonga*) can burrow up to several inches into the hard substrate, causing significant erosion, modifying the substrate in ways that may affect neighboring animals, and (in places) simply occupying considerable surface area. These effects may be quantitatively significant in portions of the park where the density of *Echinometra* species is high. Burrowing echinoids aggregated especially densely in expanses of continuous lava, often with calcareous covering, just at the seaward edge of the shore bench. However, they also occupied boulder and rubble substrate and inhabited areas much lower in the tidal excursion.

Most sea urchins graze algae by scraping the hard substrate. This continuous feeding activity by many individuals over the limited intertidal area may provide an important control on algal standing stock and may also affect the use of substrate by other benthic organisms. Shingle urchins (*Colobocentrotus atratus*) were particularly abundant in the park, and they graze widely and vigorously. The total area occupied and grazed by *C. atratus* in a midtidal band in some areas was extensive. This species was usually found on wave washed, often vertical substrate which is difficult for shore walkers to reach safely, and the urchin is hard to remove from the surface. The low vulnerability and large population of shingle urchins indicate that they will be little threatened by park visitors.

Of the sea urchins occurring in the intertidal, the 3 species with sharp, breakable, venomous spines are *Diadema paucispinum, Echinothrix diadema* and *Echinothrix calamaris* (collectively called wana in Hawaiian). None was abundant (see Table 2), but where they occurred, all occupied positions in the intertidal where they might injure unwary park visitors in the water. The spines of the ina (*Echinometra oblonga* and *Echinometra mathaei*) are not venomous, and they are slightly less dangerous structurally for causing puncture wounds. However, they can cause injury to bare skin, and the animals sometimes occur in exposed positions in the intertidal during the day. They are much more abundant than the former 3 species at KAHO. The spines of the hawae (*Tripneustes gratilla*) are short and collapsible; those of the haukeuke (*Heterocentrotus mammillatus* and *Colobocentrotus atratus*) are blunt or flattened. These 3 species are unlikely to cause injury.

The total biomass of holothurians or loli (sea cucumbers) in the intertidal may be greater than that of echinoids. The brown-speckled sea cucumber (*Actinopyga mauritiana*) was extremely abundant in total; the black sea cucumber (*Holothuria atra*) was less numerous but still abundant overall. Both were found at all tide levels, from fairly high tide pools to deep subtidal depths. They appeared to occupy almost all substrates, ranging from unbroken sand lenses to calcareous surfaces and lava of all configurations. All the local species apparently feed by browsing widely over these varied substrates and processing large quantities of sand and other unconsolidated material through the gut. They extract organic particles for nutrition and deposit most of the processed material on the substrate as copious pseudofeces. In reworking sediments, they are therefore important geologically. They may also have strong effects on other benthic organisms because of the large areas of substrate affected by their browsing.

Ophiuroids, or brittle stars, are no doubt very much more abundant than our single sighting would suggest. They are almost entirely nocturnal and hide effectively in holes, cracks and crevices by day. They may provide an important food source for some fishes and large invertebrates.

In terms of total biomass and ecological influence, the more abundant and widespread sessile Cnidaria, including corals, may be among the most important benthic animals. The soft coral (octocoral) *Anthelia edmondsoni* is widespread and moderately abundant in portions of the intertidal. Subtidally, it becomes much more important in coverage, and it is the dominant sessile animal in much of the park water area (see below). Its small, short polyps form a thick, fuzzy, lavender-gray or green mat that can be continuous over large areas of substrate. Although it feeds by extracting particles from the passing water, its extensive, dense coverage has profound influence on other benthic organisms. For example, it may prevent the growth of benthic algae, thereby reducing a major food source for many fishes, echinoids and other animals. Within the immediate intertidal, however, its coverage does not dominate. It is also too inconspicuous and unrecognizable to attract the interest of most park visitors.

Palythoa tuberculosa and *Zoanthus* species are related, low growing, mat-forming anthozoan forms (tan/brown and green, respectively) that occupy a small percentage of the total available hard substrate. Their ecological effects are qualitatively somewhat like those of *A. edmondsoni,* but their considerably lower abundance likely gives them less total influence. Their patches are large and colorful enough to attract and interest the observant visitor, but they are unlikely to catch the eye of the casual observer, and they would be unrecognized by most visitors. Subtidally, *P. tuberculosa* in particular is much more quantitatively important (see subtidal results section below).

The most conspicuous and attractive sessile cnidarians are probably the hard corals or koa (Scleractinia). They provide considerable bottom coverage and substrate structure in some deep-water zones of the park (see below). Many visitors will be aware of their ecological roles, including that of structural reef building. In the intertidal at KAHO, they are not a quantitatively important portion of the bottom cover and probably play a negligible structural role even on a time scale of decades or centuries. Potentially they could build a significant structural reef on the basalt base, but with present sea level and environmental conditions, they are apparently ephemeral in the intertidal and probably well into the subtidal. Their upper limits of distribution are relatively low level tide pools and the lower portion of the intertidal where they remain wet.

In the intertidal, the occasional, scattered colonies we observed were low growing (up to about 8 in. high, but mostly much less) and usually small in area (not more than about 12 in. across, even for low, encrusting forms). Where hard corals occur, they modify the substrate drastically and greatly affect its potential use by other organisms (enhance or deter). They produce additional hard substrate area and volume with increased relief and rugosity. They also filter feed from the overlying water. However, their relative scarcity in the intertidal precludes major ecological influences on the intertidal terrain and community.

Corals (even small colonies, if clearly visible) contribute to the scenic value of the intertidal, particularly in a few large tide pools. (The more attractive pools we found also contained a few large urchins and holothurians, some juvenile fishes, and occasional other large colonial groups or individual animals that collectively provide both aesthetic and educational opportunities for visitors.) Only 2 species of hard corals were at all common or large in the park intertidal: the cauliflower coral (*Pocillopora meandrina*) and the lobe coral (*Porites lobata*); the others we observed were so rare and small as to likely be unnoticed without careful scrutiny by a practiced eye. Because they are fairly conspicuous and can be taken without swimming, attractive tide pool colonies (especially *P. meandrina*) may be vulnerable to collection as ornamental curios by visitors.

The spaghetti worm (probably *Lanice conchilega*) is almost never seen exposed. However, it commonly spreads many long white tentacles (2-3 ft. long) from its hiding place within a cavity in the substrate and feeds by passing organic particles along them to its mouth. The tentacles are very conspicuous. Although it was not seen commonly at KAHO, the sight is potentially interesting to visitors concerned with natural history.

Among the molluscs, a few species were widespread and abundant in the intertidal. The bivalve nahawele (*Isognomon californicum*) has a two-part shell that attaches firmly to the substrate (usually in cracks or joints near midtide) by byssus threads. Its occurrence is patchy both on a large scale and locally, but when it is concentrated, many thousands occur packed tightly together. They feed by filtering from the overlying water. Locally the population represents significant biomass, filtering capacity and substrate use.

The most abundant intertidal gastropod molluscs at KAHO were periwinkles, including pipipi (*Nerita picea*) and pipipi kai (*Theodoxus neglectus*), and littorine snails such as pupu kolea (*Littorina pintado*) - probably in that order. Like all gastropods, they have a single integral shell and hold the substrate with a muscular foot. All 3 species live somewhat higher in the intertidal than those discussed below and may survive part of the tidal cycle exposed and externally dry. *L. pintado* lives highest of the three. *N. picea* and *T. neglectus* are superficially similar and apparently co-occur commonly in the KAHO intertidal. These extremely abundant species were not differentiated all along the extensive areas where one or both occurred. However, there were clear indications that *T. neglectus* was more abundant where greater freshwater intrusion occurred, including one very high pool within the tree and bush cover on shore, just south of the end of the access road from Kaloko Pond (about opposite Area 12). It seems that sea water could reach this pool only during high storm tides.

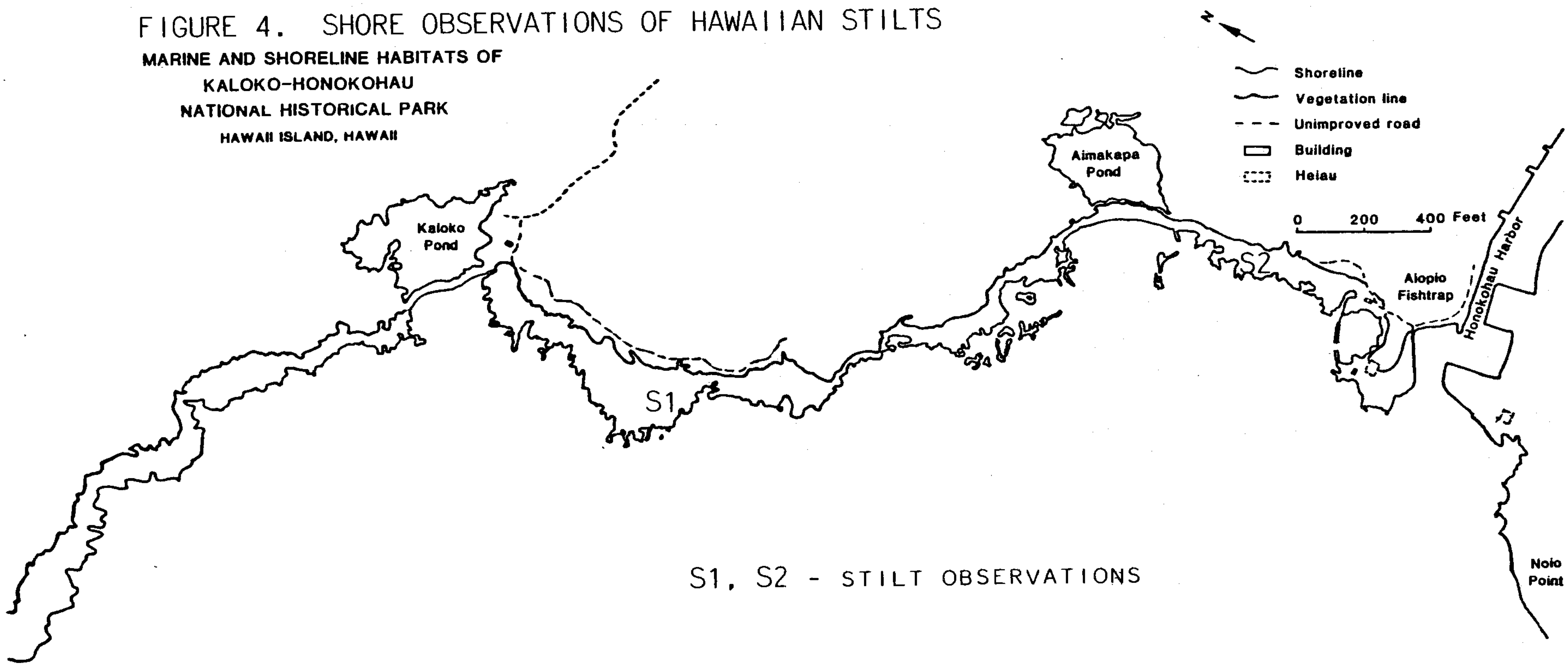
All 3 of these high intertidal gastropods feed by grazing large areas of substrate, scraping off algae with a hard radula. The ecological effects on other benthos of this substrate use by their large populations may be considerable. Pupu kolea and the 2 pipipi (at least) were used as food by ancient Hawaiians. Some limited use as food probably still occurs. Other gastropods that are believed to have had some importance to ancient Hawaiians as foods, ornaments or for other cultural values include the opihi (*Cellana* species), some of the *Cypraea* species (cowries, or leho in Hawaiian), and some of the *Conus* species (cones, i.e., pupu ala or pupu poniuniu in Hawaiian) (see Appendix Table C1). Opihi are still prized as food and are usually harvested to depletion along most of Hawaii's coasts wherever they can be reached. Probably all cowries and cones today have some value to amateur or professional shell collectors. Where they are seen in the intertidal, they enhance the viewing experience, but with many visitors, they may be depleted quickly.

A few other large shelled molluscs such as the rock oyster (*Chama iostoma*) have been (and may now be) taken occasionally for food. None of these molluscs was abundant at KAHO. It seems unlikely that any of them could support harvest or that they are especially sought at present. While any distinctive, attractive shell may be collected as an ornament, no others were seen at KAHO that seem likely to be desired.

Of the crustaceans observed in the KAHO intertidal, only the aama crabs (*Grapsus tenuicrustatus*) were common, large and conspicuous enough to contribute noticeably to the scenery or provide a potential food item. Aama were abundant, moving actively about near the water level (above and below) on most hard substrates with some vertical relief. They were especially abundant on solid lava at cliff edges. They can be easily observed and have some scenic value. Aama were relished by ancient Hawaiians and are still fished often. A number of hermit crabs were common but inconspicuous in the intertidal.

The only waterbird seen in the intertidal habitat at KAHO was the Hawaiian stilt, *Himantopus mexicanus* (=*himantopus*) *knudseni* (Hawaiian name, aeo). Several were observed on 1 occasion in the latter half of the afternoon, apparently feeding on the low lava bench in Area 17, a little north of Aiopio fishtrap (S2, Figure 4). On 3 occasions on another day, several stilts were seen in a tide pool about midway across the high lava bench (S1, Figure 4), south of Kaloko Point (Area 10, Figure 2, near where a makeshift picnic table is located beside the access road). Four of these birds arrived at the shallow pool (about 10 ft. across) about midmorning, about a dozen were in the same pool about 4 P.M., and about

FIGURE 4. SHORE OBSERVATIONS OF HAWAIIAN STILTS



S1, S2 - STILT OBSERVATIONS

25 were in or near it about 5:30 P.M. The observations on this day suggest frequent use of particular sites by these birds. Aimakapa Pond, which is very close to the shoreline at Honokohau Bay, is a major habitat for several species of waterbirds. Other inland habitat for waterbirds may also occur in the park. The ecology of these systems is the subject of separate report(s).

Subtidal Habitats And Communities

We used the physical and biological results from our SCUBA and snorkel surveys to identify 9 subtidal habitat zones, based on differences and similarities among substrate types, topography and animal communities (Figure 1). The name applied to each habitat zone reflects the dominant bottom type present in the area. Shallow water habitats include the Shallow Sand zone, the Shallow Pavement zone, the Shore Cliff zone and the Shallow Cliff zone. These habitats were similar in their exposure to surge and wave action, heavy freshwater intrusion (from subsurface groundwater) and frequently turbid water. Deeper habitats are the Deep Cliff zone, the Deep Coral Slope zone, the Pinnacles and Canyons zone and the Deep Sand zone. These habitats are characterized by low surge, little freshwater intrusion, and clear, calm water with currents of low to moderate strength. The Boulder and Deep Pavement zone is a transition zone from shallow to deeper waters and is subject to a wide range of effects from surge, currents, and freshwater input.

Shallow Sand Habitat

Limited areas of shallow sand were found near the sandy supratidal beaches within the park. There is less subtidal sand than might be expected given the large sand berms of Honokohau Beach (Beach B) and Noio Cove (Beach D). The Shallow Sand zone accounts for the smallest area of habitat in the survey. This habitat ranges from 0 to 6 ft. deep, is mostly flat, and is adjacent to the Shallow Pavement zone in the 3 places where shallow sand is found. Exposure to waves and ocean swell is minimal. The Shallow Sand habitat near Honokohau beach and Noio cove received moderate waves (1 to 2 ft.) on the roughest day observed, while the area within Aiopio fishtrap was well protected from swell by the manmade wall. Freshwater influence was noticeable subtidally, especially at Honokohau beach and Aiopio fishtrap. Visibility was low in all 3 locations, due to the influx and dilution of fresh water and a higher average turbidity than in other habitats.

The subtidal Shallow Sand habitat was inhabited by the black sea cucumber (*Holothuria atra*), the brown-speckled sea cucumber (*Actinopyga mauritiana*), and few other epibenthic macroanimals. (Appendix Table A1). Observations of other sessile and mobile invertebrates were primarily made along the margins of the sand where rocky rubble and pavement provided suitable hard substrate for urchins, corals and other anthozoans.

The ichthyofauna of the Shallow Sand habitat was characterized by a low diversity (only 29 species observed) and depauperate populations (Appendix Table B1). Only the maiii (*Acanthurus nigrofuscus*) was termed "abundant". Maiii were also abundant or common in most other habitats surveyed, and can be considered ubiquitous in park waters (especially in shallow areas). Small, juvenile pualu (*Acanthurus blochii*) were considered common in this habitat as well. None of the species observed in this zone was found exclusively in this habitat.

Shallow Pavement Habitat

A broad expanse of shallow, mostly flat, pahoehoe basalt occurs just offshore from Honokohau Beach. This habitat is extensive, occupying most of the shallow area of Honokohau Bay, and accounts for a large percentage of the overall subtidal habitat in park waters. Most of the Shallow Pavement zone is characterized by a remarkably flat or gently rolling pahoehoe substrate. Areas close to the beach typically have cobble and rubble overlying the pavement in localized areas. Along the seaward boundaries of this habitat, the pahoehoe is heavily fractured and heaved, forming potholes, crevices and low escarpments. Much of the basalt substrate is covered by a thin veneer of limestone.

Exposure to waves and swell is high throughout this area. During our survey, small waves (about 1 ft.) were constant at the northern offshore edge of the pavement zone, and breakers increased in size to the south, offshore of Honokohau Beach. Groundwater intrusion in the Shallow Pavement zone was heavy, and this, combined with wave-induced turbidity, caused low visibility (5-15 ft.) during our survey. This likely represents common conditions within the habitat.

The pale lavender octocoral (*Anthelia edmondsoni*) covered a high percentage of the substrate in the Shallow Pavement zone (50-90%), especially in the south and near the shore (Appendix Table A2). *A. edmondsoni* was considered an indicator of freshwater intrusion by Brock and Brock (1974). (However, it was common in the deepest areas far offshore at KAHO, where little freshwater intrusion likely occurs.) Patches of the colonial zoanthid mat *Palythoa tuberculosa* were common but never abundant.

Localized areas of rich hard coral growth were found in the north central region of the Shallow Pavement zone, near the area of greatest wave activity. These areas of relatively heavy coral growth (10-80% coverage) were dominated by small to large mounds (0.5-3 ft. across) of lobe coral (*Porites lobata*). Small heads of cauliflower coral (*Pocillopora meandrina*) were common in the coral rich areas, and less so outside them.

Relative abundance of urchins was high throughout the shallow pavement habitat. The short spined urchin (*Tripneustes gratilla*) was common to abundant and the pale rock boring urchin (*Echinometra mathaei*) was common on suitable substrate (primarily carbonate-capped basalt). Of the sea stars, only *Linckia* species (*Linckia multifora* or *Linckia diplax*) were present. No crown-of- thorns sea stars (*Acanthaster planci*) were reported from this habitat. Sea cucumber populations varied widely within this habitat. The speckled sea cucumber was common to abundant and the black sea cucumber was present to common.

The heterogeneous physical nature of the Shallow Pavement habitat is reflected in its relatively diverse fish fauna. A total of 79 species were sighted in the zone, many of which were abundant or common. Generally the bottom was bare, with occasional crevices, potholes and areas of low coral and rock relief. It was in association with these structures that most fish were observed. As a result, many species listed in Appendix Table B2 were considered locally abundant and may be shown in only a few surveys. Such was the case with 2 butterflyfishes or lauhau (*Chaetodon auriga* and *C. lunula*); 1 damselfish, the mamo (*Abudefduf abdominalis*); 3 three wrasses, akilolo (*Gomphosus varius*), ohua (*Stethojulis balteata*),and hinalea lauwili (*Thalassoma duperrey*); juvenile parrotfishes or uhu (*Scarus* species); the fang blenny (*Plagiotremus* sp.); several surgeonfishes, maiko (*Acanthurus leucopareius*), maiii (*A. nigrofuscus*), manini (*A. triostegus*), and lauipala or yellow tang (*Zebrasoma flavescens*); and the moorish idol or kihikihi (*Zanclus cornutus*).

Few species were found distributed over large areas within this habitat. Those that were, typically exhibit a life history adapted to substrates with little vertical relief or cover. Humuhumunukunukuapuaa (*Rhinecanthus rectangulus*) were found somewhat evenly distributed over these areas, in association with defended shelter holes. Other species that were found consistently on relatively featureless substrate were the brighteye damselfish (*Plectroglyphidodon imparipennis*) and the Pacific gregory (*Stegastes fasciolatus*). Both of these are small, territorial herbivores which defend a well defined area, often on hard, flat substrate with little relief.

The Shallow Pavement zone also contained a relatively large number of juvenile fishes, especially the wrasses. It seems the low cover which characterizes this habitat provides adequate protection for these smaller forms, while it discourages large predators that may require greater refuge size and structure.

Shore Cliff

The Shore Cliff forms the seaward limit of the lava shoreline bench. The cliff consists of a nearly vertical, fractured basalt wall with many crevices. For most of its length, the cliff base is 10 - 20 ft. deep and is strewn with rounded boulders (1-8 ft. across). The Shore Cliff zone is bounded by the Boulder and Deep Pavement habitat along its entire length. Shore cliff at Kaloko Point and Noio Point is exposed to the heaviest action from ocean swell of any habitat within the park. Turbulence from ocean swell and waves is felt from the surface, where it is often violent, to the base of the cliff, where it is often pronounced. Freshwater intrusion is moderate to heavy along the entire Shore Cliff habitat. Effects of dilution (reduced visibility and markedly colder temperatures) were detected in the middle and northern region of the zone.

Abundant coverage by the sessile invertebrate *Palythoa tuberculosa* was found, especially in the northern region (up to 80% coverage), and *Anthelia edmondsoni* commonly covered up to 30% of the substrate (Appendix Table A3). Lobe coral (*Porites lobata*) was common on both the face and the base of the cliff, as was cauliflower coral (*Pocillopora meandrina*), which frequently formed heads on the cliff face. Rice coral (*Pocillopora damicornis*) was present on the cliff, although never common. The crown-of-thorns (*Acanthaster planci*) and *Linckia* sea stars were seen along the Shore Cliff, including the greatest concentrations of crown-of-thorns sea stars observed during this study. Bandana shrimp (*Stenopus hispidus*) were present, as were spiny lobster (*Panulirus penicillatus*).

The fish fauna of the Shore Cliff habitat was characterized by a great diversity and abundance of surgeonfishes (family Acanthuridae). Eighteen of the 20 surgeonfishes present in the park were recorded along the shore cliff, and most were common or abundant there (Appendix Table B3). Most abundant were pakuikui (*Acanthurus achilles*), api (*A. guttatus*), maikoiko (*Acanthurus leucopareius*), maiii (*A. nigrofuscus*, kole (*Ctenochaetus strigosus*), umaumalei (*Naso lituratus*), and lauipala (*Zebrasoma flavescens*). Maiko (*A. nigroris),* naenae (*A. olivaceus*), and manini (*A. triostegus*) were common. Typically these fishes were found high on the cliff face near the zone of turbulent wave action where there is a heavy growth of marine algae. Some algae-covered areas of the cliff face showed evidence of heavy grazing by the mostly herbivorous surgeonfishes.

Large boulders at the base of the cliff provided extensive cover for cryptic fishes. These included the u'u, or menpachi (*Myripristis* species), and roi (*Cephalopholis argus*). Moving about over boulders at the base of the cliff were some of the more active wrasses such as hinalea lauwili (*Thalassoma duperrey*) and akilolo (*Gomphosus varius*) as well as juvenile parrotfishes or uhu (*Scarus* species). The dominant fishes of the midwater region some distance from the cliff face were mamo or Hawaiian sergeant (*Abudefduf abdominalis*) and humuhumueleele (*Melichthys niger*). These midwater species are primarily planktivorous and were often observed foraging throughout the water column in the vicinity of the Shore Cliff.

Shallow Cliff

The separation between Shallow Pavement habitat inshore and Boulder and Deep Pavement habitat offshore is sharply defined by a low cliff, or drop-off. Geologically, the shallow cliff is a submerged continuation of the shore cliff feature which extends under water for approximately 2000 ft. Depths average 13 ft. at the top of the cliff and 32 ft. at its base. Like the shore cliff, the shallow cliff is composed of fractured basalt which is deeply indented, forming underwater canyons. Rock arches are present in at least 2 of the canyons. Unlike the shore cliff, there are areas of the shallow cliff that are vertically discontinuous resulting in a series of steps several feet high. This step-like feature was observed at the northern and southern ends of the habitat.

Moderate wave and surge action was felt at the northern and southern ends of the Shallow Cliff habitat, and strong action was felt at the middle where it extends some distance out from shore and is more exposed. Freshwater intrusion was not particularly noticeable along the Shallow Cliff. Changes in turbidity were observed resulting from mild currents circulating out of Honokohau Bay; these currents frequently ran in a southerly direction toward the Honokohau Harbor boat channel.

Anthelia edmondsoni was the most common sessile invertebrate found along the cliff (Appendix Table A4). *Palythoa tuberculosa* was present in small patches. Lobe coral (*Porites lobata*) and cauliflower coral (*Pocillopora meandrina*) were present to common, usually in small colonies. *Linckia* sp. sea stars were common on the cliff, and crown-of-thorns (*Acanthaster planci*) were found in moderate abundance. The speckled sea cucumber (*Actinopyga mauritiana*) and the black sea cucumber (*Holothuria atra*) were common at the base of the shallow cliff; rarely were they found on the vertically oriented substrate. The pale rock boring urchin (*Echinometra mathaei*) was the most abundant urchin; the short spined urchin (*Tripneustes gratilla*) and the slate pencil urchin (*Heterocentrotus mammillatus*) were common.

The fish community associated with the Shallow Cliff zone was characterized by relatively high diversity and biomass. A total of 85 species were observed in this zone, many of which are large, conspicuous fishes. As in the Shore Cliff zone, acanthurids (surgeonfishes) dominated the fish community, accounting for 20% of the total species. Fourteen acanthurids were termed common or abundant in these surveys; the most abundant and conspicuous were palani (*Acanthurus dussumieri*), naenae (*A. olivaceus*), kole (*Ctenochaetus strigosus*), umaumalei (*Naso lituratus*) and lauipala or yellow tang (*Zebrasoma flavescens*). Although less conspicuous, maiko (*A. nigroris*) and maiii (*A. nigrofuscus*) were also common throughout this zone.

Menpachi or uu (*Myripristis* species) - a group highly prized by fishermen - were locally abundant in the Shallow Cliff zone, and were always found associated with densely packed boulders piled at the base of the cliff. Other important fishery species which were common or abundant in this zone include mu (*Monotaxis grandoculis)* and several goatfishes such as weke a (*Mulloides flavolineatus*), weke ula (*M. vanicolensis*), munu (*Parupeneus bifasciatus*), moano kea (*P. cyclostomus*) and moano (*P. multifasciatus*), as well as uhu (parrotfishes) such as palukaluka (*Scarus rubroviolaceus*) and uhu ahuula (*S. perspicillatus*). A number of the acanthurids mentioned above are also frequently taken by fishermen.

The Shallow Cliff zone was also rich in attractive, ornamental species, most notably butterflyfishes (9 species), damselfishes (7 species), wrasses (13 species) and triggerfishes (4 species). Green sea turtles (*Chelonia mydas*) were also commonly sighted (both at the surface and under water) in this zone (see separate Green Sea Turtles section below).

Because of its high diversity and biomass of fishes, the presence of sea turtles, shallow, calm water, and an interesting topography, it is likely that the Shallow Cliff zone is popular among local SCUBA divers, including commercial dive operations. Indeed, we observed commercial SCUBA charter boats anchored along the cliff several times during the study.

The high vertical relief and numerous canyons, caves and other structures associated with the Shallow Cliff zone undoubtedly contribute to the high diversity and biomass of fishes there. Although the zone occupies a relatively small portion of the area of park waters, it is laterally extensive, and separates two other large, very different habitats. Many of the species sighted in association with the Shallow Cliff zone were also common (although typically less abundant) in adjacent habitats.

Boulder and Deep Pavement

The largest and most heterogeneous habitat in the park is the Boulder and Deep Pavement zone. This region forms a wide, continuous band running north to south, bounded shoreward by the Shore Cliff or Shallow Cliff zones and bounded seaward by the Deep Cliff, Pinnacles and Canyons, or Deep Coral Slope zones. The Boulder and Deep Pavement zone provides a transition between wave washed shallow regions and deeper, less turbulent habitats. Depths in the zone range from 8 to 60 ft., however most of the area is 25 to 45 ft. deep. Bottom topography, water clarity and water motion characteristics over the zone varied widely.

In most areas of the Boulder and Deep Pavement zone, medium to large (1-8 ft.) rounded rocks lay upon a gently sloping pavement. The southern portion was often deeper, with small but widespread rocky rubble covering the bottom. The outer margin of the habitat was usually the most barren, especially near the Deep Cliff zone, where a large expanse of nearly featureless pavement occurred. Dense boulder cover occurred in the northern portion and along the shallow, shoreward edge of the zone along the Shallow Cliff habitat. In the region adjacent to the Pinnacles and Canyons habitat, there was often a thin veneer of sand overlying depressions in the bare pavement.

The amount of swell observed varied from practically none in deeper water near the offshore slopes and cliffs to a great deal at the interface with the Shore Cliff zone. Freshwater intrusion was noticeable in the shallower areas close to the shore and not detected in the deeper areas. Visibility varied greatly depending upon location. The worst visibility occurred when currents swept cloudy, turbid water out of Honokohau Bay (generally toward the south in the direction of the harbor and the boat channel). Very good visibility occurred in the areas adjacent to deep water.

Coral cover varied greatly from south to north within this zone. Deeper regions to the south off Honokohau Bay had the highest occurrence of coral coverage, with medium size lobe coral (*Porites lobata*, 20-35%) and stands of finger coral (*P.

compressa, ~35%) dominant (Appendix Table A5). The northern region off Kaloko had 10% or less lobe coral coverage. *Anthelia edmondsoni* was more abundant in the south, where it covered 10% of the substrate. *Palythoa tuberculosa* was present in the south and common to locally very abundant in the north, sometimes occurring in mats several feet across.

Sea stars were rare in the southern portion of the Boulder and Deep Pavement habitat. In the northern portion they were more numerous, with *Linckia* species and crown-of-thorns (*Acanthaster planci*) present. Urchin abundance followed a similar pattern; the southern portion had smaller populations and lower diversity of urchin species. Only the short-spined urchin (*Tripneustes gratilla*) was abundant (in the north); it was common in the south. The slate pencil urchin (*Heterocentrotus mammillatus*) and wana (*Echinothrix diadema* and *Diadema paucispinum*) were common in the north and present in the southern portion. The speckled sea cucumber (*Actinopyga mauritiana*) and the black sea cucumber (*Holothuria atra*) were common to abundant in the north and present in the south.

The Boulder and Deep Pavement zone had the greatest diversity of fishes of all zones surveyed. A total of 173 species were observed in the entire park during this study, of which 105 (61%) were observed within this zone (Appendix Table B5). This high diversity is primarily a reflection of the large size and heterogeneous physical nature of the zone, as well as its transitional characteristics between shallow, shore- associated fauna and deeper dwelling species.

As in most zones surveyed in this report, the majority of fishes were found associated with some kind of structure such as boulders, coral heads, potholes, etc. The fishes observed on flat, featureless pavement in the Boulder and Deep Pavement zone primarily consisted of small forms, such as territorial damselfishes and juveniles of larger, reef associated species.

In the northern portion of this zone, a dense cover of medium and large boulders provides shelter for uu, or menpachi (squirrelfish of the genus *Myripristis*), the introduced spotted grouper, or roi (*Cephalopholis argus*), young mu (*Monotaxis grandoculis*), goatfish such as weke ula (*Mulloides vanicolensis*) and many species of wrasses.

Several planktivorous damselfishes were common throughout this zone, usually associated with shelter such as caves (mamo, *Abudefduf abdominalis*) or other structure such as coral heads and rock outcrops. Some were commonly observed feeding relatively high in the water column (*Chromis verater, C. ovalis* and *A. abdominalis*) while others remained closer to the bottom (*C. vanderbilti* and *C. agilis*). All typically dart for shelter in the substrate when startled.

The planktivorous surgeonfish *Acanthurus thompsoni* was also common throughout this zone, usually in deeper areas affronting cliffs. This species was always seen high in the water column and seemed to move about without regard to substrate-related shelter.

Dense aggregations of fishes such as those observed in the Shallow Cliff zone were rare in this habitat; of the schooling surgeonfishes and parrotfishes, only small groups were usually observed. Occasionally, schools of up to 30 medium-size palukaluka (redlip parrotfish, *Scarus rubroviolaceus*) were sighted. Wide-ranging carnivores such as the goatfishes were often sighted, however usually in low numbers. Perhaps the most consistently abundant fishes in this zone were the yellow tang or lauipala (*Zebrasoma flavescens*) and the moorish idol or kihikihi (*Zanclus cornutus*).

Pinnacles and Canyons

The zone of Pinnacles and Canyons is located several hundred feet offshore from Kaloko Pond, and is characterized by high relief topography with areas rich in coral growth. Depths of this habitat range from 35 to 80 ft. The bottom is in many ways similar to the Boulder and Deep Pavement habitat; it is primarily composed of fractured pahoehoe basalt. In this region, however, the basalt is mounded and heaved in such a way as to form rounded pinnacles 20-30 ft. high. Canyons between them generally run seaward and have a light covering of rubble and sand. Little surge was felt in this zone, although mild currents were noted, generally running to the south. Intrusion of fresh water was not apparent at depth, although it was detected at the surface, particularly in proximity to Kaloko Pond.

Coral cover was extensive in much of this habitat; it had the second highest total coral coverage of all areas surveyed (Appendix Table A6). Coral cover approached 50% over the habitat as a whole and reached 100% in some areas. Thickets of finger coral (*Porites compressa*) and the octocoral *Anthelia edmondsoni* were common. Cauliflower coral (*Pocillopora meandrina*) was present throughout this habitat. The crown-of-thorns sea star (*Acanthaster planci*) was seen in relatively low numbers; other sea stars were not noted at all. The short-spined sea urchin (*Tripneustes gratilla*), slate pencil urchin (*Heterocentrotus mammillatus*), and the wana (*Echinothrix diadema*) were common in the Pinnacles and Canyons zone. The pale rock boring urchin (*Echinometra mathaei*) was present in low numbers. The speckled sea cucumber (*Actinopyga mauritiana*) was present but not common.

A total of 57 fish species were observed in the Pinnacles and Canyons zone. In view of the small area of this habitat, the zone seems to contain a highly diverse fish assemblage, possibly similar to the Shallow Cliff zone. As in the cliff face habitats, fish tend to aggregate in areas with high structure or vertical relief. This area is certainly rich in fish and undoubtedly has a relatively high biomass.

As in the Shore Cliff and Shallow Cliff zones, the fish fauna observed at Pinnacles and Canyons was dominated by surgeonfishes. The most visually impressive species were large palani (*Acanthurus dussumieri*), which were typically seen in large, inactive schools just above the bottom, naenae (*A. olivaceus*), which occurred in large, active schools, and lauipala (yellow tang, *Zebrasoma flavescens*), which were distributed throughout the entire zone singly, in small groups, or in loose aggregations. The kole (*Ctenochaetus strigosus*) was also abundant in much of this habitat, as was the planktivorous Thompson's surgeonfish (*A. thompsoni*). The latter was always observed high in the water column.

A number of important fishery species occurred in this habitat, including several of the acanthurids mentioned above. Uu (*Myripristis* spp), and to a lesser degree, roi (*Cephalopholis argus*) were common where dense aggregations of large boulders between pinnacles provided refuge. Taape or blue-lined snapper (*Lutjanus kasmira*) were found throughout the habitat, roving about in schools of up to several dozen individuals. Although not abundant, moano kea (*Parupeneus cyclostomus*) were present throughout. The wariest of these species in this habitat (and hence, most difficult to observe closely) were mu (*Monotaxis grandoculis*) and medium- to large-size palukaluka (redlip parrotfish, *Scarus rubroviolaceus*). Mu were locally abundant in the deeper areas of the zone, near offshore faces of pinnacles. Palukaluka were observed in a few schools of perhaps 20 individuals each.

Several other fishes in the Pinnacles and Canyons zone may also represent resources of some interest to park managers. Except for some market in the aquarium trade, these species likely have little commercial value. However, they are common, abundant or visually striking enough to occupy an important role in the local ecology or to be considered characteristic of the habitat. These include a damselfish, agile chromis (Chromis agilis); the longnose butterflyfishes or lauwiliwilinukunukuoioi (*Forcipiger flavissimus* and *F. longirostris*); and 3 species of triggerfishes: humuhumueleele or black durgon (*Melichthys niger*), humuhumuhiukole or pinktail durgon (*M. vidua*), and humuhumu lei or lei triggerfish (*Sufflamen bursa*).

With its rich fish fauna and great topographical relief (a few pinnacles reach to within 15 ft. of the surface from depths of 50 ft.), the Pinnacles and Canyons habitat provides opportunities for high quality diving experiences concentrated in a compact area. This zone may represent a valuable resource for the park as a site for recreational diving.

Deep Coral Slope

One of the most prominent of the deep, offshore habitats is an abrupt, steep slope covered entirely with dense thickets of live and dead finger coral (*Porites compressa*). The Deep Coral Slope is laterally broken into a southern section (approximately 2000 ft. long, from the southern limit of park waters, Noio Point, to the southern extent of the Deep Cliff habitat) and a northern section (approximately 1000 ft. long, from the northern extent of the Pinnacles and Canyons habitat past the northern limit of park waters at Wawahiwaa Point). The average depth at the crest of the slope is approximately 60 ft., and the deepest extension of finger coral thickets is approximately 120 ft.

A featureless, gently sloping, sand covered plain is found at the base of the coral slope. The finger coral substrate is brittle and unstable, and because of the steep pitch of the slope, there appears to be occasional slumping of the substrate. Such damage may be exacerbated by boat anchors and severe episodic storms. At irregular intervals mounds of bare basalt extend out from the slope. Water motion was limited to gentle currents which ran alongshore in a north-south direction; no appreciable surge was felt in this habitat.

The Deep Coral Slope is the only habitat in which the predominant substrate is of biotic origin. Live finger coral coverage ranged from 25 to 75% and dead finger coral skeletons made up the remainder of the substrate (Appendix Table A7), resulting in a physically homogeneous and spatially well defined habitat. Although *Anthelia edmondsoni* has been suggested as an indicator of freshwater intrusion, there was an abundant covering of this octocoral on dead finger coral skeletons, even at depths over 100 ft. Wire coral (*Cirrhipathes anguina*) was common to abundant deep on the slope (usually deeper than 100 ft.). Sea stars were not common, although the pin-cushion sea star (*Culcita novaeguineae*) was present. The short-spined sea urchin (*Tripneustes gratilla*) was common deep on the slope. Wana (*Echinothrix diadema* and *Diadema paucispinum*) were present although not common. Also present in low numbers were the black sea cucumber (*Holothuria atra*) and the speckled sea cucumber (*Actinopyga mauritiana*).

The Deep Coral Slope zone is bordered on the seaward side by relatively barren, unproductive habitat. Immigration of fishes to the slope from this Deep Sand zone is likely minimal, due to the paucity of fishes occurring there (see Deep Sand section, below). There seemed to be considerable exchange of fishes between the Deep Coral Slope habitat and its shallower adjacent zone (Boulder and Deep Pavement). Indeed, fish tended to aggregate along the interface of the two zones, at the crest of the Deep Coral Slope.

Because the substrate of the Deep Coral Slope zone consists almost entirely of live and dead colonies of a single species of structurally unique hermatypic coral, this zone presents a physically homogeneous refuge for demersal fishes. The zone is also relatively deep, which precludes the occurrence of many species that are abundant in shallower habitats. These characteristics combine to support a fish assemblage of somewhat limited diversity. Certain species were found consistently in large numbers only in this zone, and it was apparent that a number of these specifically used the coral substrate for food or refuge. Although a total of 85 species were observed in this habitat, the majority were found near the crest of the zone, close to its interface with the Boulder and Deep Pavement zone. The high apparent diversity near this interface is likely the result of interaction with this adjacent habitat. Relatively few species are considered truly resident on the Deep Coral Slope.

The most visually dominant species associated with the Deep Coral Slope was undoubtedly the agile chromis (*Chromis agilis*). This species was also abundant in some surveys conducted in other habitats. However, it was consistently abundant in all surveys conducted within the Deep Coral Slope zone, along the entire extent of the habitat. The agile chromis, along with 4 other planktivorous damselfishes (*C. hanui, C. verater, C. vanderbilti* and *Dascyllus albisella*) associated closely with the finger coral of this zone. When threatened, these species invariably dashed for cover among its branches.

Two relatively large, planktivorous butterflyfishes were locally abundant in the Deep Coral Slope zone. The pyramid butterflyfish (*Hemitaurichthys polylepis*) and Thompson's butterflyfish (*H. thompsoni*) were both observed in large schools in deep water during a single survey in this habitat. *Acanthurus thompsoni*, a large, planktivorous surgeonfish, was abundant or common throughout the Deep Coral Slope. Evidently plankton is available in great abundance in this habitat, which may be a result of upwelling water along the steep slope. These species were usually observed swimming high in the water column and seemed less dependent on the substrate as shelter than the others described above. Upon the approach of divers, *A. thompsoni* and the pyramid and Thompson's butterflyfishes usually swam away laterally.

Two species of small, inconspicuous wrasses (*Pseudocheilinus evanidus* and *P. octotaenia*) showed a strong affinity for the shelter of the finger coral and were rarely encountered in other areas. Other species such as the ubiquitous saddle wrasse or hinalea lauwili (*Thalassoma duperrey*), the common

Potter's angelfish (*Centropyge potteri*), and the arc-eye hawkfish or pilikoa (*Paracirrhites arcatus*), were common in many habitats, but particularly abundant in the Deep Coral Slope zone. Two corallivorous butterflyfishes or kikakapu, the multiband butterflyfish (*Chaetodon multicinctus*) and the ornate butterflyfish *(C. ornatissimus)* were also observed in greater numbers throughout this zone and presumably used the finger coral as food.

The kole (*Ctenochaetus strigosus*), lauipala *(Zebrasoma flavescens)* and kihikihi *(Zanclus cornutus)* were abundant throughout the Deep Coral Slope zone, however they were also abundant or common in many surveys conducted in most other habitats. These species readily moved between the Deep Coral Slope and Boulder and Deep Pavement habitats, and therefore are not considered residents of the Deep Coral Slope as are the agile chromis or *Hemitaurichthys* species. The gilded triggerfish (*Xanthichthys auromarginatus*), although abundant in this zone, was also common or abundant in the Deep Cliff and Deep Sand habitats. This species seems to prefer greater depths (60 ft.), along with some vertical relief.

Deep Cliff

Between the two disjunct sections of Deep Coral Slope zone, the slope abruptly changes to a vertical cliff face of bare basalt. This cliff is continuous with the southern section of the Deep Coral Slope and it continues in a northerly direction (roughly parallel to the shoreline) to the Pinnacles and Canyons zone, where the basalt cliff becomes a series of fractured steps and pinnacles.

The height of this cliff face ranges from approximately 30 to 40 ft. Depths range from 40 ft. at the top of the cliff to 95 ft. at the base. The cliff face is undercut in many areas, and contains a number of fissures, resulting in deep, narrow canyons. Occasionally large, angular basalt boulders occur at the base of the cliff, evidently fractured and fallen from the cliff face.

The substrate seaward of the Deep Cliff zone is predominantly white sand, a continuation of the same sandy habitat that occurs seaward of the Deep Coral Slope zone. In some areas, however, a band (up to 200 ft. wide) of rubble and small boulders occurs along the base parallel to the deep cliff. Also, in at least one area, another small rock step or drop-off (only about 5 ft. high) occurs offshore of and parallel to the deep cliff, at a depth of about 120 ft. Shoreward of the Deep Cliff zone, the substrate consists of a flat and featureless portion of the Boulder and Deep Pavement zone at depths of 45 to 55 ft.

Lobe coral (*Porites lobata*) and cauliflower coral (*Pocillopora meandrina*) were common in small colonies which encrusted the cliff face and the loose boulders at the base of the cliff. Colonies of *Anthelia edmondsoni* and *Palythoa tuberculosa* were less common. Isolated strands of wire coral (*Cirrhipathes anguina*) occurred along the deep margin of the Deep Cliff habitat. The sea star fauna in the Deep Cliff zone was diverse but abundance was low. The four species present were *Linckia diplax, Linckia multifora*, crown-of-thorns (*Acanthaster planci*), and the pin-cushion sea star (*Culcita novaeguineae*). Abundance of sea urchins was relatively high. The short-spined urchin (*Tripneustes gratilla*) was common to abundant and occasionally occurred in aggregations. Wana (*Echinothrix diadema* and *Echinothrix calamaris*) and the pale rock boring urchin (*Echinometra mathaei*) were few to common. Both the sea stars and the urchins occurred in greatest numbers on the vertical rock face. The black sea cucumber (*Holothuria atra*) and speckled sea cucumber (*Actinopyga mauritiana*) were found in low numbers on horizontal substrate at the top and along the base of the cliff.

The fish fauna associated with the Deep Cliff zone was not particularly diverse - only 67 species (Appendix Table B8). Although the zone was small in area compared to most others surveyed, the deep cliff seemed to have a distinct assemblage of fishes. Opelu (*Decapterus macarellus*) and iheihe or halfbeaks (Family Hemiramphidae) were observed above the cliff on at least one SCUBA survey, and were often sighted from the boat near the surface along the deep cliff. Fishermen appeared to be fishing for opelu in the same spot along the cliff (as well as at another spot farther offshore) often during our surveys.

Except for the mid-water and surface-associated species mentioned above, large aggregations of fishes were uncommon along the deep cliff. The most noticeable species encountered there was the gilded triggerfish (*Xanthichthys auromarginatus*). This planktivore was abundant in 3 of the 6 SCUBA surveys conducted in the zone, and when present, was more numerous than any other species. Gilded triggerfish were also observed deeper, however always associated with some form of cover. Two other triggerfishes, humuhumu lei or lei triggerfish (*Sufflamen bursa*) and humuhumuhiukole or pinktail durgon (*Melichthys vidua*), were also common in this habitat.

The dense populations of damselfishes observed in the other habitats north and south of the Deep Cliff zone were not observed here. The agile chromis (*Chromis agilis*) was abundant in only 2 surveys on the deep cliff and seemed to be distributed near live coral or other structurally complex substrate. The three-spot chromis (*Chromis verater*), a "deepwater" planktivorous pomacentrid, was abundant in half the surveys on the deep cliff. Two other damselfishes were locally abundant here.

Large aggregations of surgeonfishes such as those observed in other high relief or cliff face habitats (i.e. Shore Cliff, Shallow Cliff and Pinnacles and Canyons zones) were not as common in the Deep Cliff habitat, perhaps a result its greater depth. However, several acanthurids were common or locally abundant here. The most noticeable - as in most other habitats surveyed in park waters - was the ubiquitous lauipala or yellow tang (*Zebrasoma flavescens*). Umaumalei (*Naso lituratus*) and naenae (*Acanthurus olivaceus*) were common throughout this habitat, and *A. thompsoni* and *N. hexacanthus* (kala holo) were locally abundant, in schools of up to 100 individuals.

Along with many of the fishes mentioned above, 3 other demersal species that are important to local fisheries were sighted along the deep cliff. Taape or blue-lined snapper (*Lutjanus kasmira*) were observed in a single school of several hundred individuals, swimming along the cliff face during one survey. Large adult mu (*Monotaxis grandoculis*) were also abundant (sighted in a single school of up to 50 individuals) during one survey, and uu or menpachi (*Myripristis* spp.) were abundant in one area of large boulders at the base of the deep cliff.

Deep Sand

The deepest habitat surveyed in the park was the Deep Sand zone. It is also one of the most extensive, running the entire length of the park, beginning at depths ranging from 75 to 150 ft. (95 to 130 ft. along most of its length). The base of the deep cliff and the deep coral slope form the shoreward edge of this habitat, and it extends at a gentle slope beyond the offshore park boundary. The deeper limits of the Deep Sand zone were not visited during this survey because they exceed the limits of safe diving. However, it appears that this large expanse of sand continues for a great distance offshore from the park boundary.

The Deep Sand habitat is featureless, consisting of a broad, gently sloping incline of calcareous sand. This sandy plain was especially barren seaward of the deep coral slope, but near the deep cliff it was mixed with small boulders and some rubble. The sand slope appeared to be regular and unbroken near the coral slope, whereas it was broken by at least one terrace in the vicinity of the cliff (described in the Deep Cliff section above). No freshwater intrusion was detected at these depths, and water motion from swell was minimal. Mild currents were noticed running alongshore in a north-south direction.

Little suitable substrate occurs in the Deep Sand habitat for corals and other sessile invertebrates. Small patches of coral were observed on the rubble and boulders at the base of the deep cliff. *Anthelia edmondsoni* and wire coral (*Cirrhipathes anguina*) as well as small colonies of cauliflower coral (*Pocillopora meandrina*) and lobe coral (*Porites lobata*) were attached to exposed hard substrate.

The deeper dwelling pin-cushion sea star (*Culcita novaeguineae*) was common in the Deep Sand habitat. Crown-of- thorns (*Acanthaster planci*) and *Linckia* species sea stars were also present. The speckled sea cucumber (*Actinopyga mauritiana*) and the black sea cucumber (*Holothuria atra*) were commonly observed on the sand bottom. The deeper dwelling *Stichopus* species sea cucumber was observed on one occasion in this habitat.

The homogeneous, featureless sand substrate was nearly devoid of fishes. Only 2 species were observed over sand independent of rock or coral shelter. Laenihi or sharp-headed (razor) wrasses (*Cymolutes lecluse*) were seen in two surveys as far out over the deep sand as visibility allowed. One makaa or tilefish (*Malacanthus hoedtii*) was also seen over the sand. Both species are considered sand dwellers.

The remainder of the fishes reported in the Deep Sand zone (Appendix Table B9) were invariably associated with hard-bottom features from adjacent habitats and are not considered resident in the sand habitat. A few species, including the Hawaiian anthias (*Anthias thompsoni*), gilded triggerfish (*Xanthichthys auromarginatus*), pennantfish (*Heniochus diphreutes*), and bandit angelfish (*Holacanthus arcuatus*), were only observed in deeper habitats, usually in the band of rubble and boulders which separates the Deep Sand and Deep Cliff habitats.

Special Surveys

Green Sea Turtles

Early reconnaissance by boat in some areas of the park indicated that green sea turtles (*Chelonia mydas*) were abundant in park waters. A full and accurate census of the population was beyond the scope of the study, but observations were made opportunistically.

Most sightings were made from a boat (often while enroute between survey sites) as the turtles surfaced to breathe. We took measures to reduce the probability of counting a single individual more than once during a single "sighting" or survey, e.g., by (1) estimating the size of most individuals sighted, (2) counting at a location only once in a day, and (3) using the minimum estimate of the number in a group when multiple counts of individuals seemed likely. Occasionally, when the boat was anchored and turtles appeared, we swam around the immediate area, counting turtles from the surface as they rested on the bottom. Other turtles were encountered at the surface or underwater during survey dives. Both types of encounters permitted observation of habitat use by turtles. Typically turtles found at the bottom were situated between large rocks, under overhangs, or in shallow depressions in rock or coral.

When not obviously disturbed by our presence (we usually made an effort to stand off as far as possible during our observations), it appeared that turtles resting during the day were very site specific. Typically an undisturbed turtle surfaced for air every few minutes, then returned to the same resting spot. When disturbed, turtles swam away out of visual range. Whether they returned to the same resting spot after disturbance is not known. The site specificity of undisturbed turtles helped to reduce confusion between individuals during our censuses.

A total of 47 sightings of green sea turtles (counted by the above methods) were made in park waters during 6 field days (Table 3, Figure 5). Because of the conservative census methods used, each estimate represents the minimum number of turtles present at a specific site for a given day. Only at locations 8 and 9 (Figure 5) on 3 December 1988 were surveys conducted specifically to census turtles (a total of approximately 2.5 SCUBA man-hours). Other observations were made at the surface or during other field work, so it is difficult to compare census results between days.

The greatest number of turtles observed on a single day was 16. This was the result of counting turtles at the surface from a boat, as well as counting submerged turtles using snorkels (see Figure 5, locations 2 and 3). Turtles were often seen in this same general area while passing through by boat.

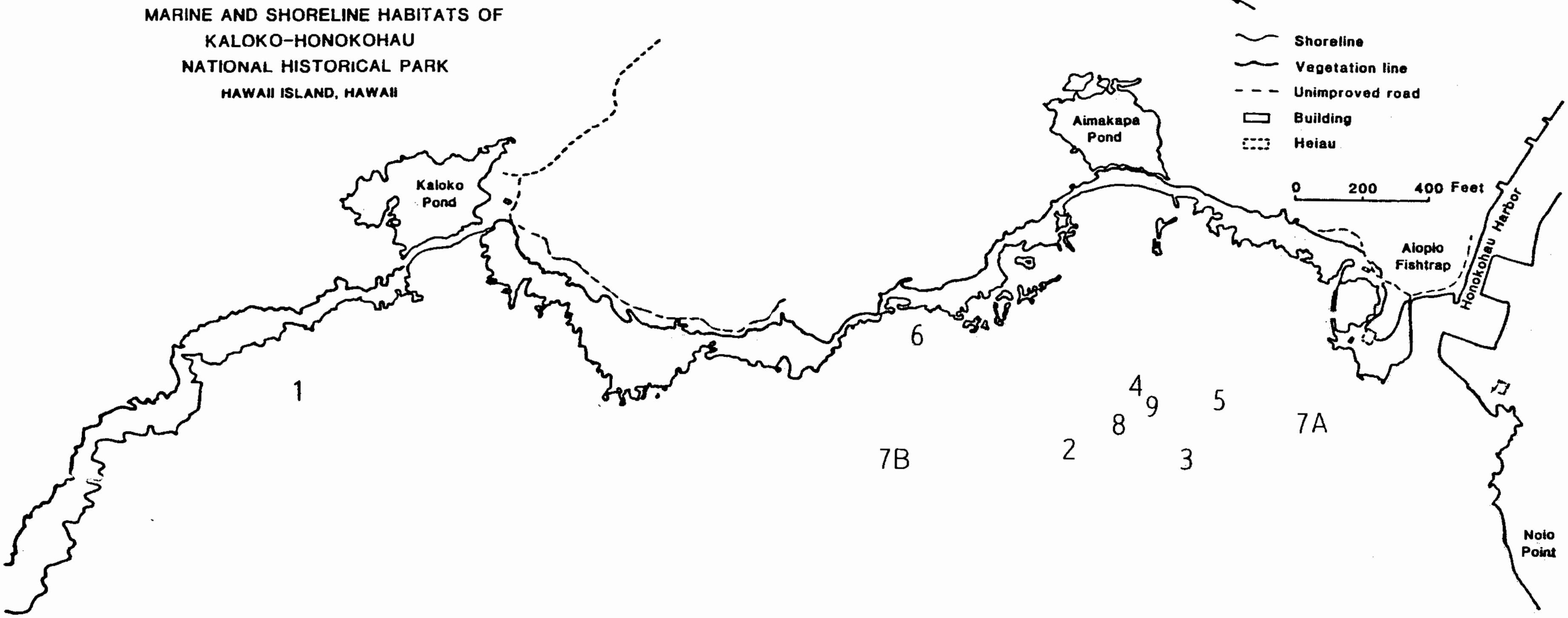
From these observations, it was clear that turtles were concentrated in at least one area directly offshore of the middle of Honokohau Bay, in the Boulder and Deep Pavement zone. Turtles sighted on these "turtle grounds" accounted for 58% of all those sighted within park waters. Turtles were also consistently observed in the nearby Shallow Cliff habitat. (For these locations see Figure 5, locations 2, 3, 8, 9, 4 and 5).

No tagged or unhealthy (e.g., tumorous) turtles were sighted at KAHO. The majority (79%) of the individuals we sighted were less than 24 in. in carapace length, suggesting that the turtle population at KAHO consists primarily of young, possibly pre-reproductive individuals. If this is the case, KAHO park waters may provide an important nursery for this species.

Underwater Cultural Resources

Many man-hours of underwater observation revealed no evidence of portable artifacts or cultural features (e.g. implements, middens) under water. No architectural structures were found that are not visible from the shore. The underwater portions of emergent structures were examined briefly using snorkel and/or SCUBA. This examination revealed

FIGURE 5. LOCATIONS OF TURTLE SIGHTINGS



little to our biologists that is not evident from above-water examination.

The major structures examined were the rock walls of Kaloko fish pond and Aiopio fish trap. The base of the former is very little below the surface at low water (of the order of half a meter), and the sea bottom slopes very gently seaward. The wall has been so damaged that its seaward face is a low, sloping jumble of rocks that blends imperceptibly with the boulders covering much of the bottom of Kaloko Bay. No estimate can be made of which boulders were ever part of the wall or where any previous alignment of the wall may have been. Its angle adjoining the north shore suggests that the alignment of at least some of the central portion has been moved landward, probably by heavy seas, but the view from underwater adds no helpful insights. The presence of a damaged mortar and rock construction (remains of a former makaha?) in the central part of the wall supports the idea that the wall has been damaged, rebuilt and modified repeatedly over a long history, with a variety of technologies.

The rock construction in the water at Aiopio fish trap is extensive and is presently less damaged and scattered by heavy seas or other forces. However, it shows clear evidence of rework, and underwater observations added little to the impressions of surface observations. The most seaward point of Maliu Pt. that extends approximately north and shelters the cove or fish trap appears to be almost entirely a natural basalt lava flow, altered little if any by human works. The wall inshore of it on the west side of the trap, the opposite wall on the east side, and the shorter, wall-like structures within are mostly or entirely manmade. However, the former wall has been modified to include a crude boat ramp on its inshore side, and the east wall has been modified to support dwelling houses and other modern structures. Our underwater observations did not discern any clues about the original configurations. Such clues might exist and be recognized by an investigator with appropriate archaeological training, however the visibility is usually poor underwater inside much of the fish trap.

Our examination of the inshore portion of Honokohau Bay in front of Aimakapa Pond revealed no evidence of underwater architecture. A relatively few large boulders occur there. Some that are awash near the south end may have been roughly piled, but we could detect no structure. What appears to be the end of an old makaha, constructed from stone and mortar, protrudes from the seaward side of the sand berm in front of the pond. Any other possible structure there must be buried in the sand berm.

Recommendations

For several problems or opportunities that park development brings, the best management option depends at least partly on basic objectives set by National Park Service (NPS) management. While some of these are clear (e.g., protection of threatened and endangered species under law, safety of park visitors), some objectives that relate to marine environments and resources are less clear. For example, NPS must make policy on the level or state of natural biotic populations desired in the park, balanced against competing uses. If an objective is to restore animal populations as nearly as possible to the levels of ancient Hawaiian times, probably no consumptive/extractive use of the native marine biota can be allowed. Although ancient Hawaiians certainly harvested marine life, human populations were low and scattered compared to Hawaii's modern population, and the technology provided relatively low fishing power. Fishing and other human activities in modern Hawaii have so reduced natural populations of most harvested animals throughout the island (and the high islands generally) that maintenance of the most stringent refuge in the park will not likely return marine populations to the levels of ancient Hawaiian times. In any case, policy decisions by management will be required regarding the desired status of the natural populations versus any consumptive/extractive/disturbing uses considered desirable.

Protection of Sea Turtles

Sea turtles are an important and sensitive element of the park marine biota. Because of their important role in traditional Hawaiian culture, their continued presence in park waters represents a significant cultural resource of the park. Because of their official status as threatened species on State and Federal lists, protection is legally required in any Federal activity potentially affecting them.

The "no management" option would simply comply with minimum requirements of the law by taking no action that would further jeopardize turtles. This may be a viable option. If park development does not result in a significant increase in human activity in the water, particularly in the resting area (turtle grounds) described above, the local turtle population will probably be little affected.

Another option would encourage and facilitate maximum and uncontrolled access to the turtles by park visitors for viewing, photography, etc. While such an approach might be popular with some users, it carries a real potential for harassment or injury that may negatively affect turtle populations. At present, the turtles can be easily approached (and harassed) by small open boats (including rental boats) from Honokohau public harbor, less than 5 minutes away.

The recommended option combines active protection of turtles and habitat, interpretation and education for park users, and data gathering to monitor the status of the population. The NPS should pursue with appropriate state authorities the legality and feasibility of routing routine coastwise boat traffic slightly farther offshore so as to minimize traffic over the heavily used turtle resting habitat. The rerouting involved would create negligible inconvenience for boat traffic, but would greatly reduce the potential for deaths or injuries from boat strikes. Restriction of more localized boat traffic would reduce the hazard of strikes somewhat further, but it would be hard to specify and enforce, short of a total ban on power boats in park waters. The level of risk does not seem to justify such a ban. It is not known whether the present considerable SCUBA diving activity within park waters results in much interaction with turtles. Discussions with the major dive operators would be desirable; depending on the findings, it may be appropriate to restrict or regulate diving operations in the major turtle resting areas.

Park informational material could acquaint visitors with the ecology, traditional uses and cultural importance of turtles, their current biological and legal status and ecological vulnerability, and appropriate behavior for their protection (e.g., avoiding harassment, using care in boat operation, reporting stranded turtles, turtles with tumors, etc.) Should the NPS or a concessionaire ever become involved in conducting boat tours of park waters, an occasional sighting of turtles at the surface may enhance the experience for some visitors, but care in boat operation will be required.

NPS personnel can gather data on turtles that may be of value in protecting the local population and may contribute to the knowledge of turtle biology and management of the larger population. Such data as records of all sightings, with date, time, location, length of time exposed, and any visible marks such as tags, scars or tumors can be taken incidentally to other duties, from shore or boat. When used with a record of the length of time available for observation, useful information on frequency of incidence may be derived; e.g., incidence of total sightings or sightings of tumors may be useful as indices of local population size and health respectively. NPS personnel should consult with Mr. George Balazs of the National Marine Fisheries Service for further (more expert) advice on management and monitoring of turtles. For both enforcement and monitoring purposes (and for a variety of reasons unrelated to turtles) the park should maintain a small boat capability and staff qualified in small boat operation and SCUBA.

Protection of Hawaiian Stilts

The Hawaiian stilt, or aeo, is an attractive, endemic bird, rather easily viewed, which probably represents a significant natural value to many park visitors. Its official status as an endangered species on State and Federal lists legally requires its protection in any Federal activity that may affect it. Its major habitat is not marine/coastal, and it is dealt with more fully in reports of other KAHO studies. However, our observations suggest that stilts use portions of exposed shore bench fairly frequently, and park related activities there may disturb the birds.

Management decisions should take into account the use of all habitat available to the birds and consider their total ecology. Experience with stilts elsewhere suggests that the use of the exposed bench is not critical to the survival or well being of stilts. The option of no specific management of stilts in that particular environment is probably acceptable, provided direct injury and gross harassment are avoided. However, park development is likely to lead to increased human traffic along the exposed bench and immediate adjacent shoreline. Thus, a somewhat more active management option may be preferable.

The extreme protection option would greatly restrict human access to some areas of the exposed bench and shoreline. This would reduce disturbance of the birds but greatly reduce enjoyment of the park environment by visitors.

The recommended option is to include in I & E materials for visitors information on the ecology and status of stilts, helping visitors to recognize them on sight and to appreciate their vulnerability as endangered species. If these materials indicate shoreline sites where stilts commonly occur and warn visitors to approach these areas with caution and restraint, disturbance of the birds will likely be reduced, and the viewing experience enhanced for visitors. (At present, what often occurs is that an unwary person comes suddenly and unexpectedly upon stilts, which immediately fly away.) Observation by park personnel should permit better localization of sites commonly used by stilts, for inclusion in I & E materials and for regular monitoring by staff.

Protection of endangered water birds is one of several reasons that pets and small domestic mammals (particularly cats and dogs) should be actively excluded from the park. Predation by cats on Hawaiian water birds has been definitely documented (Broshears and Parrish 1980). Park personnel should consult fully with bird biologists of the U. S. Fish and Wildlife Service and the Hawaii Division of Forestry and Wildlife for planning all aspects of management of stilts and other endangered native water birds.

Alien Species

Species in the park marine fauna that are known to have been introduced by man are: (1) the roi (*Cephalopholis argus*), (2) the toau (*Lutjanus fulvus*), and (3) the taape *(Lutjanus kasmira)* (Oda and Parrish 1982; Maciolek 1984; Randall 1987). All have been in Big Island waters for over 20 years; their populations are well established and probably still increasing.

The roi (*Cephalopholis argus*), a middle-size grouper (Serranidae) and well esteemed food fish in Hawaii, is fairly numerous in park waters. It is a popular catch with fishers and is vulnerable to lines, spears, and traps. Usually groupers of this sort can be fished down to low levels in a fairly short time by an active fishery. Thus, if a management goal were to reduce its numbers in the park (selectively), the means are at hand, and local fishers would probably participate willingly while catches remained high enough to be worth their while. Eradication would probably not be feasible both because of (1) the extremely high effort required with very low yield when populations became very low, and (2) (more conclusively) because of immigration and recruitment from adjacent areas.

From any perspective other than its alien status, the roi could be viewed as a desirable resource in the ecosystem. Although it consumes a variety of native fishes and invertebrates (Hobson 1974; Parrish unpublished data), it probably has no specific or conspicuous negative effect on the system. Its population size is moderate and it is in no sense a pest. The recommended alternative is no management. The expected result is that the species will retain its relative abundance in the community if the present total fishing regime continues. If overall fishing intensity increases, its relative abundance may decline somewhat; under a total fishing ban, its relative abundance may increase.

The toau (*Lutjanus fulvus*), a middle-size snapper (Lutjanidae) and also well favored food fish in Hawaii, was seen only occasionally in park waters. Its low apparent abundance relative to the introduced roi and taape is typical of other West Hawaii locations (e.g. Hayes *et al.* 1982). It is also a popular catch and is vulnerable to the same gears as the roi. The prospects for population reduction or eradication are much the same as with the roi except that high effort with low yield would be required at once with the present low populations. This situation would provide little or no motivation to fishers for a directed fishery, and catches could only be expected occasionally, incidental to other fishing. The ecological status of the toau in the community is also fairly similar to that of the roi, and (although alien) it remains more a harmless resource than a pest. The recommended option is no management, and the expected results are somewhat like those for the roi. Great increases in population seem unlikely under any circumstances.

The taape (*Lutjanus kasmira*), a rather small snapper (Lutjanidae), was seen in a number of areas of the park, with somewhat patchy abundance, but it was clearly much more abundant than either the roi or toau. In some places large schools were seen. This pattern of occurrence and abundance is typical for taape in much of the high islands of Hawaii. It has been by far the most successful introduction among the groupers and snappers. The population has exploded in all the high islands and probably continues to increase. Its value as a food fish is presently limited by small size and consumer acceptance, and it is widely considered a pest by fishers. Studies of its diet and habitat use (Oda and Parrish 1982) are so far inconclusive regarding any negative ecological effects on the native community. However, its piscivorous food habits and extreme abundance achieved over a short time in many areas may be cause for alarm.

Population control or even eradication seem desirable objectives, but for the same reasons discussed above, eradication is probably impossible (even locally). Some population control could probably be achieved with intensive, directed fishing. The taape is vulnerable to spears and traps and takes a hook readily. Its schools can also be collected fairly selectively in bottom-set gill nets, particularly when fished actively by divers. However, much sustained total effort would likely be required to produce and maintain a major reduction in the local population. Fishers would have little motivation to participate. Perhaps the strongest incentive to manage the taape population is that it does not presently appear to be overwhelming (as it is in parts of the state), so control measures might be easier and more effective now than if it later becomes better established. It is not clear that there is imminent danger of great population increase; taape populations are moderate in a number of other West Hawaii locations (e.g. Hayes *et al.* 1982). A more thorough and detailed evaluation of the distribution and abundance of taape in the park seems appropriate before deciding on a management strategy.

Crown-of-Thorns Sea Star

The density of *Acanthaster planci* observed in park waters was typical of what is seen in nearshore waters of West Hawaii. Size and behavior seem normal. As far as is known, they are a natural part of the local fauna. However, despite a rather fortunate history in Hawaii, elsewhere this species has undergone destructive population explosions. There was some indication of an increase in abundance at Puako several years ago (e.g., Hayes *et al.* 1982), which may be a normal (perhaps cyclic) phenomenon. Since this species has the potential to destroy major coral resources if a population outbreak of plague proportions occurs, management should be alert for any noticeable changes in abundance. It is recommended for any future resource inventory or other underwater work in the area, that the abundance of *A. planci* be noted at least in a casual, semiquantitative way. Our results are of this type, and they are adequate as a baseline against which major increases could be detected.

Fishing

Fishing is now done in park waters by a variety of methods, from shore and boat. Its impacts on the fauna cannot be assessed from results of this project, but some results relevant to local interpretation are available from elsewhere in West Hawaii (South Kohala, Hayes *et al.* 1982). Fish and other large marine animals in park waters do not appear as grossly depleted as in some coastal waters of the state. There is still much to enjoy visually, including some large and desirable food fishes (e.g. grouper, goatfishes, large surgeonfishes, mu). Maintaining those stocks or restoring them to levels more like those of ancient times seems an appropriate objective for the park.

Although no data are available, fishing pressure within the park does not seem especially heavy. This may be partly a result of limited road access. Thus, it does not appear that drastic new controls on fishing pressure are needed at once to counter depletion. Management may have the opportunity to accommodate some fishers with existing "equity" or history in park waters and still maintain desirable animal population levels. If it is desired to maintain/restore marine animal populations, fishing activity should not be allowed to escalate during park development and create greater discontent when more stringent regulations are later enforced.

It may never be feasible to collect adequate data to do quantitative yield analysis and predict desired levels of fishing to produce desired standing stocks. Thus, management based rigorously on level of fishing effort is probably not appropriate. Furthermore, the park shoreline represents a small portion of the similar West Hawaii shoreline and of the range of the local species. There is certainly much emigration and immigration, and the recruiting larvae that maintain the local population may come from far away. Thus, much of the dynamics of KAHO fish populations is beyond the control of local management. The best hope for maintenance and restoration of local fishes may be that the park will act as a refuge and accumulate fish through high survival of recruits and behavioral responses (immigration and retention).

The most conservative approach to management would be a total ban on all fishing (i.e., all harvest or collection of aquatic animals). This may not be an unreasonable alternative. It would affect relatively few present users (with the possible exception of fishers in the immediate vicinity of the harbor entrance), and all boat fishers could relocate their effort. It would provide the largest and most diverse standing stocks, produce least intrusion on the natural environment,. and possibly reduce some safety hazards and user conflicts. It would represent an even treatment of all fishers and all gears. Considerable enforcement might be required, but the enforcement process could be simple (at least on shore), since even possession of gear or catch would constitute a violation. The major disadvantages are the enforcement burden and the restriction on enjoyment of park resources by visitors, especially resident users accustomed to fishing in park waters.

The option of no management will almost certainly result eventually in increased fishing pressure - perhaps extreme pressure by certain gears and on certain segments of the fishery - with resulting depletion of natural populations (and decline in harvest). Recovery may never occur without stringent regulations, which will be more onerous and less socially acceptable after users have become accustomed to fishing in the park.

If a complete ban is not desired, the recommended option is to maintain the level of fishing relatively low (prevent escalation) and concentrate on controlling certain less desirable fishing practices. Means of controlling total effort near present levels might include restricting fishing to certain areas on shore, e.g. the immediate vicinity of the harbor channel, the property occupied by leaseholders, possibly the immediate surroundings of the park development south of Kaloko Pond. Although anglers might become crowded and the catch poor, some sort of fishing experience - and the resource - could probably be preserved.

Gill netting does not seem to be common at present although it was observed once just outside the harbor. However, nets may become established if not controlled. They take a wide range of fishes rather efficiently and often result in wasted by-catch. Our studies at Puako, West Hawaii (Hayes *et al.* 1982) indicated that several species were caught at pre-reproductive sizes; gill nets have since been banned at Puako. A total ban on gill nets (and trammel nets and seines) in the park seems appropriate. Fishing for ornamental aquarium fishes is a different operation that also uses net gear. It removes small ornamental native fish from the park for strictly commercial purposes. Many of the target species are colorful, attractive fishes that contribute significantly to the natural underwater scenery. There seems little reason to allow aquarium fishing to continue in the park. Trap fishing produces problems similar to gill nets as well as ghost fishing of lost or untended traps. It does not appear to be established in park waters now, but prudence suggests that traps should be excluded.

Spearfishing, particularly using SCUBA, is highly selective for the more highly prized food fishes. If effort were maintained low and moderation practiced in fishing, it could result in a sensible, controlled harvest. This control is difficult to achieve, and heavy use of an area by spear fishers usually depletes the desirable target species quickly. The most prudent option is probably to ban spearfishing with SCUBA entirely, and other spearfishing is probably acceptable only if it is restricted to shore entry where it can be monitored and controlled.

Benthic macroanimals contribute to the visual experience in park waters and are part of the natural system to be preserved. In particular, cowries and a few other large shelled molluscs can at times be seen, even at the water's edge. A few large benthic invertebrate species are collected by hand for food or decorative purposes, especially shelled molluscs, octopus and lobster. Collection is usually by hand or spear (especially for octopus). These resources are easily overfished with little or no investment in boat or gear. As indicated elsewhere, prohibiting use of SCUBA to capture lobster may provide adequate protection for them. Adequate protection for shelled molluscs may require a total ban on collection, and enforcement may never be really effective. However, some level of voluntary compliance is always achieved, and I & E materials may motivate compliance as well as protect against injuries from cone shells. Special attention may be required for tide pools on the intertidal bench, where walkers can easily remove conspicuous, ornamental benthic animals.

Enforcement of fishing from boats for any park resources will be demanding. The burden can probably be eased if staff make some effort to inform and "sell" the local boating/fishing operations and recreational groups, and post appropriate signs at the two nearby harbors. Combined visual surveillance from shore and monitoring/intercept at Honokohau Harbor of boats returning from the area may provide the most cost effective direct enforcement. The capability for park personnel to reach park waters by boat will be required, however.

Effects of SCUBA Diving

All park waters are easily accessible by small boat from Honokohau Harbor and are within range of many boats from the Kailua-Kona harbor as well. Field observations and discussions with local divers during the project indicate that park waters contain some fairly popular diving sites, both for independent recreational divers and commercial dive tours. The most frequently used areas, based on limited, casual observations, are indicated in Figure 6. This is certainly not a definitive set, however. SCUBA diving from shore within the park appears to be limited.

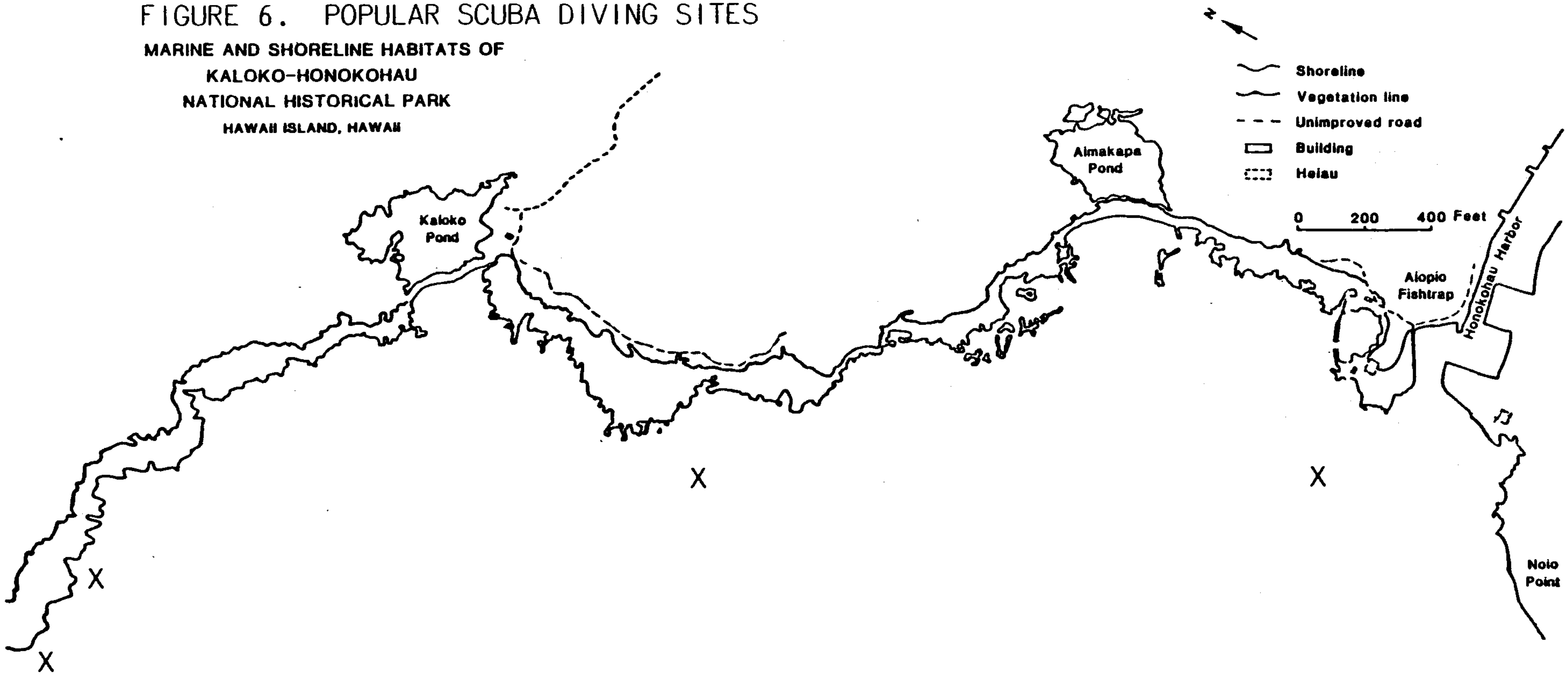
Potential negative impacts of diving activities on park resources include: (1) damage to substrate (primarily corals) from anchors and chains, (2) direct, physical damage to sessile organisms (especially corals) from diver activities on the bottom (e.g., touching, handling, collecting, overturning or breaking up in search of other organisms), (3) local depletion of organisms (especially finfish, shelled molluscs, octopus, and lobsters) by fishing/collection, and (4) harassment of turtles.

Almost no information is available about the extent of any of these impacts in the park. At present levels of diving activity, the no management option may be acceptable. Some broken coral was observed in the study that may have represented anchor damage. The substrate in much of the park waters is not highly vulnerable to damage, but diving activities tend to be concentrated near more extensive coral cover. Locations with present or potential heavy damage are almost certainly in areas of concentrated diving activity on features of particular interest. The Hawaii DLNR (and agencies in other jurisdictions) have tried to mitigate anchor damage at heavily used anchor sites with sensitive substrate by installing permanent moorings fastened into the substrate. NPS might investigate this technology if a few heavily used, sensitive areas are fully identified. It would be useful to start discussion early with local dive tour operators on a number of aspects of this subject, including the feasibility of using permanent moorings and potential locations for them.

Various State and Federal laws and administrative rules relate to impacts (3) and (4); however, they are not likely to provide adequate protection for maintaining local populations of these animals near natural levels in the face of heavy diving activity involving collection and harassment. Impact (2) occurs to some extent with all diving; it is more intense with inexperienced or uninformed divers or with serious collectors lacking conservation ethic. In a properly supervised dive (e.g., a good commercial dive tour) it can be minimized if the tour operators are properly motivated.

All the impacts can be greatly reduced by a total ban on diving within park waters, coupled with adequate enforcement. Such enforcement would likely be expensive. However, much of the activity seems to be by commercial tour operators, who would likely give better compliance, and be easier to identify if not in compliance. On the other hand, a commercial operation involves some degree of internal supervision and usually a high level of experience and knowledge of the local waters and resources. All the above impacts (on a per diver basis) may in fact be less intense with a tour boat dive operation than with independent divers. The persistence of a commercial operation within the park may be objectionable in principle. However, in terms of diver safety and control of diver impacts, it offers one means by which the NPS could manage an otherwise diffuse and elusive element of park users. Thus, another alternative might be to allow diving only by permit. Permits could be issued to commercial operators and/or individuals deemed to be qualified and responsible, and the process would allow for briefing by park personnel, restriction from certain areas (e.g. the "turtle grounds"), and reporting of any data desired. If park personnel could thereby enlist

FIGURE 6. POPULAR SCUBA DIVING SITES



the help of commercial operators in diver supervision, this might be the most effective approach to controlling impacts (2), (3) and (4).

A ban on collection of live animals, or all animals or animal parts, would reduce impact (3), if adequately enforced, and it seems consistent with the purpose and spirit of the park. The protection would be especially helpful for populations of shelled molluscs, which (as in most of the state) do not seem to be overly abundant. Live lobsters were seldom seen in the project (although parts were observed), and local lobster populations are probably depressed by diver harvest. (Diving is usually the main means of lobster harvest in West Hawaii.) Enforcement would be difficult; the most effective approach is probably the pressure for self-enforcement inherent in the diving permit system (above). Management of fishing/collecting generally (including fishing using SCUBA gear) is covered more fully in a separate recommendation.

The recommended management option for SCUBA activity depends upon the nature and level of present and predicted use by divers. NPS should assess this by direct data collection on activity, interview with users (e.g., dockside boat intercept, discussion with commercial operators), etc. With data regarding the intensity and spatial distribution of activity and the types of participants, decisions can be made on management measures. A total ban on diving seems to foreclose some legitimate, appropriate opportunities for enjoyment of basic park values, and this seems undesirable, if avoidable. If it becomes clear that management is required, recommended options would probably include installing permanent moorings, restricting certain areas, prohibiting the taking of some (or all) animals, and controlling all diving under permit.

Regardless of other enforcement mechanisms, for any action other than no management, the park should maintain the capability for park personnel to get out onto park waters by boat on a regular basis. Even with no management, the capability is needed to properly monitor user activity so as to assess whether that regime is still appropriate. In this connection, it would be appropriate for park staff to have SCUBA capability (training and equipment).

Water Access

Except for the 4 beaches described above and Honokohau Harbor, access along the entire length of park waterfront is over basalt lava flows, boulders or large cobbles. Even where a sand berm occurs supratidally, boulders, cobble or pavement are encountered at or near the water line. Much of the shoreline rock is sharp. As reported above, sea urchins are common and locally abundant. All species except 2 have more or less sharp spines; at least 3 can cause painful injury. They are not particularly abundant at KAHO compared to some other coastal tracts, but they clearly present some level of hazard to the unwary wader. There are in fact very few places and very small areas at KAHO where careless, barefoot walking in the sea is without hazard. Most Hawaii residents are accustomed to these conditions and the hazards underfoot even where there is much sand subtidally. Many non-residents are not prepared for these hazards.

Most of the northern half of the park shoreline consists of steep shore cliff which offers relatively few easy, safe places to leave the water, even when sea and swell are low. In heavier conditions, there may be no safe exit up the cliff. Thus, swimmers, snorkelers and SCUBA divers must either select entry and exit points carefully (allowing for small changes in tide level) and recognize exits accurately from the water, or they may be forced to swim long distances along shore to find other safe exits. Even in much of the south central portion of the park shore, where the shore bench is low and often boulder lined, coming ashore in moderate to heavy sea conditions may be harrowing if not life threatening. Although the park shoreline is more benign than much of the coast of West Hawaii, it can present hazards for the inexperienced, unwary or weak swimmer.

The no action option relative to this problem would be to permit unlimited use of the shoreline by swimmers, waders and divers without benefit of advice or warning. This option seems to permit an unacceptable and unnecessary level of risk that is reducible with minimum effort.

The most conservative option would be to prohibit water entry entirely or restrict it to a few limited and relatively benign areas such as the 4 beaches. Life guard protection could even be provided for a small number of such small areas, although the labor cost would be considerable. While this option would reduce the hazard, it meets the needs of only some visitors, and the experience that it encourages is perhaps less appropriate to a cultural/historical/natural park setting than the experience that it discourages - i.e. learning about the environment by the more extensive exploration of the long swimmer, snorkeler or diver. Of the beaches, only Beach A and D are in fairly convenient swimming range of some of the better natural underwater biological viewing areas. Many of the best viewing areas are accessible from other entry points that can be used safely if visitors are well directed.

The recommended option is to provide visitors with information (e.g., in the form of a written guide plus appropriate signs) indicating the nature of the hazards and the locations of more and less hazardous areas for water access and use. There seems to be no pressing environmental or safety reason not to direct visitors to the beaches as preferred areas for conventional water play. Beaches B & D will probably remain the most desirable beaches and likely present lower hazard of foot injury. Drowning within Aiopio fishtrap from Beach C seems highly unlikely, but this is otherwise an undesirable swimming area.

A more conservative management option would permit access over the more dangerous long stretches of high shore cliff only with an orientation by park staff. Staff could review the visitor's planned swim/dive, advise the visitor of the underwater environments available and the specific hazards involved, and give detailed directions (or guide him) to the best access and to alternatives that could be used for contingency. This latter approach should reduce risk and probably enhance the recreational experience. Some investment of staff time would be required, but less than would be involved with large-scale life guarding or patrolling to prevent access along long areas of shoreline.

Other Hazards

The hazard from waves and swell relates primarily to injury to swimmers from being dashed against rocky bottom or shore rocks. This has been addressed above. The exposed shore bench is not particularly hazardous to walkers by Big Island standards. However, under some sea conditions, unwary walkers approaching the edge too closely in some areas could be swept over, and injury or death could result. Warnings by such means as I & E handouts and signs are recommended.

In addition to puncture injuries from sea urchins, swimmers (and even tide pool waders) may experience puncture injuries and mild to severe poisoning from the barbs of cone shells and the spines of scorpionfishes and even crown-of-thorns sea stars. Neither of the latter 3 taxa was seen often enough to present a significant hazard. Stings from the nematocysts of corals and other sessile coelenterates may result from touching these animals on the bottom. However, the bottom coverage of coral is seldom high, especially in shallow water. The risk of injury from all these sources can be lessened by providing warning messages with brief descriptions of the animals and their habitats.

Some gelatinous planktonic animals such as jellyfish (siphonophores), cubomedusae and man-of-war may cause painful stings on contact. These are seldom serious unless the animal is unusually large. None of these nuisance animals was a problem during project field work. They may seldom cause problems at KAHO, and little can be done to reduce the hazard of injury from them. Moray eels are common enough wherever crevices or suitable shelter occur. No sharks were seen during the project work, although they undoubtedly occur. The probability of injury from these larger fishes is very remote, and no means seem available to reduce the hazard.

Access for Water Craft

Honokohau Harbor is a well protected, easily accessible public, small boat harbor. Harbor facilities include multiple public launching ramps which are well kept and usable at all tides, as well as adequate parking. The harbor entrance lies within proposed park waters (Figure 1), and any point within park waters is only a few minutes away by small power boat. There seems to be no reason to consider developing other permanent water craft access facilities within the park for either public use or park operations. If the use of some type of light, portable craft (inflatable, kayak, canoe, wave-ski, surfboard, etc.) seems appropriate for life saving, enforcement, or other park operational purposes, there are several locations where such craft could be launched in reasonable weather without modifying the shoreline and with no predictable impact on the natural environment.

Similarly, from a strictly environmental perspective, there seems no compelling reason to prohibit or discourage the use of such light craft by park visitors. There are safety considerations, primarily associated with (1) the large breakers that sometimes form in shallow areas (especially the shallow pavement in Honokohau Bay proper), and (2) the predominance of steep, rocky, wave washed shorelines where careless or unskilled recreationalists can be injured and their equipment damaged. However, currents do not appear to present much of a hazard, and the existing hazards seem to be obvious to any cautious potential user. Other considerations regarding the appropriateness of light recreational craft in the park environment and potential conflicts among various types of users are matters that (along with safety) will require development of park policy. The results of the resource studies have little to contribute to those issues.

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Table 1.

Checklist of all invertebrate taxa found within the coastal waters of KAHO Park, based on intertidal and subtidal observations. (See Appendix Table C1 for Hawaiian and other common names.)

Taxon	Intertidal	Subtidal
Phylum CNIDARIA		
Class ANTHOZOA		
Subclass Octocorallia		
Anthelia edmondsoni	x	x
Subclass Zoantharia		
Order SCLERACTINIA		
Cyphastrea ocellina	x	x
Fungia sp.		x
Leptastrea bottae		x
Leptastrea purpurea	x	x
Montipora patula/verrilli	x	x
Montipora studeri		x
Montipora verrucosa	x	x
Pavona sp (probably *varians*)	x	x
Pocillopora damicornis	x	x
Pocillopora eydouxi		x
Pocillopora meandrina	x	x
Porites compressa		x
Porites lobata	x	x
Order ZOANTHIDEA		
Palythoa tuberculosa	x	x
Zoanthus sp.	x	x
Order ANTIPATHARIA		
Cirrhipathes anguina		x
Phylum ANNELIDA		
Class POLYCHAETA		
Spaghetti worm (*Lanice conchilega*?)	x	
Phylum MOLLUSCA		
Class CEPHALOPODA		
Octopus sp		x
Class GASTROPODA		
Bursa sp.	x	
Bursa granularis	x	
Cellana exarata	x	
Cellana sandwicensis	x	
Cerithium nesioticum	x	
Conus ebraeus	x	
Conus sponsalis	x	
Cymatium intermedium	x	
Cymatium nicobaricum	x	
Cypraea caputserpentis	x	
Cypraea maculifera	x	

Table 1. (Cont'd)

Taxon	Intertidal	Subtidal
Phylum MOLLUSCA (CONT'D)		
Cypraea mauritiana	x	
Cypraea moneta	x	
Drupa ricina	x	
Littorina pintado	x	
Melanoides sp.	x	
Morula granulata	x	
Nassa serta	x	
Neothais harpa	x	
Nerita picea	x	
Peasiella tantilla	x	
Planaxis labiosa	x	
Prodotia ignea	x	
Prodotia iostomus	x	
Purpura aperta	x	
Serpulorbis sp. (?)	x	
Strombus maculatus	x	
Theodoxus neglectus	x	
Trochus intextus	x	
Class BIVALVIA		
Atrina vexillum		x
Chama iostoma	x	x
Isognomon californicum	x	
Isognomon perna	x	
Isognomon incisum	x	
Class OPISTHOBRANCHIA		
Phyllida varicosa	x	
Nudibranchs (unidentified)	x	x
Phylum ARTHROPODA		
Subclass Cirripedia		
Barnacles (unidentified)	x	
Subclass Malacostraca		
Order STOMATOPODA		
Stomatopod (unidentified)	x	
Order DECAPODA		
Leptodius sanguineus	x	
Xanthid crab (unidentified)	x	
Grapsus tenuicrustatus	x	
Pachygrapsus plicatus	x	
Hermit crabs (unidentified)	x	
Panulirus penicillatus		x
Stenopus hispidus		x

Table 1. (Cont'd)

Taxon	Intertidal	Subtidal
Phylum ECHINODERMATA		
Class ASTEROIDEA		
Acanthaster planci		x
Culcita novaeguineae		x
Linckia diplax		x
Linckia multifora		x
Linckia sp.	x	x
Class OPHIURIODEA		
Ophiuriods (unidentified)	x	
Class ECHINOIDEA		
Colobocentrotus atratus	x	
Diadema paucispinum	x	x
Echinometra mathaei	x	x
Echinometra oblonga	x	x
Echinothrix calamaris		x
Echinothrix diadema	x	x
Heterocentrotus mammillatus	x	x
Tripneustes gratilla	x	x
Short-spined urchin (unidentified)		x
Class HOLOTHUROIDEA		
Actinopyga mauritiana	x	x
Holothuria sp.	x	x
Holothuria atra	x	x
Holothuria pervicax	x	x
Stichopus sp.		x

Table 2.

General spatial distribution and abundance of all invertebrate taxa seen in intertidal waters during shoreline observations in KAHO Park. (See Appendix Table C1 for Hawaiian and other common names.)

Phylum CNIDARIA

Class ANTHOZOA

Subclass Octocorallia

Anthelia edmondsoni
Widely and patchily distributed along all shore length, locally abundant, especially just N. and S. of Aimakapa Pond.

Subclass Zoantharia

Order SCLERACTINIA

Cyphastrea ocellina
A total of 3 small colonies seen, Areas 12 and 21.

Leptastrea purpurea
About half a dozen small colonies seen, scattered widely.

Montipora patula/verrilli
1 small colony seen a little N. of Kaloko Pond.

Montipora verrucosa
Few small colonies seen near Kaloko Point and Area 21.

Pavona sp. (probably *varians)*
About half a dozen small colonies seen, divided between 2 distant sites N. and S. on bench (Areas 3 and 14).

Pocillopora damicornis
Few small colonies seen (< =15 total) in several scattered areas (Areas 1-2, 9-10, 14 and 21).

Pocillopora meandrina
Occurs irregularly in a good many areas along the whole bench; abundance ranges from a few to common.

Porites lobata
Distribution and abundance much like *Pocillopora meandrina.*

Order ZOANTHIDEA

Palythoa tuberculosa
Small patches (e.g. 8-12 in.) scattered most of length of bench S. to Area 14; common but seldom abundant.

Zoanthus sp.
Occurs scattered along the entire bench S. of Kaloko Pond except Area 16 (Beach C); occurs as few colonies few inches across.

Anemones (unidentified)
Small groups seen just N. of Kaloko Pond and in Area 21.

Phylum ANNELIDA

Class POLYCHAETA

Spaghetti worm (probably *Lanice conchilega*)
At least 1 seen at Wawahiwaa Point and a few to several in Areas 10-15.

Phylum MOLLUSCA

Class GASTROPODA

Bursa granularis
1 seen in Area 21.

Bursa sp.
1 seen near Kaloko Point.

Cellana exarata/C. sandwicensis
Both species collected; 1 or both seen almost everywhere bench surface occurs except Area 17; abundance usually 1-2, occasionally 30-50.

Cerithium nesioticum
A patch with a few to several seen in each of 3 areas: just north of Kaloko Pond, near tip of Kaloko Point, and south of it.

Conus ebraeus
1 seen near tip of Kaloko Point.

Conus sponsalis
1 seen near northern shore boundary of park.

Cymatium intermedium
1 seen between S. end of high shore bench (Area 14) and Aimakapa Pond.

Cymatium nicobaricum
1 seen a little S. of Beach A.

Cypraea caputserpentis
About 20 definite specimens seen, other probable sightings; seen from Wawahiwaa Point to Kaloko Point, apparently more common between Beach A and Kaloko Pond.

Cypraea maculifera
1 or 2 seen on Wawahiwaa Point.

Cypraea mauritiana
About half a dozen seen, all but 1between the base of Wawahiwaa Point and Kaloko Pond, 1 somewhere in the Area 15 shoreline.

Drupa ricina
About 1 or 2 (sometimes several) found individually in most areas with bench surface; may be less abundant in Kaloko Point region.

Littorina pintado
Present intermittently in most areas with bench surface; occurrence patchy, often in large aggregations, varies from 1 or a few to very abundant.

Melanoides sp.
1 seen in the transition from Area 16 to 17.

Morula granulata
1 seen at the tip of Wawahiwaa Point.

Phylum MOLLUSCA (Cont'd)

Nassa serta
1 seen in Area 14.

Neothais harpa
2 seen near northern shore boundary of park, 1 in Area 14.

Nerita picea
Occurred in numbers in most areas; sometimes common (especially in the far northern bench), often very abundant (especially on the bench from Area 12 southward); patchy.

Peasiella tantilla
Common at the tip of Wawahiwaa Point and in Area 17, abundant in Area 21.

Planaxis labiosa
Few seen in Area 14.

Prodotea ignea
1 seen in Area 14.

Prodotia iostomus
1 seen on bench just N. of Kaloko Pond.

Purpura aperta
1 seen in Area 21.

Strombus maculatus
1 seen on bench just N. of Kaloko Pond, 1 on Beach A.

Theodoxus neglectus
Abundant in Areas 6, 9 and 17 where freshwater intrusions occur; also abundant in Area 15; may occur elsewhere (especially in Areas 10-14), undistinguished from *Nerita picea.*

Trochus intextus
Perhaps a dozen seen between Areas 7 and 14, scattered throughout as individuals.

Serpulorbis sp.(?)
Occurs in small patches in rather widely scattered areas along the bench; may be less common in general Kaloko Point region.

Unidentified small limpet
Fairly common at S. edge of Beach D.

Class BIVALVIA

Atrina vexillum (?)
1 seen near Kaloko Point.

Chama iostoma
Common in 1 tide pool at tip of Wawahiwaa Point; 1 uncertain record from Area 21.

Isognomon californicum
Occurrence spotty along entire bench; 1 to several on generally northern bench except abundant on Beach A; fairly abundant in Area 15, very abundant and widespread in Area 17, abundant in Area 21; usually strongly aggregated.

Phylum MOLLUSCA (Cont'd)

Isognomon perna
2 seen just N. of Kaloko Pond.

Isognomon incisum
Seen in Area 17.

Class OPISTHOBRANCHIA
Nudibranchs (unidentified)
2 seen in Area 17.

Phylum ARTHROPODA

Subclass Cirripedia
Barnacles (unidentified)
Patch seen on Beach A, few patches in Area 17.

Subclass Malacostraca
Order STOMATOPODA
Stomatopod (unidentified)
1 seen a little S. of northern shore boundary of park.

Order DECAPODA
Leptodius sanguineus
1 collected near the tip of Wawahiwaa Point.

Xanthid crabs (unidentified)
1 seen near northern shore boundary of park, 1 little farther S., and 1 in very high pool with vegetation above Area 12.

Grapsus tenuicrustatus
Common to abundant almost everywhere on high lava bench; almost absent from Areas 16 and 17.

Pachygrapsus plicatus
1 seen near Kaloko Point.

Hermit crabs (unidentified)
Sightings scattered irregularly over the areas, usually a few per area, but some concentrations, e.g. from Area 7 to S. of the northern shore boundary of the park.

Phylum ECHINODERMATA

Class ASTEROIDEA
Linckia spp.
About a dozen seen, almost all in Areas 12-.. (except Beach B).

Class OPHIUROIDEA
Ophiuroids (unidentified)
2 seen near northern shore boundary of park (probably many present in hiding in all areas).

Phylum ECHINODERMATA (Cont'd)

Class ECHINOIDEA

Colobocentrotus atratus
Abundant on most high bench with full wave exposure and coralline algae; somewhat less abundant from general Kaloko Point region S. through Area 17.

Diadema paucispinum
About a dozen seen in total, scattered widely.

Echinometra mathaei
Present in numbers except few areas, usually common to abundant; many juveniles also; some in burrows, some exposed.

Echinometra oblonga
Present in many (but not all) areas, widely distributed; usually a few to common, occasionally abundant; often tightly aggregated.

Echinothrix calamaris
Definitely 2 on S. side of Wawahiwaa Point recorded; probably small numbers elsewhere.

Echinothrix diadema
Few seen in 1 pool near Kaloko Point, 1 in Area 12.

Heterocentrotus mammillatus
Present in most areas along entire bench; mostly a few seen in each area (about 1-5), and often these were aggregated.

Tripneustes gratilla
Present in most areas along entire bench; common in far north, several in far south, mostly few elsewhere; not much aggregated.

Class HOLOTHUROIDEA

Actinopyga mauritiana:
Common to abundant in most areas along entire bench, conspicuously absent in a few places (e.g. most of Area 4, Areas 5, 6 and 17).

Holothuria atra
Much like *A. mauritiana* except much less abundant almost everywhere; also absent in much the same areas.

Holothuria pervicax
1 seen somewhat S. of northern shore boundary of park, 1 near Kaloko Point.

Holothurian (unidentified, may not be distinct species)
Occurs at least in the northern several areas and Area 21.

Table 3.

Size and distribution of green sea turtles (*Chelonia mydas*) observed in KAHO Park waters from 16 October through 3 December 1988.

		Estimated carapace length (cm)							No size	
Location[1]	Date	30	40	50	60	70	80	90	estimate	Total
1	16 Oct			1						1
2	31 Oct		1	2	2		1			6
3			3	4	2	1				10
4	11 Nov			3	1	1				5
5			1	1	2				1	5
6	12 Nov	2								2
7[2]	25 Nov		1		1				4	6
8	03 Dec		1	2	2			1		6
9			1	3	2					6
Total		2	8	16	12	2	1	1	5	47

[1]Figure 5 shows locations of sightings.
[2]Turtles sighted while boat was moving between locations 7a and 7b, Figure 5.

Table A1.

Relative abundance and distribution of invertebrate taxa observed during 2 surveys in the Shallow Sand habitat of Koloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present. Numerals indicate actual counts of individuals, percentages indicate estimated coverage of hard substrate. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

TAXON	SURVEY 1*	SURVEY 2*
Phylum CNIDARIA		
Class ANTHOZOA		
Anthelia edmondsoni	a	75%
Palythoa tuberculosa	p	
Pocillopora damicornis	p	
Phylum ECHINODERMATA		
Class ASTEROIDEA		
Linckia diplax		p
Linckia multifora	p	
Class ECHINOIDEA		
Echinometra mathaei	c	
Echinometra oblonga	c	
Heterocentrotus mammillatus	p	
Tripneustes gratilla	c	
Class HOLOTHUROIDEA		
Actinopyga mauritiana	a	a
Holothuria atra	p	p

Table A2.

Relative abundance and distribution of invertebrate taxa observed during 10 surveys in the Shallow Pavement habitat of Koloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present. Numerals indicate actual counts of individuals, percentages indicate estimated coverage of hard substrate. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

	SURVEY									
TAXON	1*	2*	3*	4*	5*	6*	7*	8	9	10
Phylum CNIDARIA										
Class ANTHOZOA										
Anthelia edmondsoni	a	a	a				50%	<5%	75%	90%
Palythoa tuberculosa	c		c				p	p		
Pocillopora damicornis									p	p
Pocillopora meandrina	c	c		c			p	<1%	p	a
Porites lobata	p	c		a	f	f		<1%	10%	80%
Phylum ECHINODERMATA										
Class ASTEROIDEA										
Linckia diplax							c	c	c	
Linckia sp.	p	c					c			
Class ECHINOIDEA										
Echinometra mathaei			c	c			p	a	c	c
Echinometra oblonga			c	c				p		c
Echinothrix diadema	c	c					p	p		
Heterocentrotus mammillatus	c	c					c	p		p
Tripneustes gratilla	c	c			a	a	c	c	p	
Class HOLOTHUROIDEA										
Actinopyga mauritiana	c	c					f	p	a	c
Holothuria atra		c						p	p	c
Holothuria sp.					f	f				

Table A3.

Relative abundance and distribution of invertebrate taxa observed during 10 surveys in the Shore Cliff habitat of Koloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present. Numerals indicate actual counts of individuals, percentages indicate estimated coverage of hard substrate. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

	SURVEY									
TAXON	1*	2	3*	4*	5*	6*	7*	8*	9*	10*
Phylum CNIDARIA										
Class ANTHOZOA										
Anthelia edmondsoni	30%	p		c	c	a	c		a	a
Palythoa tuberculosa				c		p	80%		c	
Pocillopora damicornis	p									
Pocillopora meandrina	c				f	c	a	f	c	
Porites compressa					p					
Porites lobata	p				c	p				
Phylum ARTHROPODA										
Class MALACOSTRACA										
Stenopus hispidus							2			
Phylum ECHINODERMATA										
Class ASTEROIDEA										
Acanthaster planci		2	10					2	2	
Linckia diplax		p								
Linckia sp.						c			2	p
Class ECHINOIDEA										
Echinometra mathaei		c				p			c	a
Echinometra oblonga										a
Echinothrix diadema		c	p			p		p	p	
Heterocentrotus mammillatus		c	p			p	c	p		
Tripneustes gratilla		c				p	c	p	c	
Class HOLOTHUROIDEA										
Actinopyga mauritiana		1				a			p	
Holothuria atra		c								
Holothuria sp.					f	a	c			

Table A4.

Relative abundance and distribution of invertebrate taxa observed during 3 surveys in the Shallow Cliff habitat of Koloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present. Numerals indicate actual counts of individuals, percentages indicate estimated coverage of hard substrate. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

TAXON	SURVEY 1*	2	3
Phylum CNIDARIA			
Class ANTHOZOA			
Anthelia edmondsoni	p	20%	20%
Cirrhipathes anguina		p	
Palythoa tuberculosa		p	p
Porites lobata	c		
Phylum ECHINODERMATA			
Class ASTEROIDEA			
Linckia sp.	c		
Linckia diplax	c	c	c
Acanthaster planci	1	4	3
Class ECHINOIDEA			
Echinometra mathaei	a	a	
Echinothrix calamaris			1
Echinothrix diadema			p
Heterocentrotus mammillatus	c	c	c
Tripneustes gratilla	c	c	p
Class HOLOTHUROIDEA			
Actinopyga mauritiana	c		
Holothuria sp.	1	10	

Table A5.

Relative abundance and distribution of invertebrate taxa observed during 11 surveys in the Boulder and Deep Pavement habitat of Koloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present. Numerals indicate actual counts of individuals, percentages indicate estimated coverage of hard substrate. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

TAXON	SURVEY 1	2	3	4	5	6*	7*	8*	9*	10*	11*
Phylum CNIDARIA											
Class ANTHOZOA											
Anthelia edmondsoni	10%	50%	p	< 10%a			c	c			
Cirrhipathes anguina			p								
Montipora verrucosa		p									
Palythoa tuberculosa		p			c			c	a	p	
Pocillopora damicornis	p								p		
Pocillopora meandrina	c	c		p		c		c	c	f	
Porites compressa				35%							p
Porites lobata	p	20%		35%		c	c	c	10%	20%	a
Phylum ARTHROPODA											
Class MALACOSTRACA											
Stenopus hispidus									2		
Phylum ECHINODERMATA											
Class ASTEROIDEA											
Acanthaster planci						1		1		2	
Linckia sp.	c					f		1	p	p	
Class ECHINOIDEA											
Echinometra mathaei		c									
Echinothrix calamaris									2		
Echinothrix diadema				p		f		p		c	p
Heterocentrotus millatus		p		p	f			c		c	p
Tripneustes gratilla		p	p	c	a			c		c	p
Class HOLOTHUROIDEA											
Actinopyga mauritiana				p	a			c	c	p	
Holothuria atra				p			f				
Holothuria sp.									c	p	p

Table A6.

Relative abundance and distribution of invertebrate taxa observed during 3 surveys in the Pinnacles and Canyons habitat of Koloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present. Numerals indicate actual counts of individuals, percentages indicate estimated coverage of hard substrate. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

TAXON	SURVEY 1	2	3
Phylum CNIDARIA			
Class ANTHOZOA			
Anthelia edmondsoni			20%
Cirrhipathes anguina		f	
Pocillopora meandrina	c		c
Porites compressa	c		
Porites lobata	f		
Phylum ECHINODERMATA			
Class ASTEROIDEA			
Acanthaster planci		1	1
Class ECHINOIDEA			
Echinometra mathaei	p		
Echinothrix diadema			c
Heterocentrotus mammillatus	c		p
Tripneustes gratilla	c		c
Class HOLOTHUROIDEA			
Actinopyga mauritiana	p		p

Table A7.

Relative abundance and distribution of invertebrate taxa observed during 5 surveys in the Deep Coral Slope habitat of Koloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present. Numerals indicate actual counts of individuals, percentages indicate estimated coverage of hard substrate. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

	SURVEY				
TAXON	1	2	3	4	5
Phylum CNIDARIA					
Class ANTHOZOA					
Anthelia edmondsoni	50%	15%	5%	c	p
Cirrhipathes anguina	c	a			p
Pocillopora meandrina		c			
Porites compressa		25%		70%	
Porites lobata		<5%			
Phylum ECHINODERMATA					
Class ASTEROIDEA					
Culcita novaeguineae	1				
Linckia sp.			p		
Class ECHINOIDEA					
Diadema paucispinum				c	
Echinothrix diadema		p			
Heterocentrotus mammillatus		p	p		c
Tripneustes gratilla	c	c	c	c	c
Class HOLOTHUROIDEA					
Actinopyga mauritiana		p			p
Holothuria atra		p			p
Holothuria sp.	1			p	

Table A8.

Relative abundance and distribution of invertebrate taxa observed during 6 surveys in the Deep Cliff habitat of Koloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present. Numerals indicate actual counts of individuals, percentages indicate estimated coverage of hard substrate. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

TAXON	SURVEY 1	2	3	4	5	6
Phylum CNIDARIA						
Class ANTHOZOA						
Anthelia edmondsoni			5%			
Palythoa tuberculosa			p			
Pocillopora meandrina	p		p		c	c
Porites lobata	c		10%		c	c
Phylum ARTHROPODA						
Class MALACOSTRACA						
Stenopus hispidus			1			
Phylum ECHINODERMATA						
Class ASTEROIDEA						
Acanthaster planci	4		3			
Culcita novaeguineae	4	1				p
Linckia diplax		p				p
Linckia multifora			p			
Class ECHINOIDEA						
Echinometra mathaei	f	p	c			
Echinothrix calamaris	f					
Echinothrix diadema		f	p	c	c	p
Tripneustes gratilla	a	p	p		p	p
Class HOLOTHUROIDEA						
Actinopyga mauritiana			p	p	f	
Holothuria atra			p			
Holothuria sp.		p				

Table A9.

Relative abundance and distribution of invertebrate taxa observed during 5 surveys in the Deep Sand habitat of Koloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present. Numerals indicate actual counts of individuals, percentages indicate estimated coverage of hard substrate. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

	SURVEY				
TAXON	1	2	3	4	5
Phylum CNIDARIA					
Class ANTHOZOA					
Anthelia edmondsoni	10%				< 1%
Cirrhipathes anguina	p		c		
Palythoa tuberculosa	p		p		
Pocillopora meandrina	p	c		p	
Porites compressa	< 1%				
Porites lobata	10%			c	c
Phylum ARTHROPODA					
Class MALACOSTRACA					
Stenopus hispidus		1	1	p	
Phylum ECHINODERMATA					
Class ASTEROIDEA					
Acanthaster planci				p	1
Culcita novaeguineae				4	1
Linckia diplax	1				p
Class ECHINOIDEA					
Echinometra mathaei	c				
Echinothrix calamaris					1
Echinothrix diadema					p
Tripneustes gratilla	p				
Class HOLOTHUROIDEA					
Actinopyga mauritiana	p			c	p
Holothuria atra				p	p

Table B1.

Relative abundance and distribution of fish taxa observed during 3 surveys in the Shallow Sand habitat of Kaloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present, j = juvenile. Numerals indicate actual counts of fish. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

Species	Survey 1	Survey 2*	Survey 3*
CARANGIDAE			
Gnathanodon speciosus	2j		
LUTJANIDAE			
Lutjanus fulvus	1		
MULLIDAE			
Mulloides flavolineatus	f	p	
Parupeneus multifasciatus		p	p
CHAETODONTIDAE			
Chaetodon fremblii		p	
Chaetodon miliaris		p	
Chaetodon lunula		1	
Chaetodon quadrimaculatus		f	
POMACENTRIDAE			
Abudefduf abdominalis		p	
Abudefduf sordidus		p	
Plectroglyphidodon imparipennis		c	
Stegastes fasciolatus		p	
LABRIDAE			
Coris gaimard		p	
Coris venusta	1	p	
Gomphosus varius		p	
Stethojulis balteata	1j	p	f
Thalassoma duperrey		c	f
Thalassoma trilobatum		p	

Table B1. (Cont'd)

Species	Survey 1	2*	3*
ACANTHURIDAE			
Acanthurus achilles		p	
Acanthurus blochii	c		
Acanthurus nigrofuscus		a	
Acanthurus triostegus	c	c	
Naso lituratus		p	
Zebrasoma flavescens	1	p	
ZANCLIDAE			
Zanclus cornutus		p	
OSTRACIIDAE			
Ostracion meleagris	c	p	
TETRAODONTIDAE			
Arothron meleagris	1		
Canthigaster amboinensis		p	
Canthigaster jactator		p	

Table B2.

Relative abundance and distribution of fish taxa observed during 13 surveys in the Shallow Pavement habitat of Kaloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present, j = juvenile. Numerals indicate actual counts of fish. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

	SURVEY												
SPECIES	1*	2*	3*	4*	5*	6*	7*	8	9	10	11	12	13
MURAENIDAE													
Gymnomuraena zebra	1												
Gymnothorax flavimarginatus		1										2	
Gymnothorax meleagris				1								1	
HOLOCENTRIDAE													
Neoniphon sammara		3											
AULOSTOMIDAE													
Aulostomus chinensis		3							4				
FISTULARIIDAE													
Fistularia commersoni		4			3								
SCORPAENIDAE													
Taenianotus triacanthus								1					
SERRANIDAE													
Cephalopholis argus	2	f											
CIRRHITIDAE													
Cirrhitus pinnulatus		1		1			1						
Paracirrhites arcatus		p		p							f	c	
Paracirrhites forsteri		1		1								1	

Table B2. (Cont'd)

	SURVEY												
SPECIES	1*	2*	3*	4*	5*	6*	7*	8	9	10	11	12	13
LUTJANIDAE													
Aphareus furcatus		1											
Lutjanus kasmira		1											
LETHRINIDAE													
Monotaxis grandoculis		c											
MULLIDAE													
Mulloides flavolineatus		c			3	c		1					
Mulloides vanicolensis		c			f	c							
Parupeneus bifasciatus		f							p	c		f	
Parupeneus cyclostomus	c	f								f			
Parupeneus multifasciatus	a	f			f					c	p	f	p
Parupeneus pleurostigma	1				2								
Parupeneus porphyreus		f	2										
KYPHOSIDAE													
Kyphosus sp.		f											
CHAETODONTIDAE													
Chaetodon auriga	1	a								c			
Chaetodon ephippium									2	c			
Chaetodon fremblii		2											
Chaetodon lineolatus										2			
Chaetodon lunula	f	a		f					p	c		f	

Table B2. (Cont'd)

SPECIES	SURVEY 1*	2*	3*	4*	5*	6*	7*	8	9	10	11	12	13
CHAETODONTIDAE (Cont'd)													
Chaetodon miliaris	c												
Chaetodon multicinctus	3	f			f				p	p		p	
Chaetodon ornatissimus	c	c								2		f	
Chaetodon quadrimaculatus	f	c			2		f			f		f	
Chaetodon unimaculatus		1											
Forcipiger sp.		c										f	
POMACENTRIDAE													
Abudefduf abdominalis	a	a	p				p				p	c	c
Abudefduf sordidus	1	f	f			f							
Chromis agilis					p								
Chromis vanderbilti		5			8			c					f
Plectroglyphidodon imparipennis	a	a	a	a			a	1	p	p	p	p	p
Plectroglyphidodon johnstonianus		2								p			
Stegastes fasciolatus	a	a	a	a		c	p	p		c	p	f	f
LABRIDAE													
Anampses cuvier	2	1											
Coris flavovittata	1											1	
Coris gaimard	2	1j		1j	1				p			1j	
Coris venusta	1												
Gomphosus varius	c	aj		cj			pj		p		pj	c	c
Halichoeres ornatissimus		f						p			2		
Labroides phthirophagus		2										2	

Table B2. (Cont'd)

SPECIES	1*	2*	3*	4*	5*	6*	7*	8	9	10	11	12	13
							SURVEY						
LABRIDAE (Cont'd)													
Macropharyngodon geoffroy		c						p				f	
Novaculichthys taeniourus								pj					
Pseudocheilinus tetrataenia											1		
Stethojulis balteata	c	a	p	cj			p	c	c		p	c	c
Thalassoma ballieui		2										1j	
Thalassoma duperrey	a	aj		cj		c	c		c		c	c	
Thalassoma trilobatum		2	cj										
SCARIDAE													
Calotomus sp.		1											
Scarus perspicillatus		p											
Scarus psittacus		1											
Scarus rubroviolaceus		a			c								
Scarus sp. (juv)	a	a	p				c	p			c	c	
BLENNIIDAE													
Cirripectes sp.							1	1					
Istiblennius zebra							f						
Plagiotremus sp	p	a						3					
ACANTHURIDAE													
Acanthurus achilles		c		p		p							
Acanthurus blochii		c	p										

Table B2. (Cont'd)

SPECIES	SURVEY 1*	2*	3*	4*	5*	6*	7*	8	9	10	11	12	13
ACANTHURIDAE (Cont'd.)													
Acanthurus leucopareius	a	c	p										
Acanthurus nigrofuscus	a	a	p	p	p	c						f	
Acanthurus nigroris	c										p	a	a
Acanthurus olivaceus	2	c	p								p	c	c
Acanthurus triostegus	a	a	cj			c	p				p	c	
Ctenochaetus strigosus					p								
Naso lituratus		c				p	p		1		p	a	
Naso unicornis		2											
Zebrasoma flavescens	a	a	p		p	p	f	4				c	
Zebrasoma veliferum		f											
ZANCLIDAE													
Zanclus cornutus	a	a		p		p	2	2				f	
BALISTIDAE													
Melichthys niger		c			p								
Melichthys vidua		1			1								
Rhinecanthus rectangulus	f	c	p	p			f	c	p		f	f	
Sufflamen bursa		p			f								
OSTRACIIDAE													
Ostracion meleagris	2						2		p		1		
TETRAODONTIDAE													
Arothron meleagris	1	1									1		4
Canthigaster jactator		1		1					p		p	f	
Canthigaster amboinensis	1	2											
DIODONTIDAE													
Diodon hystrix	1												

Table B3.

Relative abundance and distribution of fish taxa observed during 11 surveys in the Shore Cliff habitat of Kaloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present, j = juvenile. Numerals indicate actual counts of fish. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

	SURVEY										
SPECIES	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*
MURAENIDAE											
Gymnothorax meleagris	1										
Gymnothorax undulatus		1									
Gymnothorax javanicus								1			
CONGRIDAE											
Conger cinereus										1	
HOLOCENTRIDAE											
Myripristis sp.		a				f	f				
AULOSTOMIDAE											
Aulostomus chinensis	1	p				3	1	3			
FISTULARIIDAE											
Fistularia commersoni		1	1	4		3				2	
SERRANIDAE											
Cephalopholis argus				1	p	4					1
CIRRHITIDAE											
Cirrhitops fasciatus								1			
Cirrhitus pinnulatus						1				1	1
Paracirrhites arcatus	f	p	c			f	c			f	p
Paracirrhites forsteri	3		1				p				
PRIACANTHIDAE											
Heteropriacanthus cruentatus						1					
CARANGIDAE											
Caranx melampygus		1									
Scomberoides lysan			1								
LUTJANIDAE											
Lutjanus fulvus						1		1			
Lutjanus kasmira			1		1						

Table B3. (Cont'd)

SPECIES	SURVEY 1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*
LETHRINIDAE											
Monotaxis grandoculis		c			c						
MULLIDAE											
Mulloides flavolineatus	f	a		1	f				f		
Mulloides vanicolensis		a			a		3	c			
Parupeneus bifasciatus	c	f	f	f	c	f	c	p	c		
Parupeneus cyclostomus	f		5			1	8	3	2		
Parupeneus multifasciatus	c	p	f	f	f	f	c	p	f	6	
Parupeneus pleurostigma	1					1					
Parupeneus porphyreus	1	f			f						
KYPHOSIDAE											
Kyphosus sp.		c	f		f	f	3	c	12	20	2
CHAETODONTIDAE											
Chaetodon auriga	f	2			p	2	f		f		
Chaetodon ephippium					1	4					
Chaetodon fremblii		p									
Chaetodon lineolatus		p				p	f	1			
Chaetodon lunula	f	a	f	f		c	2		f	f	
Chaetodon miliaris	1										
Chaetodon multicinctus		c	f	f	a	2		1	f		
Chaetodon ornatissimus	3		f	f	c	2	c	2	f		
Chaetodon quadrimaculatus	f		f	f		f			f	f	
Forcipiger sp.	f	c	f	f		c	p	c	f	c	
POMACANTHIDAE											
Centropyge potteri		c						c			
POMACENTRIDAE											
Abudefduf abdominalis	a	a	p	p	a	c	p	p	p		a
Abudefduf sordidus	c		c	c	f	c	c	c	m	c	c
Chromis agilis		a									
Chromis hanui		c									
Chromis vanderbilti	c	a			c			c			
Chromis verater		a									
Plectroglyphidodon imparipennis	c		c	c		f	p		c	a	c
Plectroglyphidodon johnstonianus						1			4	1	

Table B3. (Cont'd)

SPECIES	SURVEY 1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*
POMACENTRIDAE (Cont'd)											
Plectroglyphidodon sindonis			1								
Stegastes fasciolatus	c		c			a	p	c			
LABRIDAE											
Anampses cuvier			1				1				
Cheilio inermis							1				
Coris flavovittata			2								
Coris gaimard	2j	p	1					1j			
Gomphosus varius	c	p	pj	p	p	c	c	c	p	a	
Halichoeres ornatissimus	1	f	1					p			
Labroides phthirophagus	f		p	p			1		p		
Macropharyngodon geoffroy	f							4			
Novaculichthys taeniourus		p						1			
Pseudocheilinus octotaenia								p			
Stethojulis balteata	a		f								
Thalassoma ballieui							1	2			1
Thalassoma duperrey	a	c	cj			c	c	a		f	a
Thalassoma purpureum			1								
Thalassoma trilobatum			c						c	f	
SCARIDAE											
Calotomus sp.			a								
Scarus perspicillatus		c	cj		c		5	c			
Scarus psittacus		p				1					
Scarus rubroviolaceus					a	c	c	f			
Scarus sordidus	c	f	f						f		
Scarus sp. (juv)	a	a	a	a		2	p	p			
SPHYRAENIDAE											
Sphyraena barracuda		1									
MUGILIDAE											
Mugil cephalus											50
ACANTHURIDAE											
Acanthurus achilles	c		c	c	c	a	c	a	c	c	f
Acanthurus blochii	f		f		a	c	p		f		
Acanthurus dussumieri		a			15						a

Table B3. (Cont'd)

SPECIES	SURVEY 1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*
ACANTHURIDAE (Cont'd)											
Acanthurus guttatus		p	a			a	a	c	a		20
Acanthurus leucopareius	1	a	c		a	a	c	a	c	a	a
Acanthurus nigricans						4					
Acanthurus nigrofuscus	c		a	a	p	a	a	c	a	c	p
Acanthurus nigroris	1				c	c	a	c		c	
Acanthurus olivaceus	a		f		c	c					c
Acanthurus thompsoni					12						
Acanthurus triostegus	c	a				a	p	p	c		
Ctenochaetus hawaiiensis		p			c				3		
Ctenochaetus strigosus	f	c	f		c	a	c	a	c	c	c
Naso hexacanthus		p									
Naso lituratus	f	a	c		a	c	c	c	c	f	p
Naso unicornis	1	f	12			f		1			2
Zebrasoma flavescens	a	a			a	a		a	c		p
Zebrasoma veliferum						2				6	4
ZANCLIDAE											
Zanclus cornutus	c	p	a	a	a	c	c	a	a	p	
BALISTIDAE											
Melichthys niger		c			a	a	a	a		p	c
Melichthys vidua		f				2		1			
Rhinecanthus rectangulus	3					1	p			3	
Sufflamen bursa		p	f			f	5	p		p	
Xanthichthys auromarginatus								f			
MONACANTHIDAE											
Aluterus scriptus		2									
Pervagor spilosoma		f						f			
TETRAODONTIDAE											
Arothron meleagris	2				1	2					
Canthigaster amboinensis	2					1				1	
Canthigaster jactator	f	p		1		1	5			1	
DIODONTIDAE											
Diodon hystrix			1		1		1				

Table B4.

Relative abundance and distribution of fish taxa observed during 3 surveys in the Shallow Cliff habitat of Kaloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present, j = juvenile. Numerals indicate actual counts of fish. (See Methods for detailed explanation of surveys and table sybols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

SPECIES	SURVEY 1	SURVEY 2	SURVEY 3
MURAENIDAE			
Gymnomuraena zebra		1	
Gymnothorax flavimarginatus		1	1
HOLOCENTRIDAE			
Myripristis sp.	f	a	10
Neoniphon sammara		3	
AULOSTOMIDAE			
Aulostomus chinensis		3	1
FISTULARIIDAE			
Fistularia commersoni	2	1	2
SERRANIDAE			
Cephalopholis argus	2	f	1
CIRRHITIDAE			
Paracirrhites arcatus	3	c	c
Paracirrhites forsteri		1	5
CARANGIDAE			
Carangoides orthogrammus			1

Table B4. (Cont'd)

SPECIES	SURVEY 1	2	3
LUTJANIDAE			
Aphareus furcatus		f	
Aprion virescens	1		
Lutjanus kasmira		10	
LETHRINIDAE			
Monotaxis grandoculis		a	1
MULLIDAE			
Mulloides flavolineatus		a	a
Mulloides vanicolensis	14	a	c
Parupeneus bifasciatus	c	c	c
Parupeneus cyclostomus	5	c	6
Parupeneus multifasciatus	f	c	c
Parupeneus porphyreus		10	2
KYPHOSIDAE			
Kyphosus sp.		c	
CHAETODONTIDAE			
Chaetodon auriga	f	c	c
Chaetodon ephippium	2	1	2
Chaetodon lineolatus	f	4	6
Chaetodon lunula	f	a	a
Chaetodon multicinctus	f	c	c
Chaetodon ornatissimus	f	c	c
Chaetodon quadrimaculatus	p		
Forcipiger sp.	f	c	c
Hemitaurichthys thompsoni		1	
POMACENTRIDAE			
Abudefduf abdominalis	a	a	c
Abudefduf sordidus	f		
Chromis agilis	1	p	
Chromis vanderbilti	c	a	a
Chromis verater		f	

Table B4. (Cont'd)

SPECIES	SURVEY 1	SURVEY 2	SURVEY 3
POMACENTRIDAE (Cont'd)			
Plectroglyphidodon imparipennis			c
Stegastes fasciolatus		c	c
LABRIDAE			
Anampses cuvier		1	
Bodianus bilunulatus	2	1	1
Cheilinus unifasciatus			2
Coris flavovittata		2	2
Coris gaimard		c	2
Gomphosus varius		c	c
Halichoeres ornatissimus		c	p
Labroides phthirophagus	1	2	1
Novaculichthys taeniourus		1	
Pseudocheilinus octotaenia		p	
Stethojulis balteata		f	
Thalassoma duperrey	p	c	a
Thalassoma lutescens		1j	
SCARIDAE			
Calotomus sp.		1	
Scarus perspicillatus		c	p
Scarus psittacus		p	
Scarus rubroviolaceus	c	a	a
Scarus sp. (juv)		c	c
BLENNIIDAE			
Cirripectes sp.			1
Plagiotremus sp.		1	1
ACANTHURIDAE			
Acanthurus achilles	c	1	
Acanthurus blochii		f	p
Acanthurus dussumieri	c	a	a
Acanthurus leucopareius	c	f	
Acanthurus nigrofuscus		c	c
Acanthurus nigroris	c	c	c
Acanthurus olivaceus	a	c	a
Acanthurus thompsoni		a	6

Table B4. (Cont'd)

SPECIES	SURVEY 1	2	3
ACANTHURIDAE (Cont'd)			
Acanthurus triostegus	c	1	p
Acanthurus xanthopterus		a	
Ctenochaetus hawaiiensis	1	c	c
Ctenochaetus strigosus	c	a	a
Naso hexacanthus	1		
Naso lituratus	a	a	p
Naso unicornis		c	10
Zebrasoma flavescens	a	a	a
Zebrasoma veliferum	2	4	
ZANCLIDAE			
Zanclus cornutus	f	c	c
BALISTIDAE			
Melichthys niger	a	a	a
Melichthys vidua		p	c
Rhinecanthus rectangulus	p		c
Sufflamen bursa	f	c	c
MONACANTHIDAE			
Cantherhines dumerili		2	
OSTRACIIDAE			
Ostracion meleagris		f	1
TETRAODONTIDAE			
Arothron hispidus		2	
Canthigaster coronata		2	
Canthigaster jactator		c	c
DIODONTIDAE			
Diodon hystrix		f	2

Table B5.

Relative abundance and distribution of fish taxa observed during 13 surveys in the Boulder and Deep Pavement habitat of Kaloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present, j = juvenile. Numerals indicate actual counts of fish. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

SPECIES	SURVEY 1	2	3	4	5	6*	7*	8*	9*	10	11*	12*	13
MURAENIDAE													
Echidna nebulosa						1							
Gymnomuraena zebra						1							
Gymnothorax undulatus										1			
SYNODONTIDAE													
Saurida sp.					1								
HOLOCENTRIDAE													
Myripristis sp.							1	1	20				
AULOSTOMIDAE													
Aulostomus chinensis					1j		4		2	2	1		
FISTULARIIDAE													
Fistularia commersoni									2				
SCORPAENIDAE													
Scorpaenopsis diabolus										1			
SERRANIDAE													
Cephalopholis argus			p	p	f	2	3		c	1	c	c	
CIRRHITIDAE													
Paracirrhites arcatus			c		p		c	c	f	a	f		
Paracirrhites forsteri										2			
APOGONIDAE													
Apogon taeniopterus			1										
CARANGIDAE													
Caranx melampygus									1				
Decapterus macarellus									2				
LUTJANIDAE													
Aphareus furcatus				1					6				
Lutjanus kasmira							1					2	

Table B5. (Cont'd)

SPECIES	SURVEY 1	2	3	4	5	6*	7*	8*	9*	10	11*	12*	13
LETHRINIDAE													
Monotaxis grandoculis							12			f		2	
MULLIDAE													
Mulloides flavolineatus	1					f	c		c	30	c	c	
Mulloides vanicolensis							a		c	1	c	c	
Parupeneus bifasciatus	f	p	c			f	f	f	f	f	f	f	
Parupeneus cyclostomus		p	4			2	2		9	f		2	
Parupeneus multifasciatus	c	p	p		fj	f	f	f	c	f	f		
Parupeneus pleurostigma										1			
CHAETODONTIDAE													
Chaetodon auriga	p								f		p		
Chaetodon ephippium											1		
Chaetodon fremblii							2	2					
Chaetodon lineolatus		p	p				c	c	2	2	p		
Chaetodon lunula	2	p	p		2	f	f	f	f		c		
Chaetodon miliaris					p								
Chaetodon multicinctus	1	p	p		p	f	f	f	f	c	f	f	
Chaetodon ornatissimus		p	p			f	f		c	p	f	c	p
Chaetodon quadrimaculatus						f	f		f		1		
Forcipiger sp.			p		p	f	f	f	c	f	c	c	
Hemitaurichthys thompsoni							3						
POMACANTHIDAE													
Centropyge fisheri					p								
Centropyge potteri				p	c				3		1		
POMACENTRIDAE													
Abudefduf abdominalis	c			c		p	p	c	a		c	a	
Abudefduf sordidus						a							
Chromis agilis			c	a	a			c	a				
Chromis hanui			p		p								p
Chromis ovalis					a								
Chromis vanderbilti	c	p	c	c			c	c	a	a	30	a	c
Chromis verater				a	c								
Dascyllus albisella			p	c	c								
Plectroglyphidodon imparipennis		c				c							

Table B5. (Cont'd)

SPECIES	1	2	3	4	5	6*	7*	8*	9*	10	11*	12*	13
						SURVEY							
POMACENTRIDAE (Cont'd)													
Plectroglyphidodon johnstonianus										1			
Stegastes fasciolatus	p	p	p		p	c			p	p	a		
LABRIDAE													
Bodianus bilunulatus	1		1							2			
Cheilinus unifasciatus			p	p					2				
Coris flavovittata						1j	2						
Coris gaimard					p				3	f			
Gomphosus varius	p				p	p	p	p	a	f	c		
Halichoeres ornatissimus		p	p	1					6		1		p
Labroides phthirophagus	f		1			p	p	p	6	1			
Macropharyngodon geoffroy			c										
Pseudocheilinus evanidus			p	p						c			
Pseudocheilinus octotaenia			p						2	c			
Pseudocheilinus tetrataenia										f			
Pseudojuloides cerasinus			p	p									
Stethojulis balteata	p					f			f	f	1		
Thalassoma ballieui										1	1		
Thalassoma duperrey	a	a	c		p	f	p		f	a	c		c
Thalassoma trilobatum						c							
SCARIDAE													
Calotomus sp.										1			
Scarus perspicillatus		1							1j		1		
Scarus psittacus									f	c			
Scarus rubroviolaceus			c		p		a		f	30	c	a	
Scarus sordidus				p					a	c		a	p
Scarus sp. (juv)			c		p	a			c	c	f		
BLENNIIDAE													
Cirripectes vanderbilti						2							
Plagiotremus sp.						4							

Table B5. (Cont'd)

SPECIES	1	2	3	4	5	6*	7*	8*	9*	10	11*	12*	13
							SURVEY						
ACANTHURIDAE													
Acanthurus achilles			p	p		f	a			p	p		
Acanthurus blochii			p								f		
Acanthurus dussumieri			c					25			80		
Acanthurus guttatus		c											
Acanthurus leucopareius		p					c				p		
Acanthurus nigrofuscus		c	p			a			a	p	a	c	c
Acanthurus nigroris	p								a	p		c	
Acanthurus olivaceus	a		c	p	c			f	f	c	c		
Acanthurus thompsoni			p	a	a			25					
Acanthurus triostegus	p	a	p			c					a		
Acanthurus xanthopterus					1								
Ctenochaetus hawaiiensis									1				
Ctenochaetus strigosus			a	p	c				a	c	a	c	a
Naso hexacanthus			c	a	c			20	c		30		
Naso lituratus	f		p	a	c				f	c	a		
Naso sp.					pj								
Zebrasoma flavescens	c	a	a	p	c		c	c	a	c	a	c	c
Zebrasoma veliferum						c					1		
ZANCLIDAE													
Zanclus cornutus	f	a	c	p	p	a	c		c	f	c		c
BOTHIDAE													
Bothus mancus									1				
BALISTIDAE													
Melichthys niger	20	p	c				p	c	c		c	p	
Melichthys vidua					c								
Rhinecanthus rectangulus	c	f							1		f		
Sufflamen bursa			p				f		f	c	f		
Xanthichthys auromarginatus			p					f		2		1	a

Table B5. (Cont'd)

SPECIES	SURVEY 1	2	3	4	5	6*	7*	8*	9*	10	11*	12*	13
MONACANTHIDAE													
Cantherhines dumerili									2				
Pervagor spilosoma	2												
OSTRACIIDAE													
Ostracion meleagris		p				5			2j	1			
TETRAODONTIDAE													
Arothron meleagris									1	1			
Canthigaster jactator			p	1	p				1	f	1		
Canthigaster amboinensis	1	p				1							
DIODONTIDAE													
Diodon hystrix		p						1					

Table B6.

Relative abundance and distribution of fish taxa observed during 3 surveys in the Pinnacles and Canyons habitat of Kaloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present, j = juvenile. Numerals indicate actual counts of fish. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

SPECIES	SURVEY 1	SURVEY 2	SURVEY 3
HOLOCENTRIDAE			
Adioryx sp.			p
Myripristis sp.		c	c
AULOSTOMIDAE			
Aulostomus chinensis		1	
SERRANIDAE			
Cephalopholis argus		4	2
CIRRHITIDAE			
Paracirrhites arcatus	p	c	
Paracirrhites forsteri		4	
LUTJANIDAE			
Aphareus furcatus		2	
Lutjanus kasmira	a	c	p
LETHRINIDAE			
Monotaxis grandoculis	f	c	a
MULLIDAE			
Parupeneus bifasciatus		c	f
Parupeneus cyclostomus	3	5	5
Parupeneus multifasciatus			p

Table B6.(Cont'd)

SPECIES	SURVEY 1	2	3
CHAETODONTIDAE			
Chaetodon lunula			p
Chaetodon miliaris		2	
Chaetodon multicinctus		p	c
Chaetodon ornatissimus		1	1
Forcipiger sp.		c	c
POMACANTHIDAE			
Centropyge fisheri			f
Centropyge potteri		p	p
POMACENTRIDAE			
Chromis agilis	c	c	a
Chromis hanui			p
Chromis ovalis		c	
Chromis vanderbilti	c		
Chromis verater		f	
Dascyllus albisella	f	p	
Stegastes fasciolatus			p
LABRIDAE			
Cheilinus unifasciatus			p
Coris gaimard			p
Gomphosus varius	p	c	p
Halichoeres ornatissimus		1	
Macropharyngodon geoffroy		1	
Novaculichthys taeniourus		1	
Pseudocheilinus evanidus		c	p
Thalassoma duperrey	p	a	c

Table B6. (Cont'd)

SPECIES	SURVEY 1	2	3
SCARIDAE			
Scarus perspicillatus			2
Scarus psittacus		1	
Scarus rubroviolaceus		a	
Scarus sordidus	p		p
Scarus sp. (juv)		p	
ACANTHURIDAE			
Acanthurus achilles			p
Acanthurus dussumieri	c	c	a
Acanthurus olivaceus	c	c	c
Acanthurus thompsoni		a	a
Ctenochaetus hawaiiensis			p
Ctenochaetus strigosus		a	a
Naso hexacanthus			c
Naso lituratus		c	a
Naso unicornis		f	
Zebrasoma flavescens	c	a	c
ZANCLIDAE			
Zanclus cornutus		f	c
BALISTIDAE			
Melichthys niger	c	f	p
Melichthys vidua	c	f	p
Sufflamen bursa		a	c
Xanthichthys auromarginatus			2
TETRAODONTIDAE			
Arothron hispidus			p
Canthigaster jactator	f	1	p
DIODONTIDAE			
Diodon hystrix		1	

Table B.7

Relative abundance and distribution of fish taxa observed during 7 surveys in the Deep Coral Slope habitat of Kaloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present, j = juvenile. Numerals indicate actual counts of fish. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

	SURVEY						
SPECIES	1	2	3	4	5	6	7
MYLIOBATIDAE							
Aetobatus narinari					1		
MURAENIDAE							
Gymnothorax flavimarginatus	1						
Gymnothorax meleagris			1				
Gymnothorax undulatus					1		
HOLOCENTRIDAE							
Myripristis sp.			p	f		c	c
Sargocentron sp.						p	
AULOSTOMIDAE							
Aulostomus chinensis					1	f	1j
FISTULARIIDAE							
Fistularia commersoni						p	
SERRANIDAE							
Cephalopholis argus	p			1	c		1
CIRRHITIDAE							
Paracirrhites arcatus		c	p	a	c	f	p
Paracirrhites forsteri		p		2	f	p	

Table B7. (Cont'd)

SPECIES	SURVEY 1	2	3	4	5	6	7
CARANGIDAE							
Caranx melampygus						f	
Scomberoides lysan		1					
Seriola dumerili		1					
LUTJANIDAE							
Aphareus furcatus			1			p	
Aprion virescens			1				
Lutjanus kasmira			a			f	p
LETHRINIDAE							
Monotaxis grandoculis			c				
MULLIDAE							
Mulloides flavolineatus					f		c
Mulloides vanicolensis						a	1
Parupeneus bifasciatus	pj		p		f		p
Parupeneus cyclostomus		p				f	f
Parupeneus multifasciatus		f		f	f	c	p
Parupeneus pleurostigma		f			1	p	p
CHAETODONTIDAE							
Chaetodon kleinii						f	
Chaetodon lineolatus				2			3
Chaetodon lunula	p		1		c	f	p
Chaetodon multicinctus	p	p	p	c	c	c	c
Chaetodon ornatissimus		p	p	p	f	p	p
Chaetodon quadrimaculatus				p			
Forcipiger sp.	p		c		c	c	p
Hemitaurichthys polylepis						a	p
Hemitaurichthys thompsoni						a	
Heniochus diphreutes					c		

Table B7. (Cont'd)

SPECIES	SURVEY 1	2	3	4	5	6	7
POMACANTHIDAE							
Centropyge fisheri						f	f
Centropyge potteri	c	f	c	1	c	c	c
POMACENTRIDAE							
Chromis agilis	a	a	a	a	a	a	a
Chromis hanui	p	c	p	f	c	a	c
Chromis vanderbilti	c			a	c		c
Chromis verater						a	
Dascyllus albisella		p	p		c	p	p
Plectroglyphidodon johnstonianus						f	1
LABRIDAE							
Bodianus bilunulatus	2				p	p	
Cheilinus unifasciatus	f	1		1	p	f	p
Coris gaimard		p	p	f			c
Gomphosus varius	p						
Halichoeres ornatissimus	p			p			c
Labroides phthirophagus					p	p	3
Macropharyngodon geoffroy							p
Novaculichthys taeniourus		2					
Pseudocheilinus evanidus	p	p	p	a		c	c
Pseudocheilinus octotaenia	c	p	1	c	p	c	c
Pseudocheilinus tetrataenia				f			
Pseudojuloides cerasinus	p					f	
Thalassoma duperrey	c	p	p	c	p	c	
SCARIDAE							
Scarus perspicillatus			p				c
Scarus rubroviolaceus					f	f	
Scarus sordidus				p	p	f	p
Scarus sp. (juv)		p					p

Table B7. (Cont'd)

SPECIES	SURVEY 1	2	3	4	5	6	7
ACANTHURIDAE							
Acanthurus achilles					f	p	
Acanthurus blochii						p	
Acanthurus dussumieri			a				
Acanthurus guttatus					f		
Acanthurus leucopareius						p	
Acanthurus nigrofuscus					c		
Acanthurus nigroris				p	c		
Acanthurus olivaceus			c				c
Acanthurus thompsoni	a	c	a	a	a	a	a
Ctenochaetus hawaiiensis		f					c
Ctenochaetus strigosus	c	p	a	a	c	c	c
Naso hexacanthus					a	a	
Naso lituratus	c	l	a	p	fj	c	
Naso unicornis			p			pj	
Zebrasoma flavescens	c		a	c	a	a	a
ZANCLIDAE							
Zanclus cornutus			p	c	p	c	p
BALISTIDAE							
Melichthys niger				c	a		
Melichthys vidua		f	p		c	p	c
Sufflamen bursa		c			c	c	p
Sufflamen fraenatus							2
Xanthichthys auromarginatus		a	2			a	c
MONACANTHIDAE							
Cantherhines sp.				1	1		
Cantherhines sandwichiensis						p	
Pervagor spilosoma		1					1
TETRAODONTIDAE							
Arothron hispidus							1
Canthigaster jactator				f			
DIODONTIDAE							
Diodon hystrix					30		

Table B8.

Relative abundance and distribution of fish taxa observed during 6 surveys in the Deep Cliff habitat of Kaloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present, j = juvenile. Numerals indicate actual counts of fish. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

	SURVEY					
SPECIES	1	2	3	4	5	6
MURAENIDAE						
Gymnothorax flavimarginatus		1				
Gymnothorax meleagris			3			
HEMIRAMPHIDAE						
Hemiramphus sp.		25		p		
HOLOCENTRIDAE						
Myripristis sp.		a				
SPHYRAENIDAE						
Sphyraena barracuda		1				
SERRANIDAE						
Cephalopholis argus	c	5	3			p
CIRRHITIDAE						
Cirrhitops fasciatus		1				
Paracirrhites arcatus			p		f	p
Paracirrhites forsteri	2					
CARANGIDAE						
Caranx sp.		4				
Decapterus macarellus		100				
Seriola dumerili		1				
LUTJANIDAE						
Aphareus furcatus		1				
Lutjanus kasmira	a					
LETHRINIDAE						
Monotaxis grandoculis	a	1	p			

Table B8. (Cont'd)

SPECIES	SURVEY 1	2	3	4	5	6
MULLIDAE						
Parupeneus cyclostomus	1				p	p
Parupeneus multifasciatus	f	2		p	p	p
CHAETODONTIDAE						
Chaetodon auriga					p	
Chaetodon ephippium				2		
Chaetodon lunula	c	c	2			p
Chaetodon miliaris	3	p			p	
Chaetodon multicinctus		p	2	p	p	
Chaetodon ornatissimus						p
Forcipiger sp.	f	c	p		c	p
Heniochus diphreutes					p	
POMACANTHIDAE						
Centropyge fisheri						p
Centropyge potteri		p		p		p
POMACENTRIDAE						
Abudefduf abdominalis	c					
Chromis agilis	a	a			c	
Chromis hanui	4	c				p
Chromis ovalis	c	a				
Chromis vanderbilti	a		c			p
Chromis verater	a	c		a	a	
Dascyllus albisella		a				
LABRIDAE						
Bodianus bilunulatus	p	1		p	p	
Cheilinus unifasciatus	p	2	p			
Labroides phthirophagus		2				
Macropharyngodon geoffroy		1				
Pseudocheilinus evanidus		1	c		p	f
Thalassoma duperrey	p				c	

Table B8. (Cont'd)

SPECIES	SURVEY 1	2	3	4	5	6
SCARIDAE						
Calotomus sp.	p	2		1		
Scarus perspicillatus		1				
Scarus rubroviolaceus		2			f	
Scarus sordidus	p	2				
Scarus sp. (juv)			f			
BLENNIIDAE						
Plagiotremus sp.						p
ACANTHURIDAE						
Acanthurus blochii						p
Acanthurus dussumieri	c					
Acanthurus olivaceus	c	1j	c	p	a	c
Acanthurus thompsoni		a			c	
Acanthurus xanthopterus			p			
Ctenochaetus hawaiiensis				f		
Ctenochaetus strigosus	a	c		p	c	
Naso hexacanthus	a	a		c		
Naso lituratus	c	c	c	c	a	c
Naso unicornis		1		p		
Zebrasoma flavescens	c	a	f	c	a	c
Zebrasoma veliferum		2				
ZANCLIDAE						
Zanclus cornutus	c	p		p	c	p
BALISTIDAE						
Melichthys niger	c		p			
Melichthys vidua	c	c		c	c	p
Sufflamen bursa			c	c	p	a
Xanthichthys auromarginatus	a		a	a	c	p
MONACANTHIDAE						
Pervagor spilosoma	1				p	

Table B8. (Cont'd)

SPECIES	SURVEY 1	2	3	4	5	6
TETRAODONTIDAE						
Arothron meleagris						p
Canthigaster jactator			c		p	
DIODONTIDAE						
Diodon hystrix	20	1				

Table B9.

Relative abundance and distribution of fish taxa observed during 5 surveys in the Deep Sand habitat of Kaloko-Honokohau National Historical Park. a = abundant, c = common, f = few, p = present, j = juvenile. Numerals indicate actual counts of fish. (See Methods for detailed explanation of surveys and table symbols.) An asterisk indicates surveys conducted while snorkeling; all others were conducted using SCUBA.

	SURVEY				
SPECIES	1	2	3	4	5
SERRANIDAE					
Anthias thompsoni		f			
Cephalopholis argus					p
CIRRHITIDAE					
Paracirrhites arcatus	p	c		p	3
Paracirrhites forsteri	p	p			
APOGONIDAE					
Apogon sp.				p	
MALACANTHIDAE					
Malacanthus hoedtii		1			
CARANGIDAE					
Caranx sp.	1				
LUTJANIDAE					
Aprion virescens		1			
Lutjanus fulvus	f				
Lutjanus kasmira	f				
LETHRINIDAE					
Monotaxis grandoculis	p				p
MULLIDAE					
Parupeneus bifasciatus	cj			p	
Parupeneus multifasciatus			p	p	p

Table B9. (Cont'd)

SPECIES	SURVEY 1	2	3	4	5
CHAETODONTIDAE					
Chaetodon kleinii			p		
Chaetodon lunula	2			p	f
Chaetodon miliaris	2		a		p
Chaetodon multicinctus	2		c	p	
Forcipiger sp.	c		c	p	c
Hemitaurichthys polylepis	a				
Heniochus diphreutes			p		
POMACANTHIDAE					
Centropyge fisheri				p	p
Centropyge potteri	c		p	p	c
Holacanthus arcuatus				2	
POMACENTRIDAE					
Chromis agilis			a	p	
Chromis hanui	c			p	p
Chromis vanderbilti	c				
Chromis verater	f				c
Dascyllus albisella		p	p	p	c
Plectroglyphidodon johnstonianus	1				
LABRIDAE					
Bodianus bilunulatus			p	p	p
Cheilinus unifasciatus	p				
Coris gaimard				pj	p
Labroides phthirophagus	1				1
Cymolutes lecluse			p	p	
Pseudocheilinus evanidus	c		p	p	f
Thalassoma duperrey	c	p		p	
SCARIDAE					
Scarus perspicillatus				p	
Scarus psittacus				p	
Scarus rubroviolaceus		a		c	f
Scarus sordidus				f	
Scarus sp. (juv)				p	

Table B9. (Cont'd)

SPECIES	SURVEY 1	2	3	4	5
BLENNIIDAE					
Plagiotremus sp.					3
ACANTHURIDAE					
Acanthurus blochii				p	
Acanthurus dussumieri	c			a	a
Acanthurus olivaceus	f	p		a	f
Acanthurus thompsoni	f		p	a	a
Acanthurus xanthopterus	c				
Ctenochaetus hawaiiensis	p		p	p	
Ctenochaetus strigosus	p		p	c	
Naso lituratus	c				c
Zebrasoma flavescens	a			a	p
ZANCLIDAE					
Zanclus cornutus		f		c	f
BALISTIDAE					
Balistes fuscus					p
Melichthys niger	c				
Melichthys vidua	p				p
Sufflamen bursa	c	p	c		c
Sufflamen fraenatus			p		p
Xanthichthys auromarginatus	c		a	c	c
MONACANTHIDAE					
Cantherhines dumerili		p			
Pervagor spilosoma	1			p	1
OSTRACIIDAE					
Ostracion meleagris					1
TETRAODONTIDAE					
Canthigaster coronata	1				p
Canthigaster jactator				p	

Table C1.

Ancient and modern uses of marine invertebrates found in coastal waters of KAHO Park. Scientific name (or name of major animal group) is presented first, followed by most common Hawaiian name(s) in parentheses ( ) and most common English or popular name(s) in brackets [ ]. Major sources of information are: Hobson and Chave (1972), Titcomb (1978), Fielding (1979) and Kay (1979).

Taxon	Modern Use	Ancient Use or Significance
CNIDARIA		
ANTHOZOA OCTOCORALLIA [Soft corals]		
Anthelia edmondsoni		
ZOANTHARIA SCLERACTINIA (Koa, Akoakoa, Koa kea, Puna kea) (Hard coral, Stony coral)	Skeletons used for decorative curios.	Skeletons used to build fishing shrines, mark trails, and for abrasives ("kawaewae") e.g., to polish canoes and calabashes and remove pig bristles.
Cyphastrea ocellina		
Fungia sp. [Mushroom coral]	Skeletons used for decorative curios.	Abrasives (see Scleractinia).
Leptastrea bottae		
Leptastrea purpurea		
Montipora patula/verrucosa		
Montipora studeri		
Montipora verrucosa		
Pavona sp. (probably *varians*)		
Pocillopora damicornis		
Pocillopora eydouxi		
Pocillopora meandrina [Cauliflower coral, Rose coral]	Skeletons used as decorative curios.	
Porites compressa (Pohaku puna, Puna) [Finger coral]	Skeletons used as decorative curios.	

Table C1. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
Porites lobata (Pohaku puna, Puna) [Lobe coral]	Skeletons used as decorative curios.	
ZOANTHIDEA	Includes 2 toxic species, especially *Palythoa toxica*.	*P. toxica* used to poison people and animals orally and people by spear tip. Legend it came from ashes of vicious shark-man.
Palythoa tuberculosa		
Zoanthus sp.		
ANTIPATHARIA		
Cirrhipathes anguina		
ANNELIDA		
POLYCHAETA Terebellidae		
Lanice conchilega (?) (Kaunaoa, Kaunoa, Unaoa) [Spaghetti worm]		Used medicinally e.g., to treat cancer.
MOLLUSCA		
CEPHALOPODA OCTOPUS		
Octopus sp. (Hee) [Octopus]	Important, popular food.	Important, popular food. Bait (esp. ink sac). Medical remedies. Represented deities. Common in chants. Large, communal fishing events. Kapus to protect young stock and chiefs' privileges.
SHELLED MOLLUSCS	Few species minor food. Ornaments, curios.	Food, fishing lures, ornaments, tools, horns, medicines, rituals.

Table C1. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
GASTROPODA (Pupu) [Snail]		
Bursa sp. [Frog shell]		
Bursa granularis (Pupu lei hala) [Frog shell]		
Cellana spp. (Opihi) [Limpet] includes: *Cellana exarata* (Opihi makaiauli) *Cellana sandwicensis* (Opihi alinalina)	In markets from before 1900 to 1927. Still highly prized as food.	Important, very popular food. Bait for crabs. Shell tools for scooping, peeling, scraping. Medicine remedies. Represent deities (e.g, to calm surf). Kapus about handling shells and time for eating.
Cerithium nesioticum (Makaaha)		
Conus spp. (Pupu ala - non poisonous species) (Pupu poniuniu-poisonous species) [Cone shells]	Ornamental curios.	Probably eaten.
Conus ebraeus		
Conus sponsalis (Panapuhi)		
Cymatium intermedius (Anaunau, Ole kiwi: used for *C. pyrum*) [Triton]		
Cymatium nicobaricum (Pupu hohopu) [Triton]		
Cypraeidae (Leho) [Cowrie]	In markets from before 1900 to 1927.	
Cypraea caputserpentis (Leho kupa, Alea alea, Leho maoli) [Snakehead cowrie]	Minor food. Ornamental curios.	Major food. Ornaments. Possibly octopus lures.

Table C1. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
Cypraea maculifera (Leho kolea, Kuoho?)	Minor food. Ornamental curios.	Major food. Ornaments. Tools (e.g., scrapers).
Cypraea mauritiana (Leho-ahi, Leho kolea, Leho pouli)	Minor food. Ornamental curios.	Major food. Ornaments. Tools (e.g., scrapers). Octopus lures.
Cypraea moneta (Leho lei, Leho palaoa, Leho puna) [Money cowrie]	Eaten? Ornamental curios.	Major food. Ornaments.
Drupa ricina (Awa, Makaloa, Aupupu) [Drupe shell]		Probably eaten.
Littorina pintado (Pupu kolea) [Periwinkle]		Food. (Possibly other Littorinidae also).
Melanoides sp.		
Morula granulata (Makaawa, Makaloa)		Food.
Nassa serta (Aunauna)		
Neothais harpa	In markets from before 1900 to 1927.	
Nerita picea (Pipipi, Pipipi kai)	Minor food.	Food, especially snacks. (See *Theodoxus neglectus*).
Peasiella tantilla (Maka halili)		
Planaxis labiosa (Pipipi akolea ihiloa, Pipipi kolea ihiloa) [Cluster wink]		
Prodotia ignea		
Prodotia iostomus		
Purpura aperta (Awa, Makaloa, Aupupu)	In markets from before 1900 to 1927.	Food.
Serpulorbis sp. (?)		
Strombus maculatus (Mamaiki)		

Table C1. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
Theodoxus neglectus (Pipipi kai)	Minor food.	Food. Believed that eating caused pregnant women to bear children with small eyes.
Trochus intextus (Haupu) [Top shell]		
BIVALVIA (Olepe)		
Atrina vexillum [Pen shell]		
Chama iostoma (Kupekala, Papaua momi) [Rock oyster]		Well liked as food.
Isognomonidae (Nahawele, Pahikaua, Oaoaka) [Toothed pearl shells]		
Isognomon californicum		Popular food.
Isognomon incisum		Popular food.
Isognomon perna		Popular food.
OPISTHOBRANCHIA		
Phyllida varicosa		
Nudibranchs (unidentified)		
ARTHROPODA		
CIRRIPEDIA		
Barnacles (unidentified) (Okohekohe) [Acorn barnacles]		
MALACOSTRACA STOMATOPODA		
Stomatopod (unidentified) (Aloalo, Lohelohe kai) [Mantis shrimp]		Large species highly prized as food.

Table C1. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
DECAPODA		
Xanthid crabs (Kumimi)		Food. Poisonous "kumimi" crabs for sorcery.
Leptodius sanguineus		
Grapsus tenuicrustatus (Aama, Alamihi) [Rock crab]	Minor food. Bait.	Food. (favored sacred food of priests). Religious sacrifice. Medicine.
Pachygrapsus plicatus		
Hermit crabs (unidentified) (Unauna, Papai una, Papai pupu)	Aquarium.	Minor food?
Panulirus penicillatus (Ula hiwa, Ula koae) [Spiny lobster]	Prized as food. Major commercial fishery.	Prized as food. Sacrifice to gods.
Stenopus hispidus (Opae huna, Opae kai) [Bandana shrimp/prawn]	Aquarium.	Probably minor food. Some shrimp (mahiki) used to cast used to cast out evil spirits.
ECHINODERMATA		
ASTEROIDEA (Peapea, Paa, Hoku kai) [Sea stars]		
Acanthaster planci [Crown-of-thorns sea star]		
Culcita novaeguineae [Pin-cushion sea star]	Minor ornamental curio.	
Linckia diplax	Minor ornamental curio.	
Linckia multifora	Minor ornamental curio.	
OPHIUROIDEA (Peapea, Pea) [Brittle stars]		
Ophiuroids (unidentified)		

Table C1. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
ECHINOIDEA	Minor food.	Food (mostly gonads).
Colobocentrotus atratus (Haukeuke kaupali, Hakue) [Shingle urchin]		Favored food (less than "wana") Medicine.
Diadema paucispinum (Wana, Wana halula)	Minor food.	Most favored as food.
Echinometra mathaei (Ina kea, Ina, Ina ula) [Pale rock boring urchin]	Minor food.	Food.
Echinometra oblonga (Ina eleele, Ina, Ina uli) [Black rock boring urchin]	Minor food.	Food.
Echinothrix calamaris (Wana)	Minor food.	One of best liked urchins as food.
Echinothrix diadema (Wana)	Minor food.	One of best liked urchins as food.
Heterocentrotus mammillatus (Haukeuke ula ula, Hakue, Punohu) [Slate pencil urchin]	Minor decorative use of spines.	Favored food (less than "wana"). Spines for pencils and carved (represent deities?)
Tripneustes gratilla (Hawae, Hawae maoli?) [Short-spined urchin]	Minor food locally.	Food (not a favored urchin).
HOLOTHUROIDEA (Loli) [Sea cucumber]	Many species important as food in early 1900's.	Some species eaten (e.g., "loli pua, loli kai"). Represented deities. Legends of creatures changing between man, holothurian, caterpillar or worm, and eel, living in sea and/or land.
Actinopyga mauritiana [Brown-speckled sea cucumber]		
Holothuria sp.		
Holothuria atra (Loli okuhi kuhi) [Black sea cucumber]		
Holothuria pervicax		
Stichopus sp.		

Table C2.

Ancient and modern uses of marine fishes found in coastal waters of KAHO Park. Scientific name (or name of major animal group) is presented first, followed by most common Hawaiian name(s) in parentheses ( ) and most common English or popular name(s) in brackets [ ]. Major sources of information are: Jordan and Evermann (1903), Cobb (1905), Gosline and Brock (1960), Hobson and Chave (1972), Titcomb (1972), Tinker (1978) and Randall (1985).

Taxon	Modern Use	Ancient Use or Significance
MYLIOBATIDAE		
[Eagle ray]		
Aetobatus narinari (Hihimanu) [Spotted eagle ray]		
MURAENIDAE		
(Puhi) [Moray eels]	Important commercially as food 1900. Very minor food now.	Prized as food, especially for chiefs. Represented deities.
Echidna nebulosa (Puhi kapa) [Snowflake moray]		Savage, bites people, moves over land and trees. Used to honor Kamehameha.
Gymnomuraena zebra (Puhi) [Zebra moray]		
Gymnothorax flavimarginatus (Puhi paka, Puhi kapa) [Yellow-margined moray]		Feared because large and "fierce".
Gymnothorax javanicus		
Gymnothorax meleagris (Puhi onio) [Whitemouth moray]		
Gymnothorax undulatus (Puhi laumilo) [Undulated moray]		Highly relished as food, but rare. Occurs in song.

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
CONGRIDAE		
(Puhi) [Conger eels]	See Muraenidae (not distinguished in reports of ancient use through early 1900's).	
Conger cinereus (Puhi uha) [Mustache conger]	Some present use as food.	Favorite food, especially for chiefs.
SYNODONTIDAE		
(Ulae) [Lizardfishes]	Moderate commercial catch 1900 ("ulae" and "welea").	
Saurida sp (Ulae)		
Synodus ulae (Ulae) [Red lizardfish]		
ANTENNARIIDAE		
[Anglerfishes]		
Antennarius sp [Frogfish]		
HEMIRAMPHIDAE		
(Iheihe, Au kuau lepa/mee mee) [Halfbeaks]	Substantial commercial catch 1900.	Food.
Hemiramphus sp (Iheihe) [Halfbeak]		

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
HOLOCENTRIDAE		
[Squirrelfishes]		
Myripristis sp (Uu) [Soldierfish, Menpachi]	Major commercial catch 1900. Presently very important sport and commercial catch.	Highly esteemed as food.
Neoniphon sammara (Alaihi) [Blood-spot squirrelfish]	Alaihi a significant commercial catch 1900. Presently a minor food item.	Alaihi a minor food item, a favorite of Kamehameha III.
Sargocentron sp (Alaihi)	See *Neoniphon sammara* (alaihi).	
AULOSTOMIDAE		
(Nunu, Nenu) [Trumpetfish]		
Aulostomus chinensis (Nunu, Nenu) [Trumpetfish]	Minor commercial catch 1900.	Food.
FISTULARIIDAE		
[Cornetfish]		
Fistularia commersoni [Cornetfish]		

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
SCORPAENIDAE		
[Scorpionfishes]	Minor commercial catch 1900.	
Dendrochirus barberi [Hawaiian lionfish, Barber's scorpionfish]		
Scorpaenopsis diabolus (Nohu omakaha) [Devil scorpionfish, Humped scorpionfish]	Minor commercial catch 1900. Excellent food fish.	Favored food fish. Legend of relationship with sharks, e.g., nohu eggs produced sharks.
Taenianotus triacanthus [Leaf scorpionfish, Three-spined scorpionfish]		
SERRANIDAE		
[Grouper]		
Anthias thompsoni [Hawaiian anthias]		
Cephalopholis argus [Roi (Polynesian, not Hawaiian)]	Small commercial and sport food fishery.	Introduced to Hawaii 1956.
CIRRHITIDAE		
[Hawkfishes]		
Cirrhitops fasciatus (Pilikoa, Poopaa, Oopu kai) [Redbar hawkfish]	Trivial in commercial catch 1900.	
Cirrhitus pinnulatus (Poopaa, Oopu poopaa, Oopu kai) [Stocky hawkfish]	Often caught for food.	Important as food.
Paracirrhites arcatus (Pilikoa) [Arc-eye hawkfish]	Trivial in commercial catch 1900.	
Paracirrhites forsteri (Hilu pilikoa, Pilikoa) [Blackside hawkfish]	Trivial in commercial catch 1900.	

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
APOGONIDAE		
(Upapalu) [Cardinalfishes]	Minor commercial catch 1900.	Food.
Apogon sp (Upapalu) [Cardinalfish]		
Apogon taeniopterus (Upapalu, Upalupalu, Upapalu maka nui) [Bandfin cardinalfish]		
PRIACANTHIDAE		
(Aweoweo) [Bigeyes]	**Moderate commercial** catch for food. Presently considered fine eating.	**Important as food.** Great schools near shore foretold death of high chief.
Heteropriacanthus cruentatus (Aweoweo) [Glasseye]	Valued, important food fish.	Important as food. Great schools near shore foretold death of high chief.
Priacanthus sp (Aweoweo) [Bigeye]	See **PRIACANTHIDAE**	
MALACANTHIDAE		
[Tilefish]		
Malacanthus hoedtii (Makaa, Ulae mahimahi) [Banded blanquillo]		

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
CARANGIDAE		
(Ulua) [Jacks]	Third largest commercial catch 1900 for food. Presently important for food and sport.	Food (eyes were a favorite).
Carangoides orthogrammus (Omilu) [Forskal's jack]	Presently taken for food and sport.	Food.
Caranx melampygus (Omilu nukumoni, Omilumilu) [Blue crevally, Blue jack, Blue ulua]	Substantial commercial catch 1900 for food. Excellent food and sport fish presently, important commercially.	
Caranx sp		
Decapterus macarellus (Opelu, Opelu mama) [Mackerel scad]	Very important commercial catch for food 1900 to present. Also used for bait.	
Gnathanodon speciosus (Ulua paopao, Ulua kanio, Paapaa) [Yellow jack]	Minor commercial catch 1900. Presently valued for food and sport.	Food (best ulua eaten raw).
Scomberoides lysan (Lai, Lae) [Leatherback, Runner, Queenfish]	Substantial commercial catch1900 for food. Presently eaten and taken for sport. Skin used for fishing lures.	Food. Skin used for drum heads.
Seriola dumerili (Kahala, Amuka, Mokuleia, Kahala maoli) [Amberjack, Greater amberjack]	Important commercial catch 1900 for food. Presently important for food and sport. Recently recognized as occasional cause of poisoning.	

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
LUTJANIDAE		
[Snappers]		
Aphareus furcatus [Gurutsu, Lehi, Forktailed snapper]	Modest commercial fishery. Well liked.	
Aprion virescens (Uku) [Blue-green snapper]	Important commercial catch for food since at least 1900. Highly prized now.	One of best food fishes.
Lutjanus fulvus [Toau, Blacktail snapper]	Small fishery for food. Well liked but not abundant.	Introduced to Hawaii 1956.
Lutjanus kasmira [Taape, Bluestripe snapper, Blue-lined snapper]	Small fishery for food. Becoming very abundant.	Introduced t o Hawaii 1958.
LETHRINIDAE		
[Emperors]		
Monotaxis grandoculis (Mu, Mamamu) [Bigeye emperor]	Few in commercial catch 1900. Presently prized as food.	Excellent food fish. Gave name to particilpant in burial ceremony. Has caused poisoning.
MULLIDAE		
[Goatfishes]	Highly esteemed important food fishes.	Important, popular food fish, including juveniles ("oama").
Mulloides flavolineatus (Weke a, Weke aa, Keokeo) [Yellowstripe goatfish, Samoan goatfish]	Highly esteemed important food fish.	Important, popular food fish, including juveniles ("oama"). Offered to gods. Used in sorcery. May cause nightmares or sleeplessness.

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
MULLIDAE (Cont'd)		
Mulloides vanicolensis (Weke ula) [Yellowfin goatfish, Golden-banded goatfish]	Highly esteemed important food fish. Important commercial catch 1900 for food.	See *M. flavolineatus*. Most favored weke. Legend that Legend that death of a chief ghost caused nightmares.
Parupeneus bifasciatus (Munu) [Doublebar goatfish, Two-striped goatfish]	Important food fish.	
Parupeneus cyclostomus (Moano kea, Moano) [Blue goatfish, Yellow-tailed goatfish]	Highly esteemed important food fish.	
Parupeneus multifasciatus (Moano) [Manybar goatfish, Red & black-banded goatfish]	Highly esteemed important food fish. Important commercial catch 1900 for food.	Significant food. Legend that red color came from moano eating lehua blossoms.
Parupeneus pleurostigma (Malu) [Sidespot goatfish, Spotted goatfish		
Parupeneus porphyreus (Kumu) [Whitesaddle goatfish]	Highly esteemed, important food fish. Important commercial catch 1900 for food.	Very important food. Offered to gods by trained masters, e.g., for canoe launchings, hula ceremonies, atonement for sins. Young used in rite to deliver person from death. Forbidden to women.
KYPHOSIDAE [Chubs, Rudderfishes]		
Kyphosus sp (Nenue, Nanue, Enenue, Manaloa)	Important catch 1900 as food. Now minor food fish.	Favored food. Once reserved for chiefs

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
CHAETODONTIDAE		
[Butterflyfishes]	All members of this family are commercially important to the aquarium fish industry.	Some religious significance (details unknown).
Chaetodon auriga (Kihikihi, Kikakapu, Lauhau) [Threadfin butterflyfish]		Possibly food. See *Zanclus cornutus*
Chaetodon citrinellus [Lemon-colored butterflyfish]		
Chaetodon ephippium (Kikakapu) [Saddleback butterflyfish]		
Chaetodon fremblii (Kikakapu kapuhili, Lauhau) [Bluestripe butterflyfish]		
Chaetodon kleinii (Kikakapu) [Blacklip butterflyfish, Klein's butterflyfish]		
Chaetodon lineolatus (Kikakapu kapuhili, Lauhau) [Lined butterflyfish]		
Chaetodon lunula (Kikakapu, Lauhau, Kapuhili) [Raccoon butterflyfish]		
Chaetodon miliaris (Lauwiliwili, Lauhau wiliwili) [Milletseed butterflyfish]	Important aquarium species commercially.	Minor food.
Chaetodon multicinctus (Kikakapu) [Multiband butterflyfish]	5th most important aquarium species commercially.	
Chaetodon ornatissimus (Kikakapu kapuhili) [Ornate butterflyfish]		
Chaetodon quadrimaculatus (Lauhau) [Fourspot butterflyfish]	Minor commercial catch 1900 ("lauhau").	Minor food fish.

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
CHAETODONTIDAE (Cont'd)		
Chaetodon trifasciatus (Kapuhili) [Oval butterflyfish]		
Chaetodon unimaculatus (Kikakapu, Lauhau) [Teardrop butterflyfish, One-spot butterflyfis		
Forcipiger spp (Nukunuku, Lauwiliwili-nukunukuoioi) [Longnosed butterflyfish, Forcepsfish]	2nd most important aquarium species commercially.	Food.
Hemitaurichthys polylepis [Pyramid butterflyfish]		
Hemitaurichthys thompsoni [Thompson's butterflyfish]		
Heniochus diphreutes [Pennantfish]	Popular aquarium species. Edible.	
POMACANTHIDAE [Angelfishes]		
Centropyge fisheri [Fisher's angelfish]		
Centropyge potteri [Potter's angelfish]	3rd most important aquarium species commercially.	
Holacanthus arcuatus [Bandit angelfish, Black-banded angelfish]		

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
POMACENTRIDAE		
[Damselfishes]		
Abudefduf abdominalis (Mamamo, Mamano, Maomao, Mamo pohole) [Hawaiian sergeant, Green damselfish]	Minor commercial catch 1900 for food. Popular today in recreational pole-and-line fishery.	Food, favored by chiefs.
Abudefduf sordidus (Kupipi, Oo nui) [Blackspot sergeant, Gray damselfish]		Food.
Chromis agilis [Agile chromis]		
Chromis hanui [Chocolate-dip chromis]		
Chromis ovalis [Oval chromis, Oval damselfish]		
Chromis vanderbilti [Blackfin chromis, Vanderbilt's damselfish]		
Chromis verater [Three-spot chromis, Black damselfish]		
Dascyllus albisella (Aloiloi, Aloiloi paa paa) [Hawaiian dascyllus]		Food.
Plectroglyphidodon imparipennis [Brighteye damselfish]		
Plectroglyphidodon johnstonianus [Blue-eye damselfish, Johnston Island damselfish]		
Plectroglyphidodon sindonis [Rock damselfish, Sindo's damselfish]		
Stegastes fasciolatus [Pacific gregory, Jenkins' damselfish]		

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
LABRIDAE		
[Wrasses]	Substantial commercial catch 1900 as food. Presently not commercially important, however wrasses are popular in the recreational pole-and-line fishery.	Religious uses, e.g., offered to gods to induce pregnancy. Snack food while drinking awa, also used in fish relish.
Anampses chrysocephalus (Opule) [Psychedelic wrasse, Golden-headed wrasse]	Moderate commercial catch 1900. 8th most numerous aquarium species commercially.	Food.
Anampses cuvier (Opule, Opulepule lauli) [Pearl wrasse, Spotted wrasse]	Moderate commercial catch 1900.	Food.
Bodianus bilunulatus (Aawa, Poou) [Hawaiian hogfish, Table boss]	Most frequent labrid in market, however not highly esteemed.	
Cheilinus bimaculatus (Poou, Pilikoa) [Twospot wrasse]		Food.
Cheilinus unifasciatus (Poou) [Ringtail wrasse]	Minor commercial catch 1900. Still eaten.	Liked as food. Has caused fish poisoning.
Cheilio inermis (Kupou, Kupoupou, Kunounou) [Cigar wrasse]	Minor commercial catch 1900.	Food.
Coris flavovittata (Hilu, Hinalea hilu) [Yellowstripe coris]	Substantial commercial catch 1900. Still eaten.	Food. Magic and religious practices. Pregnant women who craved hilu produced quiet, dignified children. Extensive legends, e.g., hilu as gods in forms of fish and man.
Coris gaimard (Hinalea akilolo, Lolo) [Yellowtail coris, Gaimard's wrasse]		
Coris venusta [Elegant coris]		

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
LABRIDAE (Cont'd)		
Cymolutes lecluse (Laenihi) [Sharp-headed wrasse]		Food.
Gomphosus varius (Akilolo, Hinaleaiwi, Hinalea nukuiwi) [Bird wrasse]		Food. Medicine, e.g. "nibbled the brain" ("aki lolo").
Halichoeres ornatissimus (Lao, Ohua paawela) [Ornate wrasse]		
Labroides phthirophagus [Hawaiian cleaner wrasse]		
Macropharyngodon geoffroy (Hinalea akilolo) [Shortnose wrasse]		
Novaculichthys taeniourus [Rockmover, Clown wrasse]		
Pseudocheilinus evanidus [Small wrasse]		
Pseudocheilinus octotaenia [Eightline wrasse]		
Pseudocheilinus tetrataenia [Fourline wrasse]		
Pseudojuloides cerasinus [Smalltail wrasse]		
Stethojulis balteata (Omaka, Ohua) [Belted wrasse]		
Thalassoma ballieui (Hinalea luahine) [Blacktail wrasse]		
Thalassoma duperrey (Hinalea lauwili, Aalaihi) [Saddle wrasse]		Food. Magic. Worship.

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
LABRIDAE (Cont'd)		
Thalassoma lutescens [Yellowish-brown wrasse]		
Thalassoma purpureum (Hou, Olali, Olani, Awela, Palaea) [Surge wrasse, Purple wrasse]	Minor commercial catch 1900 for food. Has been heavily line fished recently (not abundant).	Food. Legend that its behavior signaled behavior of fisherman's wife.
Thalassoma trilobatum (Awela) [Christmas wrasse]	Minor commercial catch 1900.	
SCARIDAE		
(Uhu) [Parrotfishes]	Important commercial and subsistence catch 1900 to present.	A favorite food (especially the liver). Legends e.g.: (1) behavior of fish signaled behavior of fisherman's wife; (2) heroic deeds of large legendary uhu and uhu fishermen.
Calotomus sp (Ponuhunuhu)		
Scarus dubius (Lauia) [Regal parrotfish, Brown parrotfish]		
Scarus perspicillatus (Uhu ahuula, Uhu uliuli) [Spectacled parrotfish]		
Scarus psittacus (Uhu) [Palenose parrotfish]		
Scarus rubroviolaceus (Palukaluka) [Redlip parrotfish]		
Scarus sordidus (Uhu) [Bullethead parrotfish]		

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
MUGILIDAE		
[Mullet]	Presently an important food.	Very important as food. Legends that eating "uouoa" mullet caused nightmares. Chant that mullet bones used to appease ghosts.
Mugil cephalus (Amaama) [Striped mullet]	Top commercial value 1900. Presently an important food.	One of most important foods. Grown in fish ponds. Very common in legends e.g., amaama descended from human parents, origin of their migrations, locations where caught and used. Offerings to gods.
SPHYRAENIDAE		
(Kaku) [Barracudas]	Minor commercial catch 1900.	Sometimes eaten (*Sphyraena helleri* was preferred).
Sphyraena barracuda (Kaku, Kupala) [Great barracuda]		
BLENNIIDAE		
(Paoo) [Blennies]	Occasionally used as bait.	Eaten alive as snacks. Bait for lines. Songs and legends.
Cirripectes vanderbilti [Scarface blenny]		
Exallias brevis (Paoo kauila, Oopu paoo) [Shortbodied blenny]		
Istiblennius gibbifrons [Hump-headed blenny]		
Istiblennius zebra (Panoo, Panoa, Paoo lehei) [Zebra blenny]		
Plagiotremus sp [Fang blenny]		

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
ACANTHURIDAE [Surgeonfishes]		
Acanthurus achilles (Pakuikui) [Achilles tang]	6th in total commercial aquarium catch.	Food.
Acanthurus blochii (Pualu, Puwalu) [Ringtail surgeonfish]	Substantial commercial catch 1900 (also see *A. xanthopterus*); young may be included in 1900 *A. nigrofuscus* catch (below).	
Acanthurus dussumieri (Palani) [Eyestripe surgeonfish]	Important commercial catch 1900. Significant trap catch now.	Favored food. Forbidden to men. Legends regarding source and effects of strong odor.
Acanthurus guttatus (Api, Hapi) [White-spotted surgeonfish]	Minor food.	
Acanthurus leucopareius (Maiko, Maikoiko) [Whitebar surgeonfish]	"Maikoiko" minor commercial catch 1900.	Food.
Acanthurus nigricans [Whitecheek surgeonfish]		
Acanthurus nigrofuscus (Maii, Maiii) [Brown surgeonfish]	"Maiii" minor commercial catch 1900.	
Acanthurus nigroris (Maiko) [Bluelined surgeonfish	May be included in 1900 *A. leucopareius* catch (above).	
Acanthurus olivaceus (Naenae) [Orangeband surgeonfish]		
Acanthurus thompsoni [Thompson's surgeonfish]		
Acanthurus triostegus (Manini) [Convict tang]	Substantial commercial catch 1900 to present.	Very important food.

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
ACANTHURIDAE (Cont'd)		
Acanthurus xanthopterus (Pualu, Puwalu) [Yellowfin surgeonfish]	Substantial commercial catch 1900 (also see *A. blochii*); young may be included in *A. nigrofuscus* statistics. Presently caught in traps and on hook-and-line.	Food.
Ctenochaetus hawaiiensis [Black surgeonfish, Hawaiian surgeonfish]		
Ctenochaetus strigosus (Kole) [Goldring surgeonfish, Yellow-eyed surgeonfish]	Important commercial catch 1900. Presently minor food catch.	Valued as food. Brought luck e.g., placed in post holes when new house built
Naso hexacanthus (Kala holo) [Sleek unicornfish]	May be included in 1900 catch with *N. unicornis*. Minor food, occurs in markets.	
Naso lituratus (Umaumalei, Kala) [Orangespine surgeonfish]	Minor commercial catch 1900 Minor food now. 4th in total commercial aquarium catch.	Food. Legends.
Naso unicornis (Kala) [Bluespine unicornfish]	Substantial commercial catch 1900. Minor food now.	Food. Legends, e.g.: (1) drowning ghosts make phosphorescent glow; (2) sacred fish to a god.
Zebrasoma flavescens (Laipala, Lauipala, Laukipala) [Yellow tang]	Minor commercial catch 1900. Now 1st in total aquarium commercial catch.	Food.
Zebrasoma veliferum (Kihikihi, Maneoneo, Api) [Sailfin tang]		
ZANCLIDAE [Moorish idol]		
Zanclus cornutus (Kihikihi) [Moorish idol]	Popular aquarium fish.	Minor food.

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
BOTHIDAE		
[Left-eyed flounders]		
Bothus mancus (Pakaii,Pakii,Pakiki, Paku, Uiui) [Manyray flatfish]	Important commercial catch 1900. Probably eaten presently.	Valued as food.
BALISTIDAE		
[Triggerfishes]	Important commercial catch 1900.	
Balistes fuscus [Brown triggerfish]		
Melichthys niger (Humuhumueleele) [Black durgon]		Food.
Melichthys vidua (Humuhumuhiukole, Humuhumu uli) [Pinktail durgon]		Food.
Rhinecanthus rectangulus (Humuhumunukunukuapuaa) [Pig-nosed triggerfish, Reef triggerfish]	State fish of Hawaii. Popular aquarium fish.	Food.
Sufflamen bursa (Humuhumu lei, Humuhumu umaumalei) [Lei triggerfish]		Food.
Sufflamen fraenatus (Humuhumumimi) [Bridled triggerfish]		
Xanthichthys auromarginatus [Gilded triggerfish]		

Table C2. (Cont'd)

Taxon	Modern Use	Ancient Use or Significance
MONACANTHIDAE		
[Filefishes]		Sometimes minor food. Occasional large natural kills drifted ashore - burned as fuel.
Aluterus scriptus (Loulu, Oili lepa, Ohua, Oilepa) [Blue-lined leather-jacket]	Occasionally taken by fishermen.	Kahunas used in sorcery to cause death.
Cantherhines dumerili (Oili, Oili lepa, Oilepa) [Barred filefish]		
Cantherhines sandwichiensis (Oili lepa, Oilepa) [Squaretail filefish]		Large numbers near shore foretold death of high chief; carcasses from large fish kills burned as fuel.
Pervagor spilosoma (Oili uwiwi, Oili lepa, Oilepa) [Fantail filefish]		
OSTRACIIDAE		
[Trunkfishes]		
Ostracion meleagris (Moa, Pahu, Moa moa waa, Oopu kaku) [Spotted trunkfish]		May be poisonous.
TETRAODONTIDAE		
[Pufferfishes]	Sometimes eaten.	Some species contain tissues toxic to humans.
Arothron hispidus (Oopu hue, Keke) [Stripebelly puffer]	Probably included in 1900 fishery statistics with *A. meleagris*.	Rarely eaten. Some contain toxic body parts. Toxin used on spear tips in combat.
Arothron meleagris (Oopu hue, Keke) [Spotted puffer]	Trivial commercial catch 1900 (also see *A. hispidus*).	Rarely eaten. Some contain toxic body parts.
Canthigaster amboinensis [Ambon toby, Amboina puffer]		
Canthigaster coronata [Crown toby, Crowned puffer]		