This report describes the biotopes and marine fauna of the reefs adjacent to Pu'ū-koholā Heiau National Historic Site and offers recommendations for the maintenance of the biota and shoreline development. It is a summary of a longer report prepared for the Cooperative National Park Resources Studies Unit (Contract No. CX 8000 6 0031). The field work was conducted from April through June, 1976 with the assistance of Mr. James MacNeil and Mr. Loren Akaka.

Study Site Description

The site for the marine survey was the area bounded by Pu'ū-koholā, Ka-wai-hae Breakwater and Spencer Beach Park. It extended 150m seaward from the southern boundary of the Historic Site and formed a rough rectangle 150m by 300m, enclosing approximately 45,000m².

Survey Methods

A. Fish. S.C.U.B.A. was used to survey the fish fauna of the site. The species list was comprised from six hours of underwater observations throughout the biotope types of the bay. Silt and rubble areas had very limited populations of fishes, therefore no quantitative assessments were made in those regions. At the southern limits of the park boundary there is a rich region of living coral in the form of patch reefs separated by sand plains. In this area two 50m transect lines were installed at a depth of 4 to 5m. An inner line was set 50m out from shore with an east-west orientation. An outer line lay seaward of, and adjacent to, the first line and ran northwest to southeast.

Three replicate censuses were performed on each transect (2 April, 1000 hours; 10 April, 1000 hours; and 10 April, 1400 hours). Fish were counted 5m on each side of the line and data recorded in 5m² quadrats on underwater paper. In addition to offshore observations, intertidal, brackish water and pond fishes were captured with small hand nets and mini spears for identification.
B. Benthic Invertebrates. Quadrats of 100m² were sampled qualitatively within representative habitats for benthic epi-and infauna. Most of the information concerning molluscs was obtained by a random sampling of patch reefs and sand deposits within the offshore portion of the site and by a detailed search along the intertidal zone. Additional identification of macroinvertebrates was made from samples of living and dead coral heads, coralline and fleshy algae and basalt or limestone rubble. The infauna in sand and mud was collected by removing surface samples of 0.5 to 1m² to a depth of 2 to 10cm with a bucket dredge and filtering the sample through a 2mm square mesh larval net.

The line transects employed for the fish censuses were used to enumerate corals and other benthic invertebrates in the coral-rich fringe zone of the site. The biota and substrate type were recorded in one meter increments along the line and samples were taken at points where an immediate identification could not be made.

Discussion

The waters adjacent to the Pu'ukoholā Heiau National Historic Site contain a fauna which is nowhere as diverse as that found in similar areas along the coast of the Island of Hawai'i (Brock and Brock, 1974; Kimmerer and Durbin, 1975). Nevertheless the area is an important resource and supports a significant population of juvenile fish and a large benthic biomass.

Physical Characteristics

The dominant factors affecting the distribution of organisms within the study site are substrate and water quality characteristics. Wave activity is, except during periods of strong southwesterly swells, limited to localized wind-driven waves less than one-half meter high. It is usually minimal in the morning and reaches a peak in mid-afternoon. Turbidity generally correlates with increased onshore wind speed and wave height. It is greatest near the inner portions of the site and the waters on the outer margin of the survey site also have a relatively high turbidity when compared with offshore waters. Visibility is greatest in the morning but never greater than 3 to 10 meters anywhere within the site. Nearshore, the water is extremely turbid (visibility less than 1m) and any activity results in a fine opaque suspension.

Salinity and temperature are influenced by warm (to 29.5°C) subsurface freshwater springs, intermittent surface runoff, prevailing exchange rates and incident solar radiation. The
Freshwater springs are most noticeable in the rocky intertidal areas between Spencer Beach Park and the Breakwater. These springs produce a distinct surface layer of warm water which overlies the cooler subsurface water over most of the site. In shallow waters the zone of freshwater influence extends through the water column and results in a more-or-less estuarine environment in these areas. The outer edge of the site has salinities and temperatures approximating oceanic seawater.

The Fish Fauna

Although the Ka-wai-hae reef system must have at one time had one of the best developed reefs in the Hawaiian Islands, today its fish fauna is depauperate due perhaps to a combination of environmental disturbances associated with harbor construction and unrestricted resource exploitation at the Pu'u-koholā site. Dredge tailings have enveloped much of the reef and siltation from these tailings has spread throughout the survey area. The occurrence of reef fishes is highly dependent upon proper habitat in the form of shelter and feeding sites (Nolan, 1975) and at Pu'u-kohola, the normal habitat has been drastically altered. As expected, the coral-rich area had more individuals and a higher diversity than any other biotope in the site.

The reef ecosystem only a few hundred meters seaward of the Park site near the proposed site of a small boat harbor is not so extensively altered. The richness of this reef as documented in pre-and post-detonation surveys during Project Tugboat by the State Division of Fish and Game (Day, et al., 1972) contrasts markedly with that of the park site. Fish and Game biologists observed or collected 111 different species of fishes in thirty-four families while only about half as many species were seen in the park site (63 total—two of which occurred in brackish pools and five were restricted to tidepools). Common species observed during Project Tugboat were Thalassoma duperreyi, Chromis ovalis, and Mullloidichthys samoensis. These were also among the most common individual species found on the Park transects. The most abundant fish seen during Project Tugboat, Scarus dubius, had a low level of abundance during the Pu'u-koholā survey.

Sharks are characteristic inhabitants of the Park site. Grey reef sharks, Carcharhinus menisorrah, black tip sharks, C. melanopterus, and white tip reef sharks, Triaenodon obesus, were seen at most high tides during calm, still air conditions. Feeding bouts on mullet have been observed and it may be that the sharks have a predatory advantage over prey in the murky, turbid water. Local fishermen report that the sharks enter the bay to mate and give birth to young. Prior to the survey a female grey reef shark was taken and found to be
bearing fetuses. An additional attractant may be the elevated water temperature and/or reduced salinity of the inner part of the survey site.

The Invertebrates--Excluding Mollusks

The distribution of invertebrate species and particularly corals and crustaceans is distinct from that of fishes and is indicative of the prevailing conditions of the area. Living corals are absent in silt laden rubble areas or limited to only a few species where silt and fresh water intrusion predominate. Many coral colonies are in what appears to be a stress-state and exhibit extensive dead zones, usually in basal areas, or reduced pigmentation. A considerable fraction of the coral-based substrate, i.e. not a sand or silt bottom, is made up of dead and moribund colonies.

Crustaceans are especially numerous in and under dead coral heads and beneath algal crusts and zooanthid mats in the intertidal zone. These habitats support a diverse population of xanthid crabs and alpheid shrimp and probably represent optimal environments for these organisms.

Bryozoans are common throughout the survey site. Turbidity and sedimentation do not appear to be a problem of survival of these animals. Most are found attached to the undersurfaces of rocks and coral colonies where they would not be affected by sediments.

Polychaete annelids, which were not identified to the genus level, were an important group of invertebrates in all habitats except those areas with a high percentage of live coral or bare pavement. The extensive porous coral rubble combined with minimal water movement offer favorable conditions for the development of large populations of serpulids in intertidal regions, sabellariids, in the silted rubble, and sabellids. The polychaetes are a major infauna in living and dead coral heads and occupy small habitats in association with sponges, bryozoans, crustaceans, gastropods and echinoderms.

The Mollusks

There appears to be a remarkably smaller population of macro-mollusks in the highly silted portion of the Historic Site than in the clearer waters further offshore and to the north and south of the site (personal observation). Cowrie species such as Cyprea caputserpentis, Linn., C. isabella Linn., and C. helvola Linn. were not seen after extensive searches under rocks and coral rubble in the area. Early morning searches of sand pockets turned up some Conus quercinus Solander, C. pulicarius Hwass, and Terebra crenulata Linn. on the Spencer Beach side of the Historic Site, but nothing comparable to
the wide variety of species of sand dwellers which can be observed in sand pockets several hundred meters seaward of the Site at approx. 5-10 meters depth (e.g. T. maculata Linn., T. guttata Roeding, T. strigilata Chem., T. areolata Link, T. affinis Gray, Hastula lanceata Linn., and H. lauta Pease).

The intertidal zone was dominated by Nerita pioea Recluz and Littorina scabra Linn., the latter being found in abundance on Kiawe (Prosopsis pallida HBK) branches hanging in the ocean. Only small populations of crabbed mollusks were observed along the coastline from Spencer Beach Park to the beach near Make-āhua Gulch during the night or day. The beach and the shoreline along the artificial breakwater bordering the northern end of the marine portion of the Historic Site were not surveyed for crabbed specimens because of the large number of empty shells available in the breakwater rubble which could become crabbed and not be representative of the living mollusks of this region.

**Man-Related Site Features**

A. Sharks, Hale-o-Kapuni and toxic organisms. Sharks are common in the site, nevertheless, local fishermen report that they have never been molested by these large carnivores and they are rarely seen swimming inside the bathing area of Spencer Beach Park (which should attract the attention of the swimmers!). Because the presence of these animals reinforces the historical significance of the shark heiau, Hale-o-kapuni, they should be protected, or at least not disturbed.

With the exception of the concentration of sharks within the apparent site of Hale-o-Kapuni, positive evidence for the existence of the structure is lacking. The area is presently heavily silted and no rock outcroppings or artificial structures are visible. The site is identified (not clearly) on Jackson's map of 1870 (Soehren, 1964) where it appears to rest about 30m offshore in line with Pu'u-koholā and Maile-kini. Soehren (1964) writes of an informant speaking of a channel leading into a structure ("heiau") where bodies were placed for sharks. Whether the bodies were human or animal was not stated. A recent archaeological survey of the site (Carol Link, personal communication) failed to reveal the presence of any subsurface structure. Thus the true significance of Hale-o-Kapuni remains unclear and it cannot be stated if it was an actual heiau or merely a site of concentrated shark activity.
Except for the sharks, few other toxic or dangerous organisms are present at Pu'ukohola. The toxic echinoids, *Echinothrix calamaris* and *E. diadema*, otherwise known as wana, are very common in shallow waters facing the rocky natural shoreline and could be a hazard to swimmers or waders in the area. A few small (1 to 3 foot) moray eels are present inshore among the coral heads and boulders.

B. Human Waste. An abundance of litter in the form of car bodies, boats, engine blocks, tires, bottles, cans and wire may be seen on the bottom and along the shoreline. Much could be done to improve the aesthetic qualities of the site both in the water and on the land by removing the litter and educating the public as to the nature of the park in an effort to maintain a relatively natural and litter-free environment.

The Ka-wai-hae breakwall and fill is a major visual obstruction but cannot be easily modified. Vegetation compatible with the park site should be placed along the breakwall facing the park to improve the visual setting, at least from sea level. An additional benefit to the plantings may be reduction in sand and silt erosion into the water from the fill area.

C. Recreational Impact. Public use of the park site can be expected to increase once access and aesthetic improvements are made. Presently gill nets are set in the northern portions of the survey site and hook and line fishermen sometimes work through the kiawe trees to fish from the shoreline. The fish species taken most frequently by these fishermen are pāpío (young of several species of ulua or jacks), mullet and moana (*Parapeneus multifaciatus*). Spearfishermen are common but their catch rates appear to be very low compared with the catch in areas north or south of the site.

Greater use of the intertidal zone is expected with increased public awareness of the park and heavier use of the neighboring county park. The organisms in this zone and subtidal areas are relatively resistant to non-consumptive use and should be protected to the limits of the survey site although some fishing could be permitted.

D. Present and Future Development. The greatest impact on the water quality and marine biota of Pu'ukohola will come from the construction and maintenance of the proposed Ka-wai-hae small boat harbor and industrial
developments in and around Ka-wai-hae harbor. For example, turbidity resulting from dredging operations can extend into adjacent areas and possibly affect the type and rate of colonization of marine organisms. Secondary impacts of these and park developments will be the release of pollutants from boats, industrial sources and cesspools.

The influence of future development on the Pu'u-koholā marine fauna will probably be overshadowed by the ongoing impact of the Ka-wai-hae breakwater. This structure undoubtedly effectively blocks longshore currents and facilitates the deposition and resuspension of detrital and organic sediments. Unless the nearshore circulation can be reestablished, the marine fauna of Pu'u-koholā will continue to undergo change to silt tolerant species.
Literature Cited


