Environmental Impact Assessment
Biological Community Evaluation

For

Pearl Farming Development
In

Keʻehi Lagoon
Oʻahu, Hawaiʻi

prepared for:
Black Pearls Inc.
P.O. Box 525, Holualoa, Hawaiʻi 96725

prepared by:
Kuʻulei Rodgers
Independent Consultant
Coral Reef Ecologist
Hawaiʻi Institute of Marine Biology
P.O. Box 1346 Coconut Island, Kāneʻohe Hawaiʻi

May 1999

1) Physical Description of Sites

a) General Description of Habitats

1) Historical

Ke‘ehi Lagoon is a fringing coral reef that has been significantly altered by dredging and landfill operations since the 1930’s. Prior to excavations and shoreline extensions for the Honolulu International Airport and Hickam Air Force Base Golf Course, Ke’ehi Lagoon was comprised of extensive mud flats behind the fringing reef with some benthic exposure during low tides. Shallow waters provided sparse navigable area. Following the construction of three seaplane runways during World War ll, navigable channels and a triangular reef remnant were created.

2) Borrow Area

A borrow area was dredged for fill material. The depth in this area ranges from 7 to 13 meters. It is almost devoid of hard substrate, consisting of fine silt.

3) Reef Flat and Slope

Subsequent dredging also substantially altered the physical environment of the reef in the lagoon. Large rock outcrops dominate the reef edge on the margins of the borrow area. The slope is more pronounced on the southern margin of the reef, descending rapidly at a steep angle. The northern and eastern margins incline gradually. Calcareous rock and rubble and course grained sand are found in the reef flat and slope areas between 0 and 5 meters, particularly on the southern margin of the reef, due to relative increased wave action. Three perennial streams provide freshwater influence to Ke‘ehi Lagoon, Moanalua, Kalihi and the Nu‘uanu Streams.

4) Outer Fringing Reef

The seaward outer reef flat is a large shallow area composed of consolidated limestone, rubble and sand. A spur and groove environment fronts the reef. A circulation channel and the Kalihi Ship Channel bisect the reef at opposite ends of the lagoon. This continuous reef margin is less than 1 to 2 meters in depth. Moving landward, the substrate changes from solid limestone to rubble, limestone outcrops and patchy sand pockets.

5) Islets

Numerous calcareous islets are found within the lagoon on the reef flat, creating a habitat for mangrove establishment. These mounds of coral, sand and rubble are mostly altered at various locales near the margins of the reef flat. Some of these islets are occupied permanently by residents, and others by transient squatters and fishermen or serve as a base for recreational activities.

6) Circulation

The circulation of the lagoon is dependent on tidal current influent and effluent and typical tradewind patterns. The residence time of the water within the lagoon was greatly improved with the addition of the Circulation Channel which provides a counter-clockwise circulation pattern around the triangular area. Flood tide currents enter through the Kalihi Channel and to a lesser degree over the reef flat. Seaward flow exits primarily through the Circulation Channel at the end of the reef runway. During ebb tide, waters from Honolulu Harbor drain into Ke‘ehi Lagoon and out the Kalihi Channel and to a lesser degree out the Circulation Channel. Thus, the Circulation Channel serves as an exit for seaward flows regardless of the tidal phase due to tidal and tradewind driven circulation.

2) Description of Sites and Stations

a) Site Selection

Eight sites were selected as representative of the area proposed for oyster cultivation (figure 1). Criteria for site selection included the proximity to the proposed cultivation area and their thorough representation of the surrounding borrow area. The water circulation pattern was a consideration in site selection. Flood tide currents enter through the Kalihi Channel and also over the outer fringing reef. Exit of water occurs primarily through the Circulation Channel.

Site 1

This site is located near the islet closest to the borrow area. This islet is the proposed land base for oyster operations and security. Anthropogenic impacts from oyster habitation of the islet was a consideration in site selection.

Site 2 &3

Inner fringing reef sites 2&3 are areas most susceptible to any impacts generated by the proposed pearl farm operations. Water flow is directed over the inner fringing reef from the borrow area. Sedimentation deposits are heaviest in this area relative to other sites.

Site 4

This site is located at the end of the borrow area making it more susceptible than other sites to any changes in water quality due to its high water retention rate.

Site 5 & 6

Outer fringing reef sites 5&6 are located seaward of the borrow area. These sites represent areas of high water circulation and exchange, least affected by proposed operations due to their up current position.

Site 7

Effluent flows out the Circulation Channel from both the borrow area and the inner harbor of Ke‘ehi Lagoon contacting Site 7 on both the incoming and outgoing tides.

Site 8

This site is located on the west, Ewa side of the dredged channel. This is the least protected of the sites representing an area where oceanic conditions prevail.

b) Location

Global positioning system coordinates were recorded for verification and future reference. Exact locations will assure return for resurvey should future monitoring of sites be proposed subsequent to proposed aquaculture operations.

Site number	North GPS coordinate	West GPS coordinate	Location
1	21^{o} 18’ 23.9”	157^{o} 54’ 26.3”	Inner circulation channel-near islet
2	21^{o} 18’ 21.4”	157^{o} 54’ 35.2”	Inner fringing reef
3	21^{o} 18’ 22.6”	157^{o} 55’ 57.0”	Inner fringing reef
4	21^{o} 18’ 19.3”	157^{o} 55’ 24.0”	West end of borrow area
5	21^{o} 18’ 11.2”	157^{o} 55’ 11.4”	Outer fringing reef

Site number	North GPS coordinate	West GPS coordinate	Location
6	21^{o} 18' 18.2"	157^{o} 54' 11.4"	Outer fringing reef
7	21^{o} 18' 10.2"	157^{o} 54' 42.7"	Outer fringing reef
8	21^{o} 18' 05.2"	157^{o} 54' 26.5"	West side of circulation channel

c) Station Selection

At each site, 3 stations were selected. Stations at 1, 3, and 10 meters address the stratification of organisms by depth providing overall representation of the sites. In Ke'ehi Lagoon, hard substratum declines in deeper waters. Habitat diversity, and diversity and abundance of organisms are also highly influenced and stratified by depth. Spatial variability within each station was addressed with replicate transects. Seasonal variability was reduced by surveying sites within the same temporal frame. All data were collected between February and April 1999. The 1m station surveys the reef flat environment with relatively high algal diversity and abundance. The 3m station includes the reef slope with higher coral cover than other depths. The 10m station reaches the bottom edge of the slope and at many sites the bottom of the lagoon. The average depth of the borrow area is 12m. This environment is characterized by low biotic diversity and considerable silt accumulation. No stations were selected below 10m since it was determined by prior observations that silt totally dominates these depths.

3) Methods of Benthic Community Evaluation

A total of 72 transects encompassed 8 sites and 3 depths. At each station, three 25m transect lines were placed on the bottom along the 1m, 3m, and 10m isobaths. A $1m^2$ quadrat was placed at 15 randomly selected points along each line. Data was recorded *in situ* using visual estimates of percent cover of all

macroscopic species and substratum occupying each quadrat. Field observations were made to qualitatively record additional species not occurring on the transects in order to compile a more complete species list and more representative estimates of abundance and distribution of coral species. Virtually all corals recorded from field observations were represented on the transects.

a) Macroalgae

Seaweeds were divided into functional form groups based on internal anatomy and external morphology. The major algal assemblages consisted of:

- Macroalgae which is defined here as large, more rigid and morphologically complex algal forms with canopy heights of > 10 mm.
- Coralline algae consists of calcareous, crustose corallines.
- Algal turfs are described here as a complex mixture of species that is widespread with heights of < 10mm. Algal turfs at Ke‘ehi stations are synonymous with the data sheet category dead coral and rubble, which they cover with fine, filamentous assemblages. Exclusion of this category in statistical analyses was due to difficulty in species identification and risk of exclusion of hard, non-biological substrate.

  Macroalgae was identified in the field to species level. Algal turfs and coralline algae encrusting rubble and dead coral were not identified to species level.

b) Substratum

Non-biological substrate was separated into the following benthic types:

- Silt is defined as fine, particulate sediment generally <64 μm of terrigenous and calcareous origin.

- Sand are grains coarser than silt of calcareous origin ranging between 64 μm and 2 mm.
- Rubble consists of unattached calcareous material ranging in size from 2 mm to 10 cm.
- Dead coral is defined here as calcareous coral skeleton lacking live tissue with surfaces dominated by filamentous algal turf < 10 mm.

The biological benthic community was subdivided into coral, seaweeds and macro-invertebrates.

c) Invertebrates

- Coral was identified to species level *in situ*. Verification and taxonomic identification of less common species or species of unusual morphology were established by biologists at the Coral Reef Ecology Laboratory at the Hawai‘i Institute of Marine Biology, University of Hawai‘i.

- Macro-invertebrates were identified to species level whenever possible. Species in the Phyla Porifera were identified to Phylum only.

4) Results and Observations

Overall Observations

Ke‘ehi Lagoon is a very poor area biologically relative to most Hawaiian coastlines and bays. This can be expected from the high turbidity and organic loading. Reef-building corals are important indicators of coastal conditions. At Ke‘ehi, habitat complexity is relatively low. Topographical relief is also low due to planar, shallow reef flats and a linear mud bottom. Differences in community structure consist primarily of differences in species organization. The primary mechanism for controlling abundance and diversity of corals is disturbance. In more protected areas like Ke‘ehi Lagoon, temperature, light, salinity, turbidity, predation and bioerosion are of equal or greater importance. There are 42

species of corals belonging to 16 genera found in the Hawaiian Islands. Twelve species belonging to 8 genera were documented at Ke‘ehi Lagoon (Table 1).

Coral Distribution and Abundance

Distribution and abundance patterns in Ke‘ehi Lagoon are typical of a disturbed environment. Coral colony size within the lagoon is small. Although all depths surveyed are in the euphotic zone, corals below 10m are nearly absent. Turbid conditions may impede feeding and limit light used by zooxanthellae for photosynthesis. The thick layer of silt at this depth inhibits recruitment due to lack of suitable settlement substrate. A total average percent cover of 0.06 at 10m substantiates this claim (figure 2). Diversity was lowest at this depth (figure 3). Station 8, exposed to cleaner, more oceanic conditions, is the anomaly with the highest average percent coral cover, 0.3.

The 3m depth has the highest average percent coral cover, 1.7 (figure 2). This may be due to less disturbance from wave energy and sufficient suitable substrate available for recruitment. Coral diversity was also highest at this depth, recording 10 species (figure 3). Dead coral and rubble dominate at this depth. Station 8 was again the outlier showing significantly higher coral cover and diversity than the other stations. The oceanographic differences of this station reflect the biological differences. *Porites lobata* and *Pocillopora meandrina*, characteristic of high wave energy environments, are found here in greater abundance than other stations.

The reef flat at 1m depth has low coral cover (0.5) with colonies of very small size due to high wave energy conditions (figure 2).

Macroalgal Diversity and Abundance

A strong correlation between algal abundance and diversity and depth occurs (figure 3). Forty-one species of algae are found at stations above 1m, declining to only 14 species at the 3m depth, with a further sharp decline to 4 species at

10m (table 2). Algal species found at 10m either grew unattached or were found attached loosely to the fine silt dominating this depth. Algal diversity was relatively constant across stations at each depth. Algal abundance at the 10m depth (2.4%) was similar to the 3m depth (2.3%) due to the wide coverage of *Halophila hawaiiensis*, an endemic seagrass (figure 2). Algae showed a 26.8% coverage at the shallow depths as expected, significantly higher than the other two depths surveyed. A total of 43 macroalgae were recorded from transects during this survey (table 3). The outer fringing reef stations showed higher average percent cover of both algae and coral although they were not significantly different due to high standard deviations (figure 4).
Species like *Acanthophora spicifera* and *Spyridia filamentosa* are highly tolerant of stagnant water. The high percent of these species reflects the poor water circulation in some areas. Many algal species have high numbers of epiphytes, another indication of polluted conditions. Pollution tolerant forms such as blue-green Cyanophytes like *Lygbya* and *Symploca* are also present in significant abundance. *Acanthophora* and *Ulva* also tolerate low circulation environments. These algae compete with coralline algae, limiting recruitment surface for coral larvae. Most of the common macroalgae found in Ke‘ehi Lagoon require or tolerate high levels of inorganic nutrients indicating high organic loading in the area. At the cleaner stations 7 & 8, percent algal cover was low and coral cover high compared to stations receiving less water circulation (figure 5).

Invertebrates

Rock boring urchins characteristic of a high energy environment were common on the reef flat (table 3). Species living in mud and dead coral (e.g. feather dusters and Christmas tree worms) were present in significant quantities. Hydroids, sponges and tunicates, typical of harbors and lagoons were also found in abundance.

5) Description and Evaluation of Environmental Impact on Benthic Substrate and Organisms

a) Primary Impacts- habitat modification and loss

1) Rare or endangered species

No impacts on the biota are expected from proposed oyster cultivation. No rare or endangered species of coral or algae were found within Keʻehi Lagoon during this survey. All recorded species are found elsewhere along the south shore of Oʻahu.

Halophila hawaiiensis was found in some abundance along the reef slope edge and bottom of the silted dredged portions of the borrow area. Little is known of the distribution and abundance of this endemic seagrass. It serves as an important food resource for the endangered green sea turtle, *Chelonia mydas*. It also serves as an important substrate for other native epiphytic species of algae. The proposed pearl farm is located away from the reef slope and is thus unlikely to disturb seagrass beds. *Halophila hawaiiensis* is found in soft substrate unsuitable for permanent anchorage.

2) Anchor Damage

Setting of anchors from small boats associated with the pearl farm will not affect the coral reef environment since they will be restricted to the dredged borrow area. Deployment of anchors from the sub-surface long-line system and working platforms placed at depths below 5m would have little impact. Few corals are located at these depths.

b) Introductions

Concerns of introduced alien epiphytic species or disease that may be transferred to native populations from farm oysters are unfounded. Spat from aquacultured oysters will be from animals native to Hawaiʻi and spawned under laboratory conditions.

c) Positive Impacts

1) Water Quality

Oysters improve water quality by filtering and removing particulate organic material from the water.

2) Benefits to the Native Oyster Population

Pearl farming operations can have positive effects on the environment and the biota. Pearl farming can be an activity benign to the environment. *Pinctada margaritifera* , the black lip pearl oyster is native to Hawai‘i. They are uncommon in the main Hawaiian Islands, found in patchy distributions throughout the archipelago. The farm may serve to reestablish and enhance the natural populations. Scattered individuals were recorded near the proposed area on the reef slope. The Ke‘ehi oyster population should benefit from the reproductive capacity of the farm. Stock from a pearl farm can also prevent possible founder effects from small population size. Low density and patchy distribution may increase susceptibility to environmental stresses, catastrophic events or anthropogenic activities. Pearl farming provides conditions favorable to the increase of the native population. Low reproductive rates due to small population size can limit populations. Depleted populations can be enhanced by larval recruitment from farm oysters.

Pinctada margaritifera is a protected marine fisheries resource. It is illegal to take, kill, possess, remove or sell this species in Hawai‘i without a permit. The black lip pearl oyster was a vital part of the native culture and must be retained, protected and managed for the survival of cultural practices and spiritual values.

Conclusions

Pinctada margaritifera is a filter feeding organism that obtains its resources from the seawater. No added nutrients that may affect species composition in the surrounding area are needed to culture farm raised oysters. Platforms, lines and

buoys will provide added substrate for recruitment of organisms naturally occurring in the vicinity. As no short or long term negative impacts to the biotic community are foreseen, no environmental protection plan or mitigating measures are necessary.

References

Devaney and Eldredge. 1977. Reef and Shore Fauna of Hawaii. Section 1: Protozoa through Ctenophora. B.P. Bishop Museum Special Publication. 64(1). Bishop Museum Press. Honolulu, Hawaii. 278 pp.

Fielding, Ann. 1985. Hawaiian reefs and tidepools. 3rd edition. China color printing company, Inc. Taipei, Taiwan, Republic of China. 103 pp.

Harvey, George. W. 1970. Final Report. Keehi Lagoon Ecological Survey. Oceanic Institute.

Kay**,** E.A. 1979. Hawaiian Marine Shells. Reef and Shore Fauna of Hawai'i, Section 4: Mollusca. Bernice P. Bishop Museum Special Publication 64 (4). Bishop Museum Press, Honolulu, Hawai'i.

Magruder and Hunt. 1979. Seaweeds of Hawaii. 1st edition. The Oriental publishing company. Honolulu, Hawaii. 116 pp.

State of Hawaii. Dept. of Transportation, Harbors Division. 1989. Keehi Lagoon Recreational Plan and Draft Environmental Statement. Honolulu, Hawaii.