APPENDIX J
MARINE SURVEYS

APPENDIX J, PART 1

REVISED FINAL DRAFT BASELINE MARINE ENVIRONMENTAL SURVEYS AT PROPOSED EHIME MARU SHALLOW-WATER RECOVERY SITES, OAHU, HAWAII

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June 4, 2001

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1.0 PURPOSE

The purpose of the marine environmental surveys described herein is to provide a baseline description of major benthic communities and associated species, including threatened and endangered species, located in the vicinity of three proposed *Ehime Maru* shallow-water berthing sites. The surveys provide a description of the affected marine environment upon which an assessment of potential direct and indirect impacts associated with shallow-water berthing, surface vessel mooring, and crewmember recovery operations will be based. This information will be utilized in an environmental assessment, prepared in accordance with implementing regulations of the National Environmental Policy Act, which will analyze and disclose the environmental consequences of the proposed *Ehime Maru* crewmember recovery project.

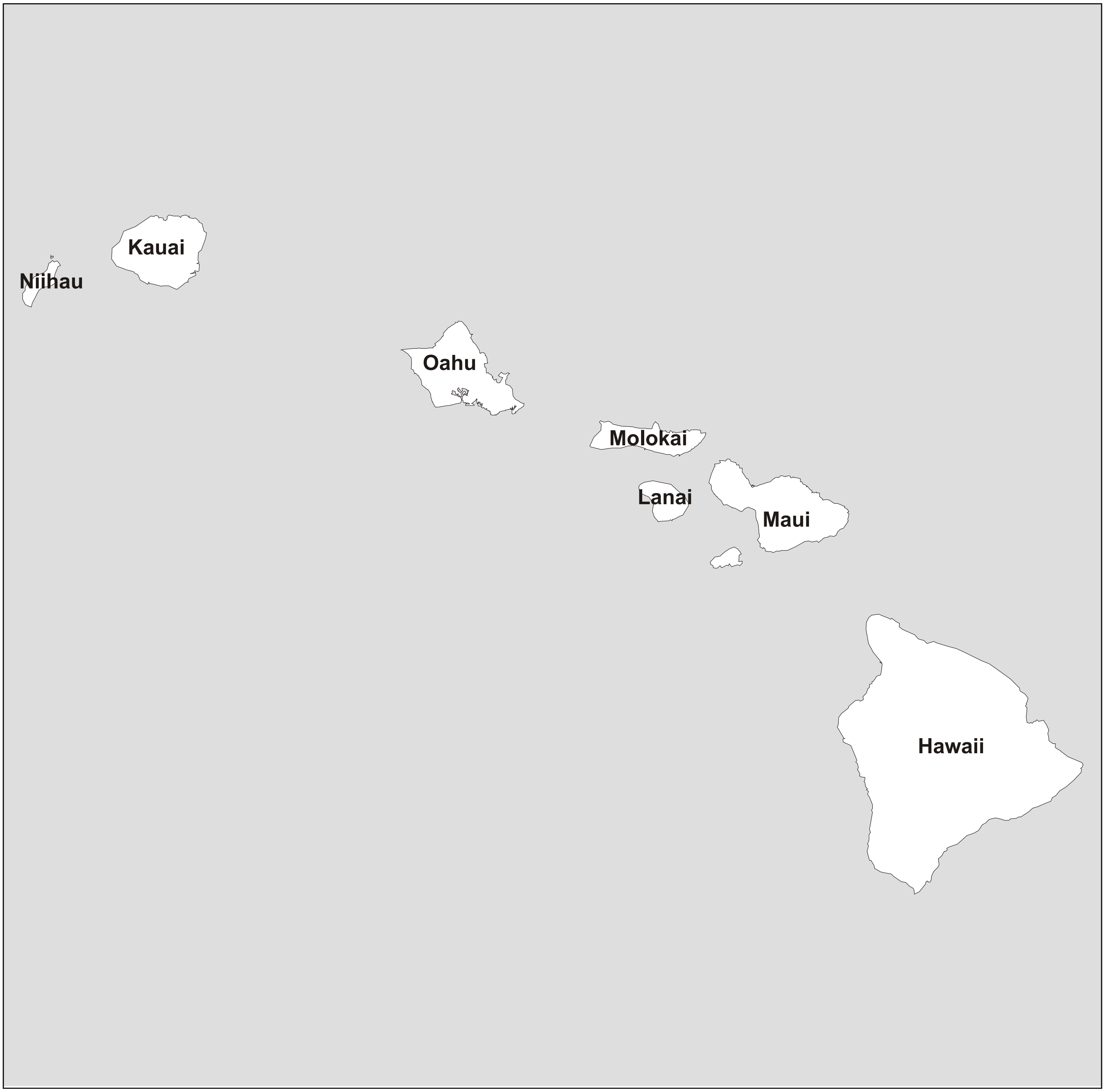
2.0 INTRODUCTION

The Hawaiian Islands are part of a linear chain of volcanoes that spans 3,800 miles (6,100 km) from the central to the northern Pacific Ocean. About halfway up its length, the chain bends, dividing the older sunken Emperor Seamounts (guyots) from the younger Hawaiian Ridge and the main Hawaiian Islands to the south (Figure J-1).

Ecologically complex marine ecosystems occur in Hawaiian waters to depths of 16,500 feet (5,000 meters) and extend inland from the coasts to include coastal marine ponds. Several factors control the variety, distribution, and abundance of marine life, including geographic isolation, subtropical climate, storm waves, and human-caused pollution and development.

Geographic isolation from the continents and other major island areas and reef systems has limited colonization by marine species. Species that were successful in reaching Hawaii sometimes evolved into new species that filled previously unoccupied ecological niches. Situated at latitudes ranging from 19 to 28 degrees north, Hawaii is exposed to cooler winter seawater temperatures and destructive waves creating a naturally harsh, mostly subtropical marine environment inhabited by fewer species than reported in the equatorial and tropical western Pacific. Hawaii’s mid-ocean location permits storm waves from both the Arctic and Antarctica to reach the Islands unimpeded, causing repeated cycles of beach erosion, reef damage, and disruption of marine ecosystems. Storm surges and waves from tropical cyclones also cause significant disturbance to coastal and near shore benthic habitats (Juvik and Juvik [eds.] 1998).

Island subsidence, earthquakes, tsunamis, freshwater flooding, and coastal discharges have also affected the marine ecosystem. In recent times, agriculture-induced soil erosion, human-caused pollution, and coastal development have taken a significant toll on the marine environment around many of the main Hawaiian Islands.



Main Hawaiian Islands

No Scale

NORTH

Figure J-1

J_1SiteMap

3.0 METHODS AND PROCEDURES

The three proposed shallow-water recovery sites are located in coastal waters of leeward Oahu, Hawaii. Prior to initiation of the field surveys, the U.S. Navy provided position coordinates (latitude and longitude) to the consultant team for three proposed candidate recovery sites. These candidate sites met defined physical environmental conditions (depth, sand deposits) required for safe diving, mooring of the recovery vessel, and temporary seafloor berthing of the *Ehime Maru* during crewmember recovery operations.

Water depths ranging from 70 to 300 feet (21 to 90 meters) and associated limited bottom time precluded utilization of self-contained breathing apparatus (SCUBA) at the proposed shallow-water recovery sites. Instead, an underwater video system integrated with Differential Global Positioning System (DGPS) navigation was utilized to characterize and document bottom substrates, benthic habitats, and associated species.

The ***Sea-AllÔ*** video system consists of a high-resolution, color video, underwater camera integrated with DGPS. The camera is positioned in a weighted camera mount with a symmetrical hydrofoil shape. The camera mount stabilizes the camera during underwater surveys. The camera is aligned for a downward view while the survey vessel slowly moves along a defined transect line. A computer-based DGPS navigation system directs the pilot of the survey vessel along pre-planned transect lines.

The camera's field of view is approximately the same width as the distance of the camera above the substrate. The camera was maintained approximately 10 to 15 feet (3 to 5 meters) above the bottom. This provided a wide field of view and minimized the risk of accidentally damaging the camera or sensitive benthic communities. The camera was occasionally lowered to within a meter of the seafloor to define the presence of small features, such as individual coral heads or algae patches.

The DGPS coordinate information is superimposed onto the video image before recording onto Hi-8 videotape. The positioning information is logged onto the system's computer at a rate of once per second.

After completion of the survey, the videotapes are analyzed. Data analysis involves trimming the data files to include only that portion of each transects within the defined survey boundaries. A working copy of the computer data file is created and any coordinate information outside of the project area is deleted from the working copy of the computer file. Video analysis is then conducted on the portions of the videotape corresponding to the project survey grid.

During videotape analysis, attributes for each data point/coordinate surveyed are assigned. This datum is added to the DGPS coordinate files that were created during the survey. Attributes included habitats such as sand, coral rubble, and debris (tires, cables, and ballast), and resources such as live coral, seagrass, algae, and sea turtles. Data files containing coordinate and attribute information are then imported into AutoCAD to create a map of each location.

Sea Engineering, Inc., of Waimanalo, Hawaii, provided bathymetry data shown in the habitat maps. These data were provided as an AutoCAD layer and imported into the habitat maps.

3.1 Survey Locations

Underwater video surveys were conducted at three locations along the south shore of Oahu, Hawaii (Figure J-2). At each location, an area 1,000 feet by 1,000 feet (1,000,000 square feet [92,900 square meters]) was initially surveyed. Communications with U.S. Navy, federal, and state natural resource officials led to the establishment of the aforementioned dimensions of the survey grid. These dimensions were based on the length of the *Ehime Maru* and the mooring requirements for the relocation vessel and the diving barge.

Reef Runway Shallow-water Recovery Site

The proposed Reef Runway shallow-water recovery site is located south of the Honolulu International Airport Reef Runway, Honolulu, Hawaii. The 1,000,000 square foot (92,900 square meter) study area was centered at 21º17.6' north latitude and 157º55.8' west longitude, with transects running east to west (Figure J-3).

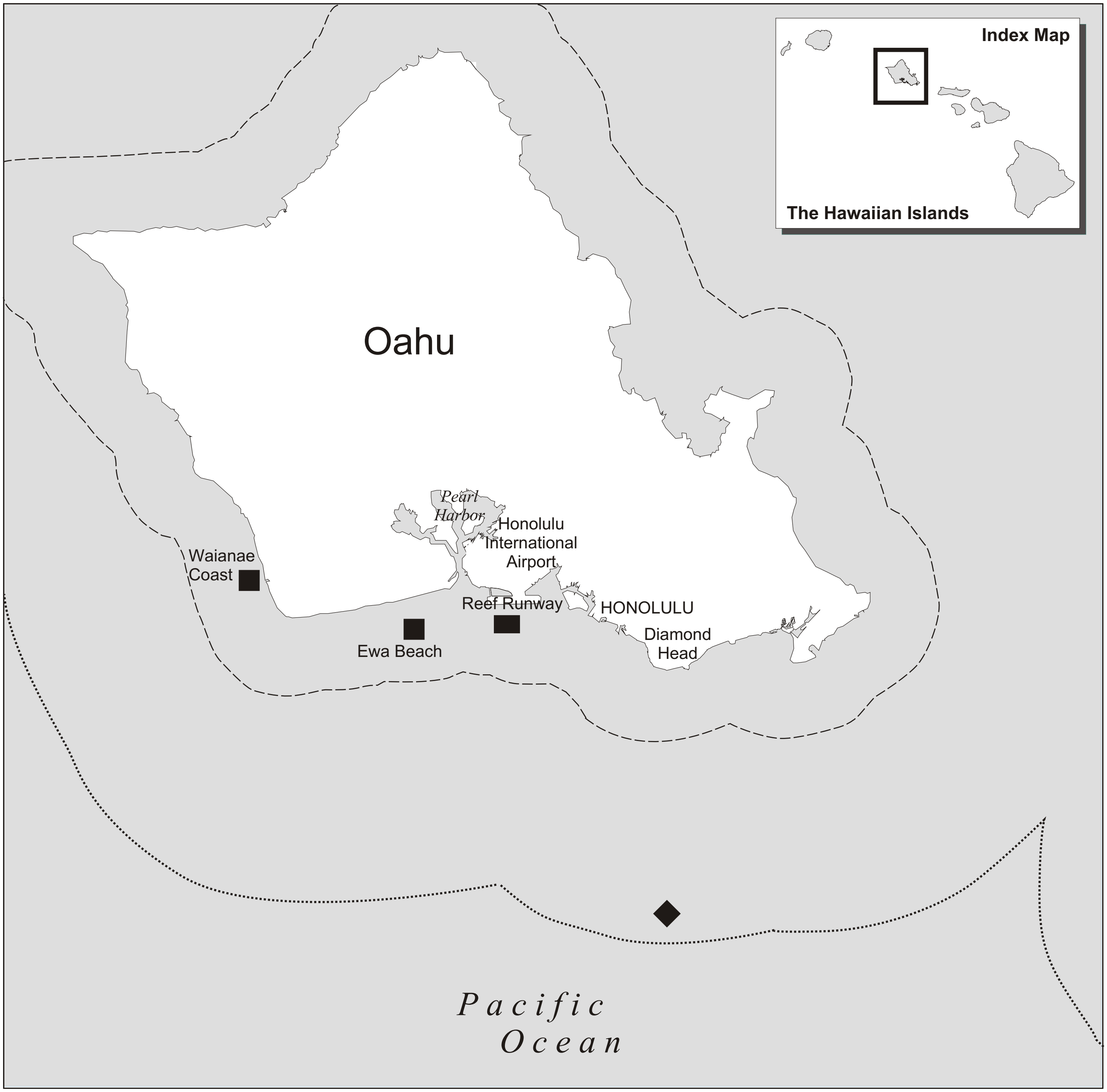
In consultations between Navy officials and the mooring design consultant, the survey area was expanded to cover an area 5,904 feet (1,800 meters) in length and 3,280 feet (1,000 meters) in width along the south side of the Reef Runway. The expanded study area extended from a depth of approximately 50 feet (15 meters) to 300 feet (90 meters), with transects running north to south (Figure J-4). The expanded survey area provided a broader range of siting opportunities for recovery vessel mooring and temporary shallow-water berthing of the *Ehime Maru*. Underwater video surveys were conducted at the expanded site on May 19 and May 23, 2001. Underwater diving surveys were conducted at point locations within the expanded site on May 31 and June 4, 2001.

The coordinates of the expanded study area are shown in Table J-1.

Table J-1. Longitude and Latitude Coordinates for the Expanded Reef Runway Shallow-water Recovery Area

Corner	Northing	Easting	Latitude	Longitude
NW	2355400	609600	21 deg. 17’ 49.88”	157 deg. 56’ 36.14”
NE	2355400	611400	21 deg. 17’ 49.29”	157 deg. 56’ 33.67”
SW	2354400	609600	21 deg. 17’ 17.16”	157 deg. 56’ 36.37”
SE	2354400	611400	21 deg. 17’ 16.77”	157 deg. 55’ 33.91”

Northing and Easting coordinates are in UTM, Zone 4 North, NAD 83, Meters. Geographic (Latitude/Longitude) coordinates are in NAD 83.



LEGEND

- ◆ Current Location
- ■ Potential Shallow-water Recovery Areas
- .... U.S. Territorial Waters (12 Nautical Miles)
- – – – – Hawaii State Waters (3 Nautical Miles)

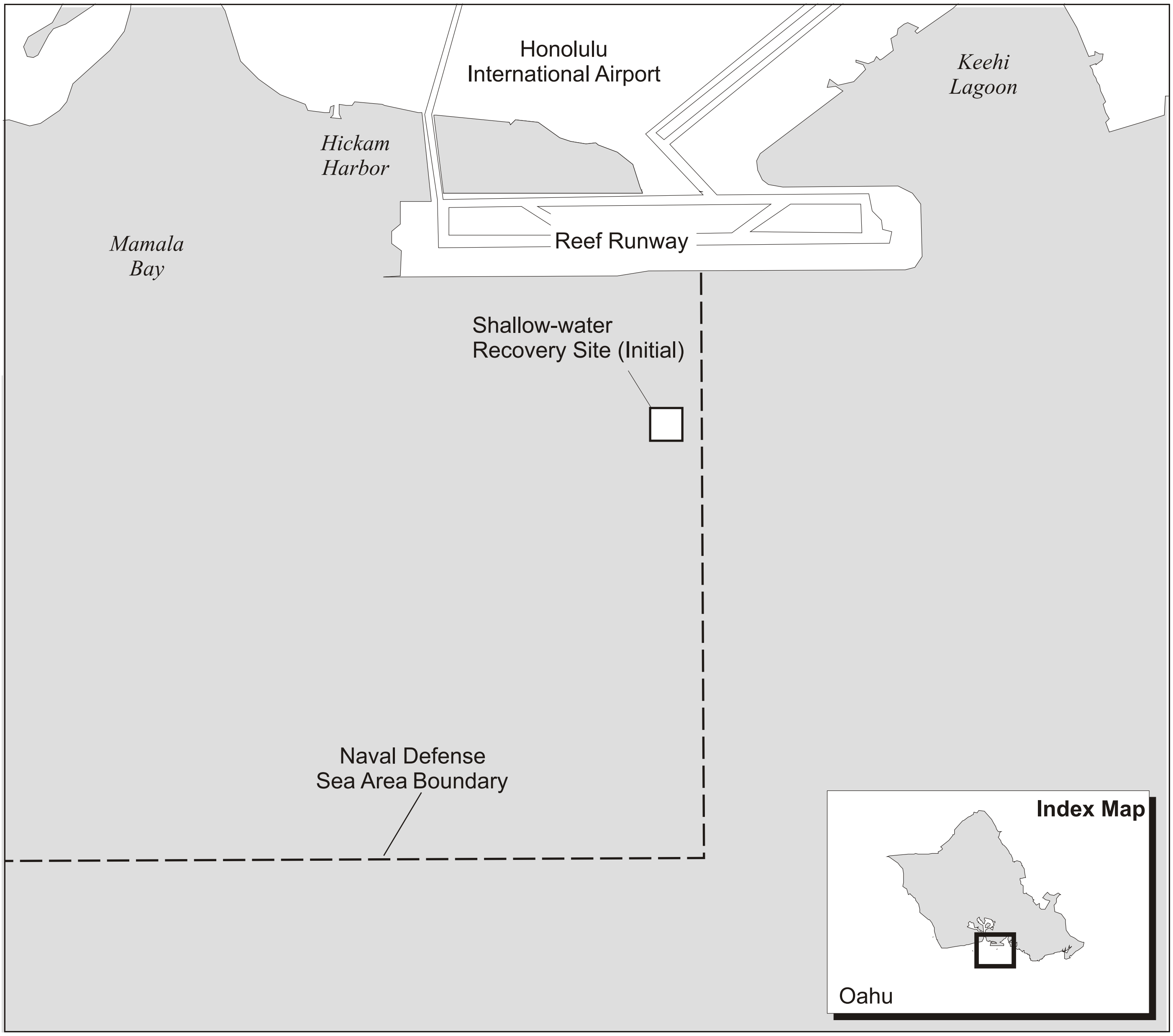
Shallow-water Recovery Sites

NORTH

No Scale

Figure J-2

2_1RelocationSite053101



LEGEND

Shallow-water Recovery Site

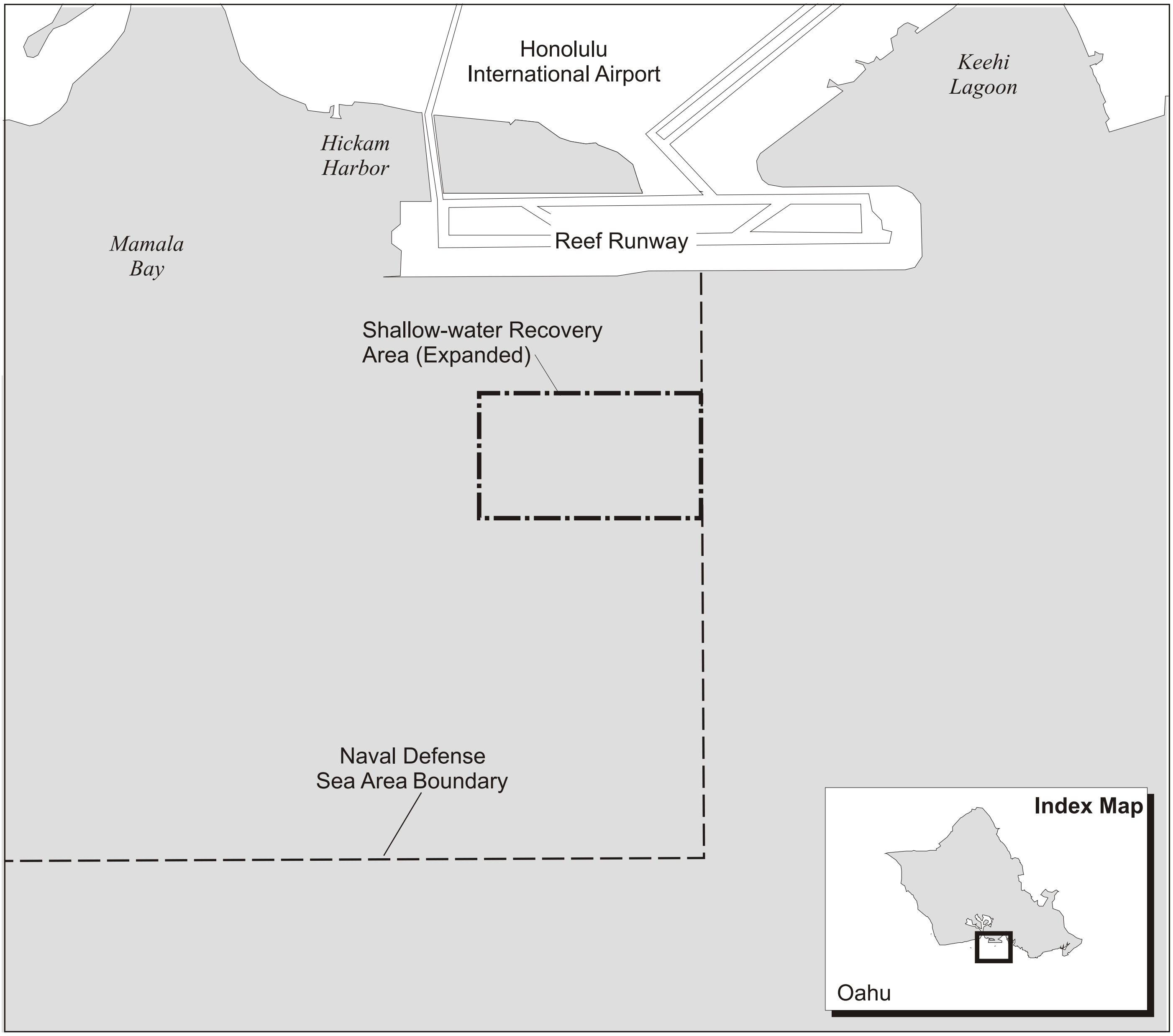
Reef Runway

NORTH

No Scale

Figure J-3

J_3ReefRunway



Reef Runway Shallow-water Recovery Area

NORTH

No Scale

Figure J-4

J_4ExpandedArea

Ewa Beach Shallow-water Recovery Site

The proposed Ewa Beach shallow-water recovery site is located seaward of Ewa Beach and west of the mouth of Pearl Harbor, Oahu, Hawaii. The 1,000,000 square foot (92,900 square meter) study area was centered at 21º17.5' north latitude and 158º00.8' west longitude, with transects running east to west (Figure J-5).

Waianae Coast Shallow-water Recovery Site

The proposed Waianae Coast shallow-water recovery site is located north of Barbers Point, Oahu, Hawaii, and offshore of the Ko Olina Resort. The 1,000,000 square foot (92,900 square meter) study area was centered at 21º19.8' north latitude and 158º08.4' west longitude, with transects running north to south (Figure J-6). Due to a transcription error that occurred during project mobilization the center of the area surveyed was 0.1' to the west from the planned center point (158º08.3' west longitude). This resulted in an offset of approximately 173 meters (568 feet).

3.2 Survey Methods

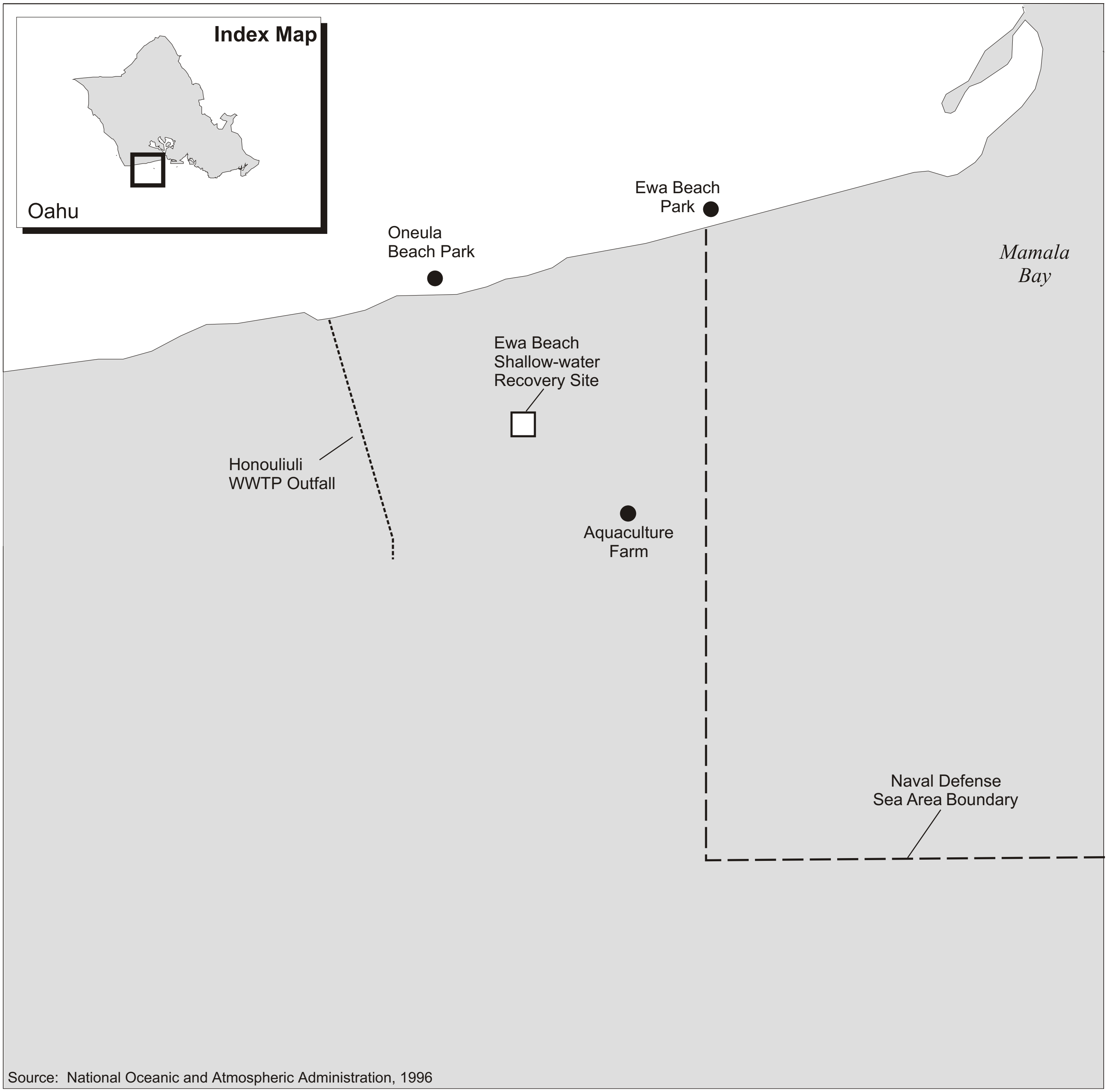
The ***Sea-AllÔ*** video mapping system was used to document and describe seafloor substrates and benthic habitats. At each location, 13 transects, approximately 1,500 feet-long (455 meters) and spaced approximately 100 feet (30 meters) apart, were established to provide representative coverage of the 1,000,000 square foot (92,900 square meter) survey site. The center point of each location was converted into the Universal Transverse Mercator (UTM) coordinate system using Corpscon for Windows Version 5.11.08 (freeware program provided by U.S. Army Corps of Engineers). The coordinate system used was UTM, Zone 4 North, North American Datum 1983, in meters.

A series of transect lines were then generated around the center point. Transects were laid out to run generally parallel to the shoreline. Therefore, they were configured to run either east to west or north to south, depending on the predominant direction of the adjacent shoreline at each proposed shallow-water recovery site. The survey vessel followed these transects while recording bottom features.

Site-Specific Notes

The proposed Waianae Coast shallow-water recovery site was surveyed on April 24, 2001. A total of 13 transects were surveyed (Figure J-7). The beach runs diagonally at this site from the northwest to the southeast. As a result, the survey area was skewed slightly, with the northeast corner being closest to the beach.

Surveys were conducted at the proposed Ewa Beach shallow-water recovery site on April 23, 24, and 25, 2001. Additional north-to-south transects, aligned perpendicular to the beach, were also surveyed (Figure J-8). The additional survey transects were analyzed in the field and no post-processing was performed. The surveys conducted on April 23 – 24, 2001, were to provide additional information on water depths and to document the



LEGEND

☐ Shallow-water Recovery Site

Ewa Beach

NORTH

No Scale

Figure J-5

J_5EwaBeach

LEGEND

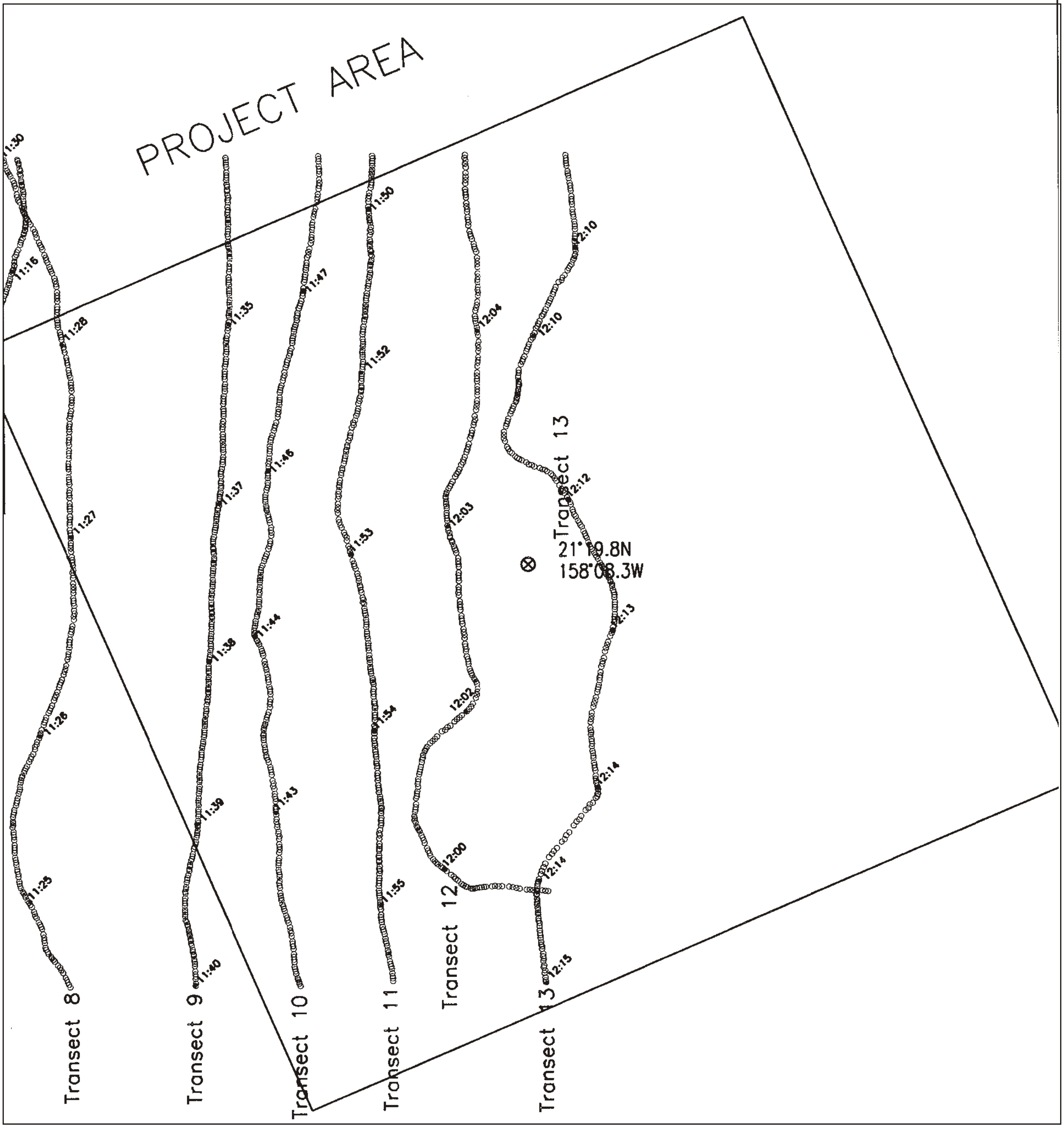
☐ Shallow-water Recovery Site

Waianae Coast

NORTH

No Scale

Figure J-6



LEGEND

Vessel Track

*11:39 Time Stamp

NORTH

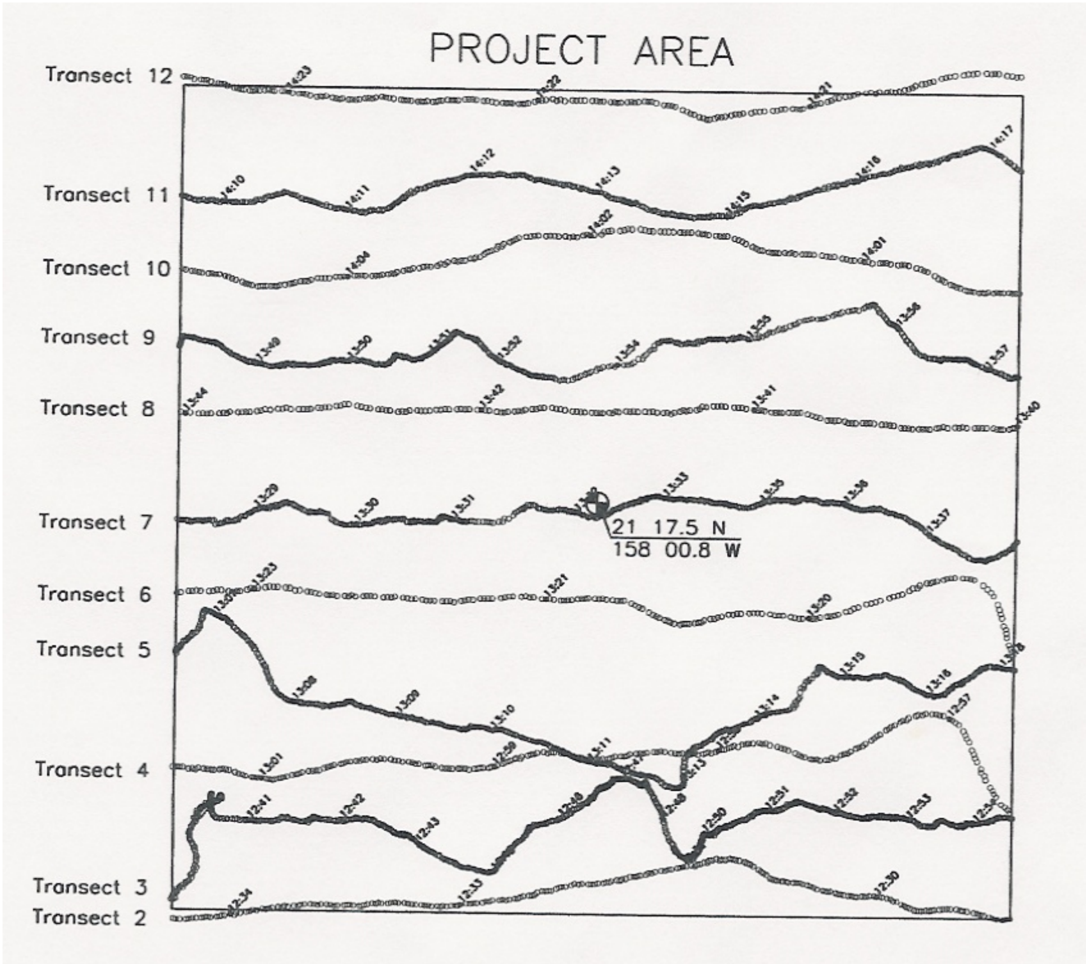
0 30 60 Meters

0 98 196 Feet

Waianae Coast Video Habitat Survey Transects

Figure J-7

J_7VideoHabitat



LEGEND

Vessel Track

*11:39 Time Stamp

Ewa Beach Video Habitat Survey Transects

0 35 70 Meters

0 114 228 Feet

NORTH

Figure J-8

J_8VideoHabitatEwa

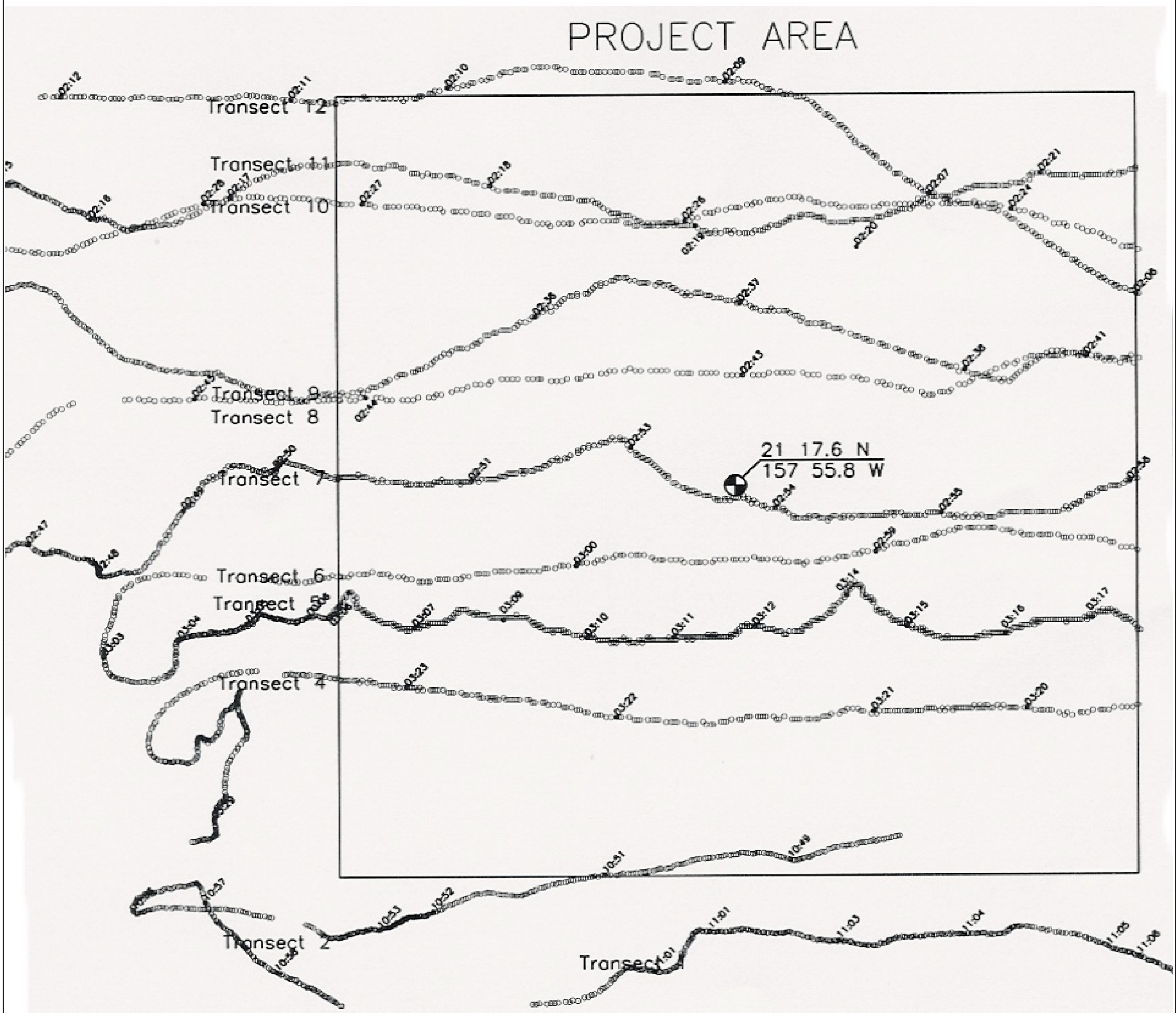
presence or absence of seagrass that represented potential forage for sea turtles. The survey conducted on April 25, 2001 was to allow National Marine Fisheries Service (NMFS), U.S. Fish & Wildlife Service (USFWS), and Hawaii State Department of Land and Natural Resources (DLNR) personnel to observe and document bottom substrates, benthic habitats (e.g., live coral, coral rubble), and associated fish and invertebrates. The videotape from the April 25, 2001 survey was not analyzed.

The underwater video system was deployed at the proposed Reef Runway shallow-water recovery site on April 22 - 23, 2001 to survey the 13 established transects. Additional north-to-south transects were surveyed on April 24 - 25, 2001 (Figure J-9). The added survey transects were analyzed in the field and no post-processing was performed. The survey conducted on April 24, 2001 provided additional information on water depths and seagrass distribution and abundance. The April 25, 2001 survey enabled NMFS, USFWS, and DLNR personnel to observe benthic habitats and locate areas potentially supporting native seagrass and other potentially sensitive resources. The state and federal resource agency personnel then surveyed selected areas within the survey grid using SCUBA to confirm video observations, develop species checklists, and collect seagrass samples for taxonomic identification.

During videotape analysis, data collected to the west and south of the proposed Reef Runway shallow-water recovery area was included in order to address the possibility of moving the project site to the west to avoid disturbance to corals and seagrass beds.
The original 1,000,000 square-foot (92,900 square meter) study area located off the south side of the Reef Runway was found to be of insufficient size and depth for the planned anchoring array required for the mooring of the *Ehime Maru* recovery vessel.

During surveys of the expanded Reef Runway study area, the transects were spaced at 246-foot (75-meter) intervals (Figure J-10). Transect numbering started at transect 14, continuing the sequence where the previously surveyed transect numbers ended. Transects were aligned perpendicular to the shore along a north/south axis. The north end of each transect was located at a depth of approximately 50 feet (15 meters). Each transect ended when the camera was lowered to the maximum length of the video cable and the bottom substrate could no longer be viewed. This usually occurred at a depth of approximately 130 feet (40 meters). All transects ending at a depth of approximately 130 feet (40 meters) were conducted on May 19, 2001.

Subsequent to the completion of the May 19, 2001 surveys, recovery vessel mooring design plans indicated the possible need for moorings to be placed at depths in excess of 130 feet (40 meters). Because the length of the video cable utilized on the May 19, 2001 surveys was insufficient to record substrate and habitat data at depths in excess of 130 feet (40 meters), a second video camera with a 500-foot (152-meter) cable was installed. The new camera successfully interfaced with the video mapping system, and the remaining transects were conducted on May 23, 2001. Transects surveyed on May 23, 2001 focused on the western half of the study area to avoid the potential presence of sensitive resources on the eastern side of the study area.



Source: Pentec, 2001

LEGEND

Vessel Track

*11:39 Time Stamp

NORTH

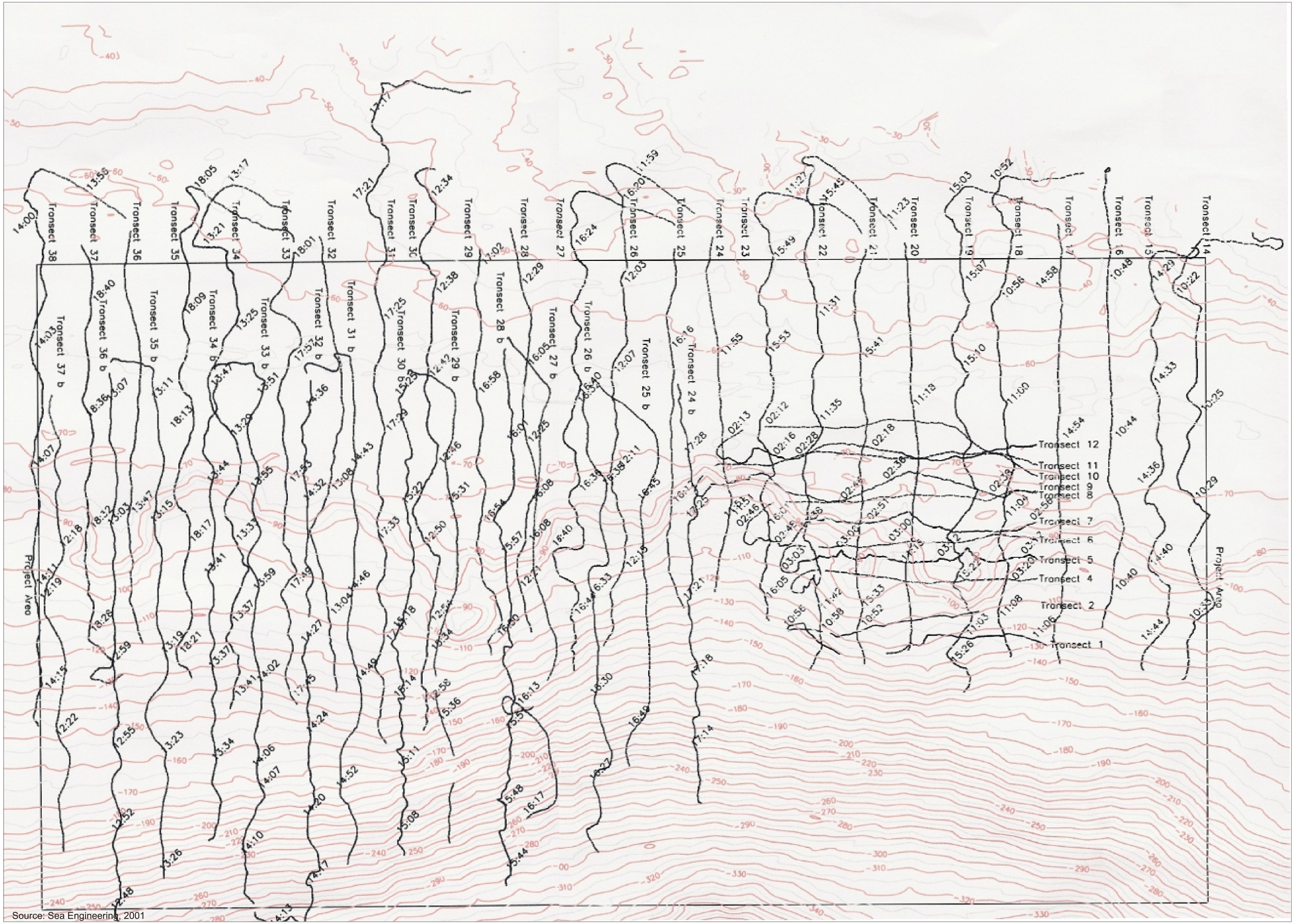
0 35 70 Meters

0 114 228 Feet

Reef Runway Video Habitat Survey Transects

Figure J-9

J_9VideoHabitatReef



Expanded Area Reef Runway Video Habitat Survey Transects

LEGEND

Vessel Track

*11:39 Time Stamp

NORTH

0 75 150 Meters

0 246 492 Feet

Figure J-10

J_10ExpandedReefHabitat

The expanded deepwater transect lines were spaced 246 feet (75 meters) apart and aligned to fall between transects surveyed on May 19, 2001. Transects were identified with the letter “b” to indicate their position between previously surveyed transect lines. These transects covered a water depth of approximately 70 to 250 feet (21 to 76 meters). Two transects (26b and 28b) extended to a depth of 300 feet (91 meters). Since the bottom topography in the survey area was known from transect lines 14 through 38, the camera was operated closer to the substrate along “b” transects. This provided greater detail in viewing bottom features, particularly at depths in excess of 130 feet (40 meters), but narrowed the field of view.

Lighting conditions were favorable, allowing video surveys to be conducted using ambient light, even at depths in below 250 feet (76 meters). Supplemental lighting was utilized only on transect 24b, which ended at a depth of 270 feet (82 meters). This transect was surveyed between 1714 and 1730 hours when the sun was at a low angle to the water.

A complete record of all transect substrate, habitat, species occurrence and distribution data obtained during the surveys conducted on May 19 and May 23, 2001 is found in approximately 13 hours of Differential Global Positioning System (DGPS)-referenced video tape, that is a part of the project’s permanent data record. These data provide approximately 47,000 discrete DGPS-referenced transect coordinates that are integrated with the corresponding substrate or habitat feature(s). The section that follows provides a summary of the major substrate and habitat features, and represented species populations, that characterize the expanded Reef Runway shallow-water recovery area survey grid.

4.0 RESULTS

4.1 REEF RUNWAY SHALLOW-WATER RECOVERY SITE

4.1.1 Overview

The Reef Runway shallow-water recovery site is located on the seaward reef slope immediately south and offshore of the mid-point of the runway. The fringing coral reef that once formed the seaward boundary of Keehi Lagoon was destroyed during construction of the Reef Runway. Prior to World War II, Keehi Lagoon was a tideland lagoon located on mudflats and a fringing coral reef that extended from Barbers Point to Diamond Head. The western terminus of the Reef Runway abuts the Pearl Harbor Channel. During World War II, the U.S. Navy initiated dredging operations to create seaplane runways in Keehi Lagoon. Three seaplane runways, dredged to approximately 13 feet (4 meters) mean sea level were constructed; each was 1,000 feet (303 meters) wide and between 10,000 and 16,000 feet (3,030 and 4,848 meters) in length. Later dredging resulted in the creation of a small boat channel just south of the Fort Kamehameha Military Reservation (Federal Aviation Administration, 1972).

As a result of dredging, the Keehi Lagoon became a popular recreational area for boating, fishing, sailing, swimming, and waterskiing. More recently, thrillcraft (jet-ski) recreation has assumed prominence. Little attention was given to the mass transport of water and the circulation patterns within Keehi Lagoon when Kalihi Channel, seaplane runways, and the channel leading to Hickam Harbor were constructed. As a result, inadequate circulation patterns created a trap for organic and inorganic pollutants that contributed to significant water pollution from sewage, industrial discharges, and other point and non-point pollution sources. The watersheds of Kalihi, Moanalua, and Kapalama streams were also contributors of pollutants and sediments of terrestrial origin to Keehi Lagoon.

Construction of the Reef Runway between 1973 and 1977 resulted in the destruction of 1,240 acres (5,018,000 square meters) of marine and estuarine habitat as a result of filling, dredging and channel construction. The former Keehi Lagoon fringing reef was destroyed by runway filling and placement of massive basalt boulders and pre-cast concrete dollose for shore protection. A total of 19,000,000 cubic yards (14,526,500 cubic meters) of fill was obtained through hydraulic suction dredging. Approximately 765 acres (3,059,000 square meters) of the 1,240 acres (5,018,000 square meters) of affected lagoon was described as "offshore land" (Federal Aviation Administration, 1972).

As part of runway construction, a new channel was dredged to allow access of small boats to Hickam Harbor. A second channel was dredged around the eastside of the Reef Runway for water circulation into and out of the lagoon. Kalihi Channel was also widened and deepened to provide an additional source of fill material for runway construction. A 240-acre (971,000 square meter) marine pond was dredged on the north side of the runway to provide additional fill material. Eleven circulation culverts were constructed to increase water exchange between the pond and adjacent waters. However, water quality within the pond is poor, as demonstrated by year-round eutrophic conditions. High levels of fecal coliform bacteria were consistently recorded east of the runway where sewage effluents were previously discharged. Diversion of sewage effluents from an outfall one-half mile offshore to a deep outfall site in about 240 feet (73 meters) of water nearly two miles offshore reportedly improved water quality within Keehi Lagoon and adjacent near shore waters (U.S. Army Engineer District, 1979).

Three designated naval anchorage areas (Anchorages B, C, and D) are located along the south side of the runway beginning at roughly the mid-point of the runway and extending about one mile (1,600 meters) to the east. A designated dump site (for dredged materials) is located about 3 miles (4,800 meters) south (seaward) of the west side of the runway (National Oceanic and Atmospheric Administration Map No. 19357, dated September 18, 1999).

4.1.2 Physical Setting

The original Reef Runway shallow-water recovery study area demonstrates water depths of approximately 70 feet (21 meters) on the north (landward) side and 110 feet (33 meters) on the south (seaward) side. The overall slope across the survey grid averages about 4 percent. A roughly 15-foot (5-meter) escarpment with an estimated slope of 30-35 percent occurs between the 72 to 90 foot (22 to 27 meter) depth contours. This feature was identified during underwater video surveys conducted on April 22, 2001, and subsequently confirmed on April 25, 2001 during dive surveys conducted by NMFS, USFWS, and DLNR personnel. Sand, coral rubble, and occasional live corals dominate the substrate at depths above 75 feet (23 meters). Surface relief is about 3 feet (1 meter) or less and results from mounds of coral rubble and live coral. At depths between 90 and 95 feet (27 and 29 meters) sand is abundant and interspersed with patches of limestone rubble and occasional live coral outcrops. Surface relief is about 2 feet (0.6 meters) or less. At depths below 95 feet (29 meters) the substrate is dominated by limestone with a coralline sand veneer. Vertical relief in waters below 95 feet (29 meters) is negligible.

The expanded Reef Runway shallow-water recovery study area grid is located within latitude and longitude coordinates identified in Table J-1. The expanded study grid is 5,904 feet by 3,280 feet (1,800 by 1,000 meters) in dimension, encompassing a surface area of 19,365,000 square feet (1,800,000 square meters) (Figure J-4). The entire 1,000,000 square-foot survey area described in section 3.1 is located within the eastern quadrant of the expanded study grid.

Vertical relief along the extreme north side of the study grid ranges between an estimated 3 to 6 feet (1.2 – 1.8 meters) at water depths between 30 and 40 feet (9 – 12 meters). Vertical relief in this inshore area results from fringing reef surge channels and reef depressions, eroded reef limestone, limestone rubble, and live and dead coral colonies. Most of this area was outside the expanded survey grid and was excluded from the data record.

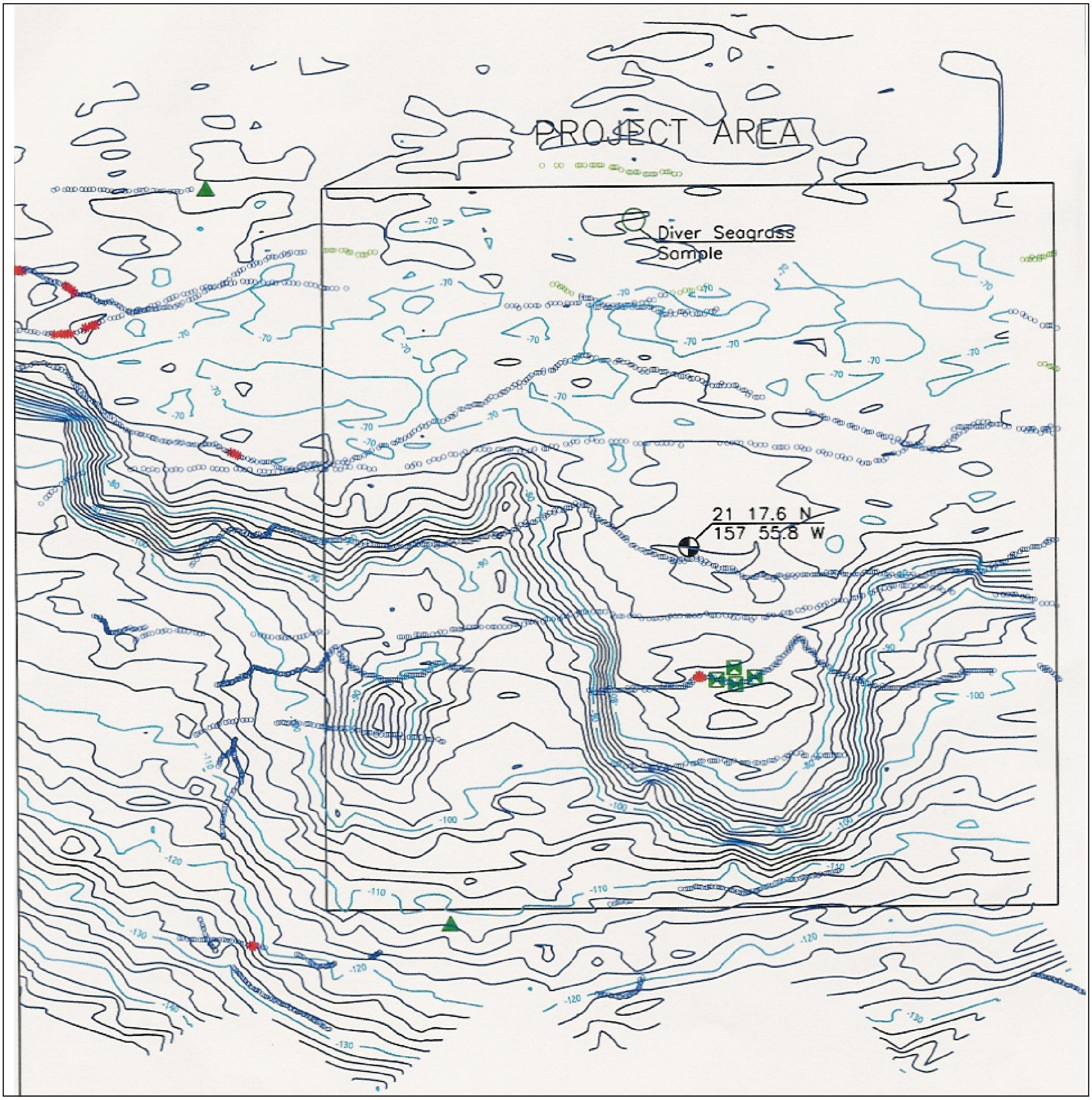
A submarine terrace dominated by sand and coral rubble is the most conspicuous physical feature along the northern half of the grid. The terrace occurs between the 60 and 70-foot (18 – 21 meter) depth contours and is 500 to 1,400 feet (152 – 427 meters) wide. The slope across the terrace ranges from approximately 0.007 to 0.02 percent. Vertical relief is estimated at less than 2 feet (0.6 meters) and is a result of coral rubble, live and dead coral outcrops, and debris. Debris has been defined as anthropogenic materials, including tires, appliances, ballast, anchors, cables, bottles, and other unidentified objects observed on or extending above the substrate.

The seaward reef slope ranges between 5 and 8 percent at depths between 70 and 120 feet (21-37 meters). Between 120 and 250 feet (37 – 76 meters) the slope increases to 10 percent on the west and up to 16.5 percent on the east side of the grid. Vertical relief is estimated at less than 1.5 feet (0.5 meters) at water depths between 70 and 170 feet (21 – 52 meters), and is the result of coral rubble, live coral colonies, and debris.

Vertical relief at water depths between 170 and 300 feet (52 – 91 meters) is estimated at one foot (0.3 meters) and is a result of sand mounds produced by burrowing worms.

4.1.3 Biota

At the original Reef Runway shallow-water study area, corals were common on the upper reaches of the study area but overall population density is low (Figure J-11). *Pocillopora meandrina* (cauliflower coral) is the most common coral observed on transects with highest densities occurring in waters of 90 feet (27 meters) or less. Overall coral coverage is generally less than 1 percent in waters of 90 feet (27 meters) or less, though localized areas, particularly along the escarpment, occasionally demonstrate an estimated 5 - 25 percent coverage. Other corals occasionally observed, though generally uncommon, are *Porites lobata* (lobe coral) and *Porites compressa* (finger coral) (Table J-2). Pockets of coral rubble are often dominated by dead and fragmented *P. compressa* colonies. A single table (bracket-forming) coral, possibly



LEGEND

- Live Coral
- Coral Rubble
- Seagrass
- Debris
- Ballast

NORTH

0 35 70 Meters

0 114 228 Feet

Reef Runway Benthic Habitats

Figure J-11

Porites rus or *Montipora verrucosa,* was observed in 95 feet (29 meters) of water during video surveys. Several colonies of the antler coral, *Pocillopora eydouxi,* were also observed atop the escarpment.

Table J-2: Checklist Of Corals, Algae, Seagrass And Invertebrates, Reef Runway Shallow-Water Recovery Site*

ALGAE

Chlorophyta (Green Algae)
Neomeris annulata

Rhodophyta (Red Algae)
Asparagopsis taxiformis
Liagora sp.

SEAGRASS (MARINE ANGIOSPERM)

Halophilia discipiens ***(introduced species)***

PHYLUM CNIDARIA (CORAL, HYDROIDS, SEA ANEMONES, JELLYFISHES)

Class Scleractinia (Stony Corals)
Family Acroporidae
Montipora sp. (*verrucosa*?)

Family Poritidae
Porites lobata ***(Lobe coral)***
Porites compressa ***(Finger coral)***
Porites sp. (*rus*?) (bracket-forming)

Family Pocilloporidae
Pocillopora meandrina ***(Cauliflower coral)***
Pocillopora eydouxi ***(Antler coral)***

PHYLUM PORIFERA (SPONGES)

Phorbas sp.
Clathria (Microciona) sp.
PHYLUM ECHINODERMATA (SEA STARS, SEA URCHINS, SEA CUCUMBERS)

Class Asteroidea (Sea Stars)
Family Acanthasteridae
Acanthaster planci ***(Crown-of-thorns starfish)***

Class Echinoidea (Sea urchins)
Family Diadematidae
Diadema sp. (Black sea urchin)
Echinothrix diadema ***(Black sea urchin)***
Echinothrix calamaris

Family Echinometridae
Echinostrephus aciculatus

Table J-2: Checklist Of Corals, Algae, Seagrass And Invertebrates, Reef Runway Shallow-Water Recovery Site* (Continued)

<u>Family Toxopneustidae</u>
Tripneustes gratilla (Collector urchin)

<u>Family Cidaridae</u>
Chondrocidaris gigantea

Class Holothuroidea (Sea Cucumbers)
<u>Family Holothuridae</u>
Holothuria atra (or *Holothuria nobilis*) (Black sea cucumber)

PHYLUM MOLLUSCA (CLAMS, SNAILS, OYSTERS, NUDIBRANCHS)

Class Gastropoda (Snails and Slugs)
Smaragdia bryanae

Class Bivalvia (Clams and Oysters)
Arca sp.
Pinctada radiata *(Pearl oyster)*

Class Nudibranchia (Nudibranchs)
Phyllidia varicosa

PHYLUM ANNELIDA (WORMS)

Class Polychaeta (Segmented Worms)
<u>Family Serpulidae</u>
Spirobranchus giganteus *(Christmas tree worm)*

PHYLUM CRUSTACEA (CRABS, LOBSTERS, SHRIMP)
Class Decapoda (True Crabs)
<u>Family Xanthidae</u>
Trapezia ferruginea

* Checklist provided by Kevin B. Foster, Fish and Wildlife Biologist, U.S. Fish & Wildlife Service, Pacific Islands Ecoregion, Honolulu; *A. planci* record provided by John J. Naughton, Pacific Islands Environmental Coordinator, National Marine Fisheries Service, Southwest Region, Honolulu, Hawaii. Data from dives conducted on April 25, 2001 and May 2, 2001. *Holothuria atra* (or *Holothuria nobilis*), Porites sp. and *Montipora* sp. records from video survey data.

Earlier studies in the vicinity of the Reef Runway reported the coral *Pavona duerdeni* and the zooanthid *Palythoa tuberculosa* as common on the upper reef slope (U.S. Army Engineer District, 1979). The same study also cited *P. compressa* as the dominant coral at a depth of 65 feet (20 meters).

The fish fauna is generally limited to small coral-associated species that were generally found in or adjacent to live coral outcrops. A total of 33 species representing 16 families were recorded during dive surveys conducted on April 25, 2001 and May 2, 2001 (Table J-3). The moorish idol, *Zanclus cornutus,* was observed on several occasions, as was the reef triggerfish, *Rhinecanthus rectangulus.* Large schools of the Hawaiian dascyllus, *Dascyllus albisella,* were observed in or hovering in close proximity to *P. meandrina* colonies. A yellow-margined moray (*Gymnothorax flavimarginatus)* and an undulated moray (*Gymnothorax undulatus)* were also recorded. Introduced fishes observed in the study area included the blue-spotted grouper, *Cephalopholis argus,* and the bluelined snapper, *Lutjanus kasmira.* Other represented families included various mullids (goatfishes), chaetodontids (butterflyfishes), pomacentrids (damselfishes), labrids (wrasses), scarids (parrotfishes), and acanthurids (surgeonfishes).

Earlier studies have reported a moderately diverse fish fauna on the reef slope adjacent to the Reef Runway. Fish species identified as "abundant" in the area included *Acanthurus triostegus*, *A. nigrofuscus, Ctenochaetus strigosus, Thalassoma duperrey, Chaetodon multicinctus, Chromis vanderbilti, Stegastes fasciolatus, Canthigaster jactator* and *Scarus* sp. (U.S. Army Engineer District, 1979).

The invertebrate fauna was composed of 16 identified invertebrates with echinoderms accounting for half of the checklist (Table J-2). The invertebrate fauna associated with the sand-veneered limestone terrace at depths of 95 feet (29 meters) or greater is dominated by black sea urchins (*Diadema* sp. and *Echinothrix diadema*). Unidentified black holothurians (sea cucumbers) (*Holothuria atra* or *Holothuria nobilis*) were also common in rubble or sand patches below a depth of 95 feet (29 meters). A single *Acanthaster planci* (crown-of-thorns starfish) was observed feeding on a live coral colony. A single pearl oyster, *Pinctada radiata*, was observed at a depth of 100 feet (30 meters) on the seaward reef slope. The presence of *P. radiata* is somewhat unusual, as this species is relatively uncommon and normally occurs in shallow estuarine waters.

The introduced seagrass, *Halophila discipiens,* was observed in sandy areas. This species is believed to be a recent introduction into Hawaiian waters, its normal range being tropical waters to the southwest (Foster, personal communication). This species is taxonomically similar to the native *Halophilia hawaiiana*, which was not observed in the survey area. Both species may provide forage for the green sea turtle (*Chelonia mydas*).

Table J-3: Checklist Of Fishes, Reef Runway Shallow-Water Recovery Site*

Family Muraenidae (Moray Eels)
Gymnothorax flavimarginatus *(Yellow-margined moray)*
Gymnothorax undulatus (Undulated moray)

Family Aulostomidae (Trumpetfishes)
Aulostomus chinensis *(Trumpetfish)*

Family Holocentridae (Squirrelfishes and Soldierfishes)
Myripristis kuntee *(Pearly soldierfish; Shoulderbar soldierfish)*

Family Serranidae (Groupers)
Cephalopholis argus *(Blue-spotted grouper)***

Family Lutjanidae (Snappers)
Lutjanus kasmira (Bluelined snapper)**

Family Mullidae (Goatfishes)
Mulloides vanicolensis *(Yellowfin goatfish)*
Parupeneus multifasciatus *(Multibarred goatfish)*

Family Chaetodontidae (Butterflyfishes)
Chaetodon quadrimaculatus (Fourspot butterflyfish)
Chaetodon miliaris *(Milletseed butterflyfish)*
Chaetodon lineolatus (Lined butterflyfish)
Chaetodon ornatissimus (Ornate butterflyfish)
Chaetodon multicinctus (Multiband butterflyfish)

Family Pomacentridae (Damselfishes)
Dascyllus albisella (Hawaiian dascyllus)

Family Labridae (Wrasses)
Bodianus bilunulatus *(Hawaiian hogfish)*
Thalassoma duperrey (Saddle wrasse)
Thalassolma ballieui (Blacktail wrasse)
Gomphosus varius (Bird wrasse)

Family Scaridae (Parrotfishes)
Scarus sordidus (Bullethead parrotfish)
Scarus rubroviolaceus (Redlip parrotfish)

Family Zanclidae (Moorish Idol)
Zanclus cornutus (Moorish idol)

Family Acanthuridae (Surgeonfishes and Unicornfishes)
Acanthurus triostegus (Convict tang)
Acanthurus leucoparius (Whitebar surgeonfish)
Acanthurus olivaceus (Orangeband surgeonfish)
Acanthurus nigroris (Bluelined surgeonfish)
Naso lituratus (Orangespine unicornfish)
Naso hexacanthus (Sleek unicornfish)

Table J-3: Checklist Of Fishes, Reef Runway Shallow-Water Recovery Site* (Continued)

Family Balistidae (Triggerfishes)
Rhinecanthus rectangulus (Reef triggerfish)
Melichthys vidua (Pinktail durgon)
Sufflamen bursa (Lei triggerfish)

Family Ostraciidae (Trunkfishes)
Lactoria fornasini (Thornback cowfish)

Family Tetraodontidae (Puffers)
Arothron hispidus (Stripebelly puffer)

Family Carangidae (Jacks/Trevallies)
Decapterus macarellus ***(Mackerel scad)***

* Checklist provided by John J. Naughton, Pacific Islands Environmental Coordinator, National Marine Fisheries Service, Southwest Region, Honolulu, Hawaii. Data from dives conducted on April 25, 2001, and May 2, 2001.

** Introduced species

At the expanded Reef Runway shallow-water recovery site, the expansive terrace that occurs between the 60 and 70-foot (18 – 21 meter) depth contours is characterized by a diversity of habitats, including limestone rubble, sand, sand and algae patches, sand-veneered limestone, and live and dead coral outcrops (Figure J-12). Surface features and habitats differ significantly across the terrace due to the occurrence of surge channels that were once a part of the Keehi Lagoon fringing reef (the latter destroyed by Reef Runway filling). During periods of heavy ocean swell and wave action, rubble and corals from more biologically diverse inshore habitats are likely transported seaward and down-slope and deposited onto the terrace. Areas on the terrace in proximity to what appear to be surge channels generally demonstrate greater limestone rubble accumulations, as well as more live and dead coral coverage, than other areas at some distance from surge channels. Unconsolidated sands dominate the terrace substrate in areas away from surge channel outlets.

Corals are common on the terrace in areas where limestone rubble provides a solid substrate for coral larval attachment and growth. *Pocillopora meandrina* (cauliflower coral) is the most abundant coral observed in the study area with estimated coverage averaging less than 1 percent, though occasionally demonstrating up to 30 percent coverage along the escarpment bordering the north side of the terrace and on vertical to near vertical slopes within surge channels. *P. meandrina* occasionally accounts for an estimated 90 percent coverage in localized areas at depths less than 90 feet (27 meters). Areas with high coral coverage are infrequent and are generally restricted to narrow escarpments with steep limestone or rubble slopes.

Mound-shaped *Porites lobata* (lobe coral) and *Porites compressa* (finger coral) are also conspicuous on the terrace, as are colonies of *Pocillopora eydouxi* (antler coral). The prostrate, encrusting growth form *P. lobata* is also occasionally observed in areas dominated by coral rubble at water depths above 95 feet (29 meters). Colonies of bracket-forming *Montipora* spp. was also occasionally observed, but was generally uncommon on the terrace.

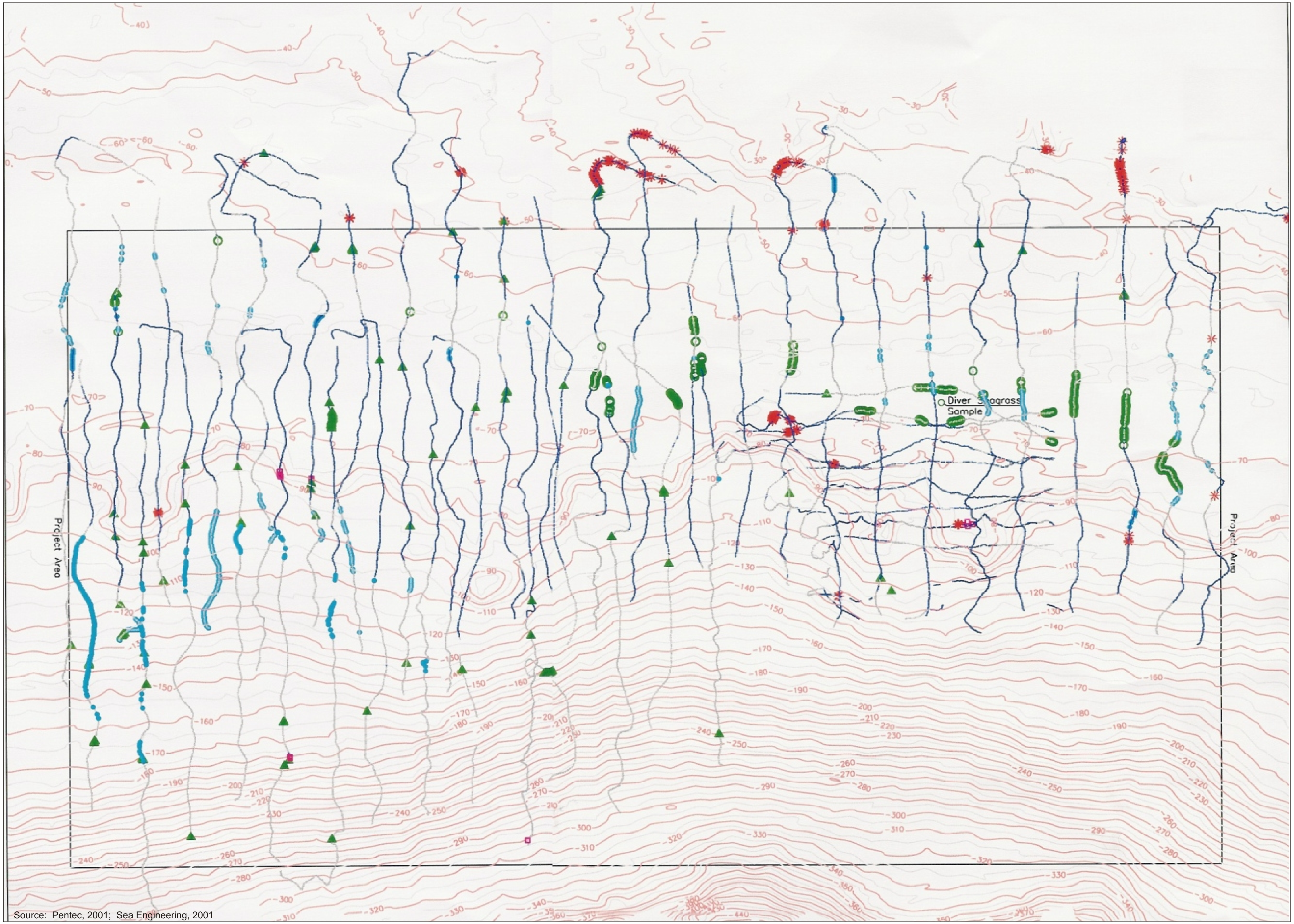
The escarpment located between the 80 and 90-foot (24 - 27 meter) depth contours is a zone of dense coral coverage. Coral coverage along this narrow escarpment ranges from an estimated 40 to 90 percent along transects 18, 35b, and 36 b. These coral stands were generally composed of a mixed community of *P. meandrina, P. compressa, P. lobata, Montipora* sp., and *P. eydouxi*. A diverse coral community demonstrating approximately 80 percent coverage also occurs at a depth of about 50 feet (15 meters) on transect 30.

The deepest live coral colony observed during the surveys was a single bracket-forming *Montipora* spp. colony that was observed at a depth of 165 feet (50 meters) on transect 30b. Corals are rare at depths in excess of 120 feet (37 meters). The few live colonies observed at depths in excess of 120 feet (37 meters) were generally small; their presence at these depths possibly resulting from storm wave deposition.

Fishes associated with the reef terrace included small coral-associated species that were generally found hovering over or in the vicinity of live coral colonies. A total of 33 species of fish representing 16 families were recorded during dive surveys (describedin section 4.1.3). Families observed during May 19 and 23, 2001 surveys included chaetodontids (butterflyfishes), pomacentrids (damselfishes), labrids (wrasses), scarids (parrotfishes), acanthurids (surgeonfishes), balistids (triggerfishes), mullidae (goatfishes) and the zanclid (one species constitutes the family Zanclidae), *Zanclus cornutus*. The most abundant fish observed in the study area was *Dascyllus albisella* (Hawaiian dascyllus). *D. albisella* aggregations were often numerous hovering over or in the vicinity of live *P. eydouxi* corals at depths between approximately 50 feet (15 meters) and 120 feet (37 meters).

A dense assemblage of *Diadema* spp. (black sea urchin), numbering in the thousands, was observed on a limestone slope at a depth of 70 feet (21 meters) on transect 35b. Although urchins were common on limestone and rubble substrates throughout the study area, the density of this aggregation is unusual. The aggregation occurred in a band approximately 15 feet (5 meters) wide along a corridor estimated to be at least 30 feet (9 meters) long. The density of this aggregation is estimated at 100 per square meter. A single *Acanthaster planci* (crown-of-thorns starfish [sea star]) was observed on a live coral colony on transect 27b at a depth of 65 feet (20 meters). A single sea star, possibly *Mithrodia fisheri*, was observed on transect 36b at a depth of approximately 190 feet (58 meters).

Macro-algae and the introduced seagrass *Halophilia discipiens* were widely distributed in sandy areas on the reef terrace with the greatest densities occurring on the east side of the grid (transects 15 through 26). *H. discipiens* samples were not collected for taxonomic identification during the May 19 and 23, 2001 surveys. It has been assumed, on the basis of water depths and habitat similarities, to be the same seagrass identified by U.S. Fish and Wildlife Service taxonomists during the earlier surveys (Appendix J, Part 1).



Expanded Area Reef Runway Benthic Habitats

LEGEND

Live Corel
Corel Rubble
Sand
Seagrass
Algae
Debris
Ballast

0 75 150 Meters
0 246 492 Feet
NORTH

Figure J-12

An unidentified tube-dwelling, mound-building, nocturnal terebellid (family Terebellidae) polychaete worm dominates the infauna at water depths between 170 and 260 feet (52 – 79 meters). One isolated assemblage was also observed on transect 34b at a depth of 140 feet (43 meters). Terebellid densities ranged from an estimated 1 to 3 per square meter at water depths between 170 and 260 feet (52 – 79 meters). Terebellid density was an estimated 9 per square meter on transect 34b. Although individual worms were not observed during the diurnal surveys, their presence is readily discernible in the form of tentacle tracks in bottom sediments that radiate out from an elevated cone in a distinctive spoke-like pattern. Long contractile tentacles are a unique feeding organ found in many terebellid worms.

No other discernible benthic or epibenthic macrofauna, or infauna were observed at depths between 260 feet (79 meters) and 300 feet (91 meters), though irregular to sometimes linear tracks were occasionally observed on the substrate at water depths between 170 and 260 feet (52 – 79 meters). These tracks, which disturb the substrate surface layer, may result from gastropod (snail) foraging or the movement or grazing activities of other benthic invertebrates.

Accidental disturbances to the seafloor substrate by the camera housing during illuminated surveys conducted on transect 24b indicated the presence of a thin brownish-green mat at depths in excess of 170 feet (52 meters). Such mats are often composed of living and dead diatoms, zooplankton, phytoplankton, organic detritus, and heterotrophic bacteria.

Small fragments of detached macro-algae were occasionally observed at depths between 260 and 300 feet (70 – 91 meters). These macro-algae likely originated in shallow inshore areas and were transported by water currents to deeper offshore waters where they eventually settled to the bottom.

Swarms of macroscopic zooplankton were occasionally detected in the water column within 10 to 15 feet (3 - 5 meters) of the bottom at depths between 260 and 300 feet (70 – 91 meters). Zooplankton was particularly noticeable under artificial light illumination on transect 24b. They were less noticeable, though still discernible at water depths between 260 and 300 feet (70 – 91 meters) under ambient light conditions.

Fish were generally rare below a depth of 130 feet (40 meters) because of the absence of coral reef habitat. However, a mixed school of at least twenty *Z. cornutus* (moorish idols) and several *Chaetodon fremblii* (bluestripe butterflyfish) was observed at a depth of 170 feet (52 meters) on Transect 34b. Both species would normally be found in coral reef habitats. Demonstrating somewhat unusual behavior, the mixed school of *Z. cornutus* and *C. fremblii* swam ahead and to the side of the camera housing for over 20 seconds.

An adult *Sphyraena barracuda* (great barracuda) was recorded on Transect 35b at a depth of 230 feet. This individual had an estimated length of approximately 4 feet (1.2 meters) and displayed what appeared to be aggressive behavior toward the passing camera housing.

4.1.4 Threatened and Endangered Species

A single pod of humpback whales (*Megaptera evangelae*), comprising two to three individuals, was observed spouting on April 22, 2001, about 2 miles (3,200 meters) offshore of the Reef Runway shallow-water recovery area. It is somewhat unusual for humpback whales to be observed in late April in Hawaiian waters (Oishi, personal communication). The pod appeared to be navigating in a westerly direction towards the Barbers Point area and was likely enroute to summer feeding areas in the North Pacific Ocean.

At the expanded Reef Runway shallow-water recovery site, an adult green sea turtle (*Chelonia mydas*) was recorded on transect 30 at a depth of 70 feet (21 meters) on May 19, 2001. This individual appeared to be resting on the reef terrace in an area sheltered by coral outcrops.

4.2. EWA BEACH SHALLOW-WATER RECOVERY SITE

4.2.1 Overview

The most extensive deposition of reef limestone on Oahu during a higher stand of the sea occurred over the Ewa plain. Deep borings conducted 600 feet (182 meters) behind the shoreline of Ewa Beach penetrated a 1,000-foot (303-meter) thick deposit of raised reef, sand, lagoonal muds and alluvial muds before reaching the basaltic core of Oahu. Ancient high and lower stands of the sea have been inferred from these results (U.S. Army Engineer District, 1979).

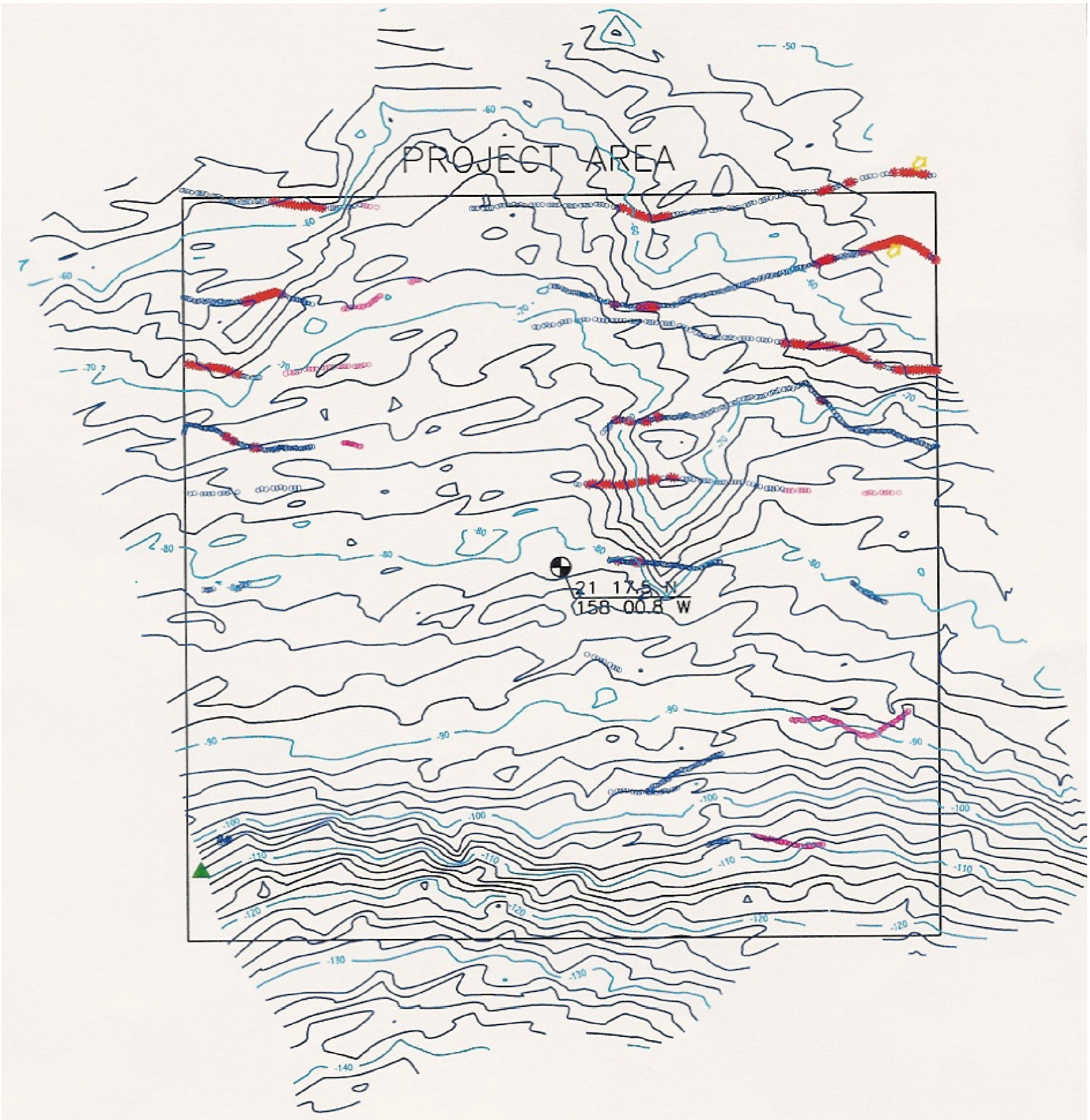
The Ewa shoreline is a narrow and straight sand beach with dozens of residential homes lining the back beach area. The beachfront is steep and is sometimes backed by a storm-built gravel berm. The coast is subject to high surf and tsunami flooding. The tsunami of 1960 caused a run-up to 9 feet (3 meters) above sea level (U.S. Army Engineer District, 1979).

4.2.2 Physical Setting

The submerged reef that extends seaward from the Ewa coast is widest fronting Ewa Beach. Water depth increases very gradually offshore with the reef edge located about 4,500 feet (1,364 meters) offshore. Limestone rubble and sand litter the reef terraces found offshore at depths greater than 50 feet (15 meters) (U.S. Army Engineer District, 1979). Vertical relief is greatest at water depths of 65 to 80 feet (20 to 24 meters) where live corals are abundant. Below approximately 85 feet (26 meters), the substrate is composed of a mix of ancient reef limestone, coral rubble, sand, and occasional live coral outcrops. Sand deposits are sometimes deep and vertical relief is provided by cone- shaped mounds resulting from the activities of unidentified burrowing organisms. The seaward slope increases significantly at a depth of 98 feet (30 meters) and reaches a depth of 124 feet (38 meters) at the seaward terminus of the survey grid.

4.2.3 Biota

Video surveys conducted on April 22, 2001 indicated that corals ranged from locally abundant on the northern inshore reef slope at the Ewa Beach shallow-water recovery site, to uncommon on the broad sandy slopes on the south (seaward) side of the site (Figure J-13). Coral coverage ranges from 80 to 90 percent at depths between 58 and 78 feet (18 and 24 meters) to less than 1



LEGEND

Live Coral

Coral Rubble

Algae

Debris

Turtle

NORTH

0 35 70 Meters

0 114 228 Feet

Ewa Beach Benthic Habitats

Figure J-13

J_13EwaBenthic

percent in water depths from 78 to 120 feet (24 to 36 meters). The coral community is dominated by *P. meandrina, P. lobata* and *P. compressa.* Substrate depressions are littered with massive mounds of fresh coral rubble and coral shards composed primarily of *P. compressa.*

A diverse and abundant fish fauna is associated with areas of high coral coverage and vertical relief. During the April 22, 2001 survey the most common families represented were surgeonfishes (acanthurids), butterflyfishes (chaetodontids), damselfishes (pomacentrids), wrasses (labrids), triggerfishes (balistids), and moorish idols (zanclidae).

Earlier studies identified 59 species of fishes in the vicinity of Ewa Beach, of which 20 were regarded as abundant (U.S. Army Engineer District, 1979).

Common invertebrates associated with the Ewa Beach shallow-water recovery site included holothurians, echinoids (rock-boring and black sea urchins), and sponges.

4.2.4 Threatened and Endangered Species

Green sea turtles were common in the study area on the afternoon of April 22, 2001. At least four adult green sea turtles were observed basking on the surface and two additional turtles were recorded resting on the seafloor at depths of 52 and 58 feet (16 and 18 meters) during videotape transects.

4.3 WAIANAE COAST SHALLOW-WATER RECOVERY SITE

4.3.1 Overview

The Waianae Coast shallow-water recovery site is situated north of Barbers Point Harbor and offshore of the Ko Olina Resort. The Waianae Coast site is located on the leeward side of the Waianae Mountains, its protected location providing many opportunities for surfing, swimming and fishing. Commercial and recreational diving is also popular due to the prevailing clear water and extensive coral reef development. The natural shoreline inshore of the study site was modified during construction of Ko Olina Resort to create four protected swimming lagoons. Other shoreline modifications occurred during construction of Barbers Point Harbor and Channel.

4.3.2 Physical Setting

The Waianae Coast shallow-water recovery site is dominated by unconsolidated sand that occurs along the largely flat to slightly undulating seaward reef slope. Water depths range from approximately 40 feet (12 meters) at the northeast (landward) side of the study area to 92 feet (28 meters) on the southwest (seaward) side. The substrate is dominated by unconsolidated sand with occasional patches of limestone rubble, except on the northeast (landward) side of the study area where a well developed coral reef occurs. Vertical relief in areas of coral development is about 3 to 5 feet (1 to 2 meters); elsewhere it is limited to just a few inches of current-rippled sand.

4.3.3 Biota

Inshore areas at depths between 40 and 70 feet (12 to 21 meters) demonstrate a modestly diverse coral community with coverage in localized areas ranging from an estimated 40 to 50 percent (Figure J-14). *P. meandrina* is the dominant coral, followed by *P. lobata, P. compressa,* and rarely, *Montipora* sp. (*verrucosa?*). Upright flattened branches on several colonies were suggestive of *P. eydouxi,* but the presence of this species was not confirmed at this site. Coral coverage declines markedly below depths of 75 feet (23 meters) where expansive, gently sloping sand flats harbor only an occasional colony of *P. meandrina* on an otherwise featureless sand bottom.

Fishes are rare across the broad sandy bottom, except where an occasional colony of *P. meandrina* or debris provides habitat. The Hawaiian dascyllus, *D. albisella,* is often abundant in such areas. Small schools of pennantfish (*Heniochus diphreutes)* were observed on two occasions. Two Hawaiian cleaner wrasses (*Labroides phthirophagus)* were encountered at a depth of 90 feet (27 meters) on a "cleaning station" whose only physical attribute was a short length of coiled steel cable. Moorish idols (*Zanclus cornutu*s) and several unidentified damselfishes (pomacentrids) and surgeonfishes (acanthurids) were observed being attended (cleaned) by the cleaner wrasses. Surgeonfishes (acanthurids), triggerfishes (balistids), wrasses, (labrids), and butterflyfishes (chaetodontids) comprised the remaining fish fauna.

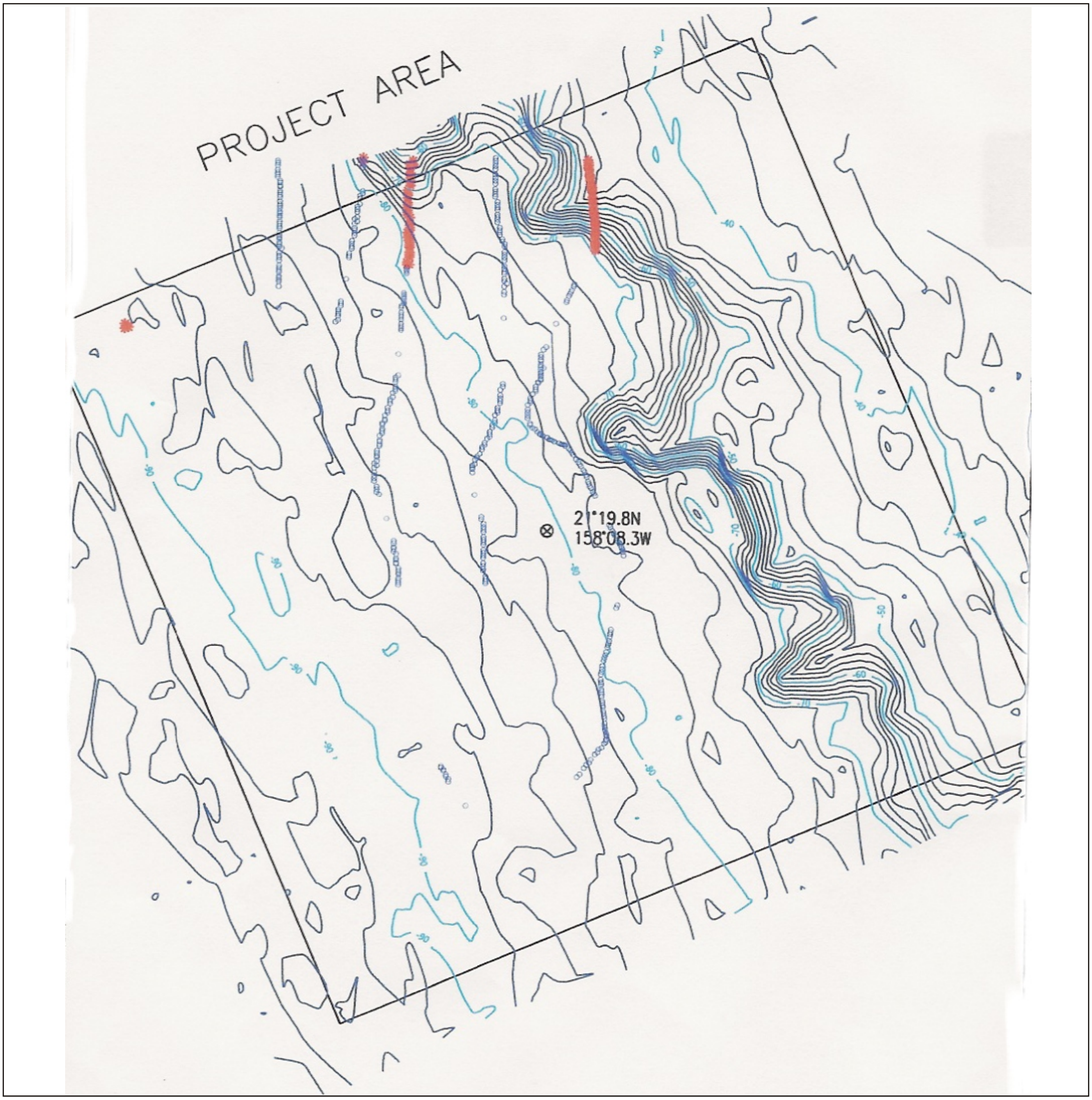
Earlier surveys conducted in the vicinity of Barbers Point Harbor identified 57 species of fish associated with large boulders and a "drop off" at a depth of 45 feet (14 meters). The most abundant species were the smalltail wrass (*Pseudojuloides cerasinus),* fantail filefish *(Pervagor spilosoma),* and the blackfin chromis (*Chromis vanderbilti)* (U.S. Army Engineer District, 1979).

Common invertebrates observed within the proposed Waianae Coast shallow-water recovery site included black sea urchins and unidentified sea cucumbers. Both species were associated with coral rubble patches.

An unidentified filamentous green algae that grows upright with delicate intertwined wispy filaments is common over wide areas of sandy substrate at depths between 75 and 92 feet (23 and 28 meters).

4.3.4 Threatened and Endangered Species

One green sea turtle was observed during marine surveys conducted on April 24, 2001. NMFS staff has indicated that the green sea turtles is abundant in the area and frequently utilize caves and ledges along the fringing reef as a resting area (Naughton, personal communication).



LEGEND

Live Coral

Coral Rubble

Algae

Debris

NORTH

0 30 60 Meters

0 98 196 Feet

Waianae Coast Benthic Habitats

Figure J-14

J_14WaianeaHabitat

5.0 DISCUSSION

The nature and extent of marine biological community development in Hawaiian waters is largely determined by the type of bottom substrate, water currents, wave exposure, and depth. Localized natural and manmade disturbances such as *tsunamis*, volcanic eruptions, coastal development, freshwater flooding, and sediment loads associated with natural as well as agricultural runoff also influence the composition of near shore biological communities.

Hawaii has three basic types of coral reef environments (Fielding and Robinson, 1989). The first type of coral reef environment is dominated by *P. meandrina. P. meandrina* is found in areas with high wave energy and strong sunlight. It is a pioneer species on disturbed substrates and the dominant coral in shallow areas exposed to heavy wave action.

The second type of coral reef environment is characterized by *P. lobata.* This species is found in calmer waters than *P. meandrina.* It is normally found in shallow waters along semi-protected coastlines, or in deeper waters along wave-exposed coastlines.

The third type of coral reef environment is dominated by *P. compressa.* This species is found only in the most protected waters because of its fragile branching growth form. It normally occurs at water depths below those that are considered optimal for either *P. meandrina* or *P. lobata.* Therefore, *P. compressa* may occur in shallow protected bays or on the deeper ocean side of fringing reefs, such as are found off the leeward coast of Oahu.

Video surveys conducted at the expanded Reef Runway shallow-water recovery site showed moderately diverse coral reef habitats in shallow, inshore areas, with coral diversity and coverage decreasing with depth. Exceptions to this generalized pattern occur on narrow slopes, escarpments, and in surge channels where coverage in localized areas ranges between 40 and 90 percent. Areas with coral coverage exceeding 40 percent were uncommon.

Coral zonation was evident in some survey locations with *P. meandrina,* and *P. lobata* representing the dominant shallow-water species (the latter represented by both hemispherical and encrusting growth forms). *P. compressa, P. eydouxi,* and *Montipora* spp. were normally found in mid- to deep-water locations, but rarely exceeded the coverage provided by *P. meandrina*. The lack of obvious zonation patterns in these areas may result from storm wave energy that can detach or fragment corals growing in shallow water and transport them into deeper water. Limestone rubble accumulations and coral development on the terrace seaward of fringing reef surge channels suggest that the channels are a conduit for the transport of coral rubble, detached corals, and coral shards from shallow to deep water.

The *P. compressa* coral community shows evidence of storm wave damage in some locations, though this species was generally uncommon at all depths along the Reef Runway transects. Areas of apparent *P. compressa* destruction may be the result of storm-wave damage associated with recent regional cyclonic disturbances (e.g., Hurricane *Iwa* and/or Hurricane *Iniki*).

Corals are rare at depths in excess of 120 feet (37 meters) and those present are likely the result of storm wave transport and deposition. Finding a single large bracket-forming colony of *Montipora* spp. in sand at a depth of 165 feet (50 meters) was unusual. Even the hardiest corals rarely settle or survive on substrates dominated by unconsolidated sand. It is assumed that this isolated colony is the result of storm wave deposition.

Regardless of the site selected for mooring of the surface recovery vessel and shallow-water crewmember recovery operations, certain unavoidable impacts upon the marine environment are expected. The following sections identify potential project impacts on the marine environment that would be expected within the expanded Reef Runway shallow-water recovery site.

<u>5.1 Mooring and Diver/Diver Support Activities at the Shallow-water Recovery Sites</u>

Temporary mooring of the recovery vessel and diving barge, berthing of the *Ehime Maru* on the seafloor, and diver and diver-support activities are expected to disturb bottom substrates and biotic communities of generally low biological diversity and density. These disturbances would effect the habitat of various benthic organisms, suspend sediments in the water column, increase turbidity, reduce light penetration, and result in elevated nutrient levels in the water column. These disturbances are expected to result in only temporary and localized reductions in water quality. However, suspension of bottom sediments could stress coral colonies as a result of sediment deposition on coral polyps. Damage to corals would be greater on slopes and escarpments that demonstrate high coral coverage.

Disturbances to live corals could result from surface vessel anchoring and deployment and positioning of anchors, anchor chains, and mooring cables on the seafloor. In general, coral impacts should be minimal if anchors, mooring chains, and cables are positioned in a manner that would avoid slopes and escarpments at water depths above 95 feet (29 meters). At depths below approximately 120 feet (37 meters) impacts will be limited to a loss of or disturbances to infaunal polychaetes and other benthic organisms that are adapted to a detrital-based food chain. Corals and associated fish populations are rare at depths below 120 feet (37 meters). Thus, project activities at depths below 120 feet (37 meters) would not be expected to impact any significant area of coral development or reef fish habitat.

With the exception of escarpments and slopes, overall live coral coverage averages less than 1 percent throughout the survey area. Thus impacts to corals from mooring and diver-support activities are expected to be minor.

<u>5.2 Oil/Fuel Release</u>

An oil or fuel release could potentially affect the threatened green sea turtle. Although only one green sea turtle was observed within the Reef Runway survey grid, they have been observed resting along the Fort Kamehameha sewer outfall alignment in the Pearl Harbor Channel. Given the few green sea turtles that have been observed in the vicinity of the Reef Runway and Pearl Harbor Channel, and the resources available to remove any fuel or oil resulting from an accidental release, the likelihood is small for an oil release affecting the green sea turtle.

The impacts of a fuel or oil release on the marine ecosystem at the proposed shallow-water recovery sites will vary as a function of the type of hydrocarbon released, resources present, tide level, and type of substrate. Lubricating oils or fuels could be released from surface support vessels or from the *Ehime Maru*. Diesel fuel is relatively non-persistent and is expected to volatilize quickly as a function of prevailing winds, surface water and air temperatures, and water current patterns. Diesel fuel and lubricating oils would rise to the surface and would not be expected to impact benthic communities, though shoreline inter-tidal communities could be impacted. Oil that comes in contact with rubble or sand on the sea floor could result in localized areas that could prove toxic or inhibitory to benthic marine organisms. However, any sediment oiling would be detectable by divers and would be quickly removed. Given the Incident Action Plan resources that would be mobilized to contain and clean up any release, it is unlikely that a release could adversely impact sensitive benthic or intertidal communities.

Mangrove stands located on the north (Keehi Lagoon) side of the Reef Runway could be potentially affected by an oil release. Hawaiian mangroves are dominated by *Rhizophora mangle,* an introduced species that has successfully colonized intertidal and estuarine mudflats and sandflats throughout the state since its introduction in 1902, and *Bruguiera gymnorrhiza*, which was introduced from the Philippines in 1922 (Wester, 1981). A combination of their intertidal distribution and the presence of sub-aerial air-breathing roots (pneumatophores) make them potentially vulnerable to floating oil. However, given the resources that would be mobilized in the event of an accidental oil release, any disturbance to this community is considered remote.

Another potential source of oil is from vessel bilge waters. Emptied oil compartments can be used to adjust trim and ballast and can inadvertently be a source of oil pollution. However, strict adherence to the project's Incident Action Plan should preclude bilge discharges from representing a potential source of an oil release.

An oil or fuel release could affect the threatened green sea turtle at any of the proposed shallow-water recovery sites. Because of the number of basking or resting green sea turtles observed during surveys at the Ewa Beach shallow-water recovery site, the potential for turtle oiling is considered greater at Ewa Beach than at the other proposed sites. Although only one green sea turtle was observed during site surveys at the Waianae Coast shallow-water recovery site, they are reportedly common in the vicinity of the fringing reef (Naughton, personal communication). Green sea turtles have also been reported resting along the Fort Kamehameha sewer outfall alignment in the Pearl Harbor Channel, which is near the proposed Reef Runway shallow-water recovery site. However, given the resources available to mobilize and remove any fuel or oil resulting from an accidental release, the likelihood is small of an oil release affecting green sea turtles at any proposed shallow-water recovery site.

5.3 Ciguatera

Physical disturbances to shallow-water benthic communities and reef substrates have been associated with outbreaks of ciguatera fish poisoning in Hawaii and elsewhere in the tropical and subtropical Pacific. The poisoning is caused by the dinoflagellate *Gambierdiscus toxicus* growing in high densities on macroscopic algae or other substrates that are consumed by herbivorous fish. The triggering mechanism for a ciguatera outbreak is not well understood. However, the toxin is amplified as it moves up the food chain from herbivorous to carnivorous fishes. Ciguatera can be mildly toxic to fish, with toxicity increasing in mammals, including humans. Outbreaks generally result from consumption of reef fishes such as adult carangids (jacks), sphyraenids (barracuda), and muraenids (moray eels). The chance of a ciguatera outbreak occurring as a direct or indirect result of project actions is considered negligible because of the limited amount of reef substrate disturbance that is anticipated, and the short duration of the recovery phase of the project.

5.4 Non-Indigenous Species Introductions

Mobilization of a deep-water recovery vessel from other parts of the world presents the opportunity for the accidental introduction of non-indigenous marine or estuarine species into Hawaiian waters. Marine or estuarine species associated with vessel bilge waters and fouling organisms attached to bilge water tanks or exterior hull surfaces could be released into Hawaiian waters where they could potentially become established. Hawaii has a history of accidental as well as purposeful marine species introductions, some of which have resulted in deleterious impacts to native marine and estuarine biota. The Hawaii State Government presently has no regulations governing non-indigenous species associated with vessel bilge waters (Oishi, personal communication). However, the International Maritime Organization (IMO) has established voluntary standards that recommend exchange of ballast water while at sea. It is anticipated that such standards will be followed for any vessels utilized in this project that originate in foreign ports.

6.0 RECOMMENDATIONS

On the basis of marine biological surveys conducted at three candidate shallow-water recovery sites (described in Appendix J, Part 1), the proposed Reef Runway shallow-water recovery site remains as the recommended location for crewmember recovery operations. This recommendation is based on the history of marine habitat losses and disturbances involving earlier Reef Runway construction, channel dredging, and reef and lagoon quarrying. These actions collectively decimated the former Keehi Lagoon fringing reef and its associated coral reef and reef flat habitats. Only remnants of the former Keehi Lagoon fringing reef exist outside of the study area. This recommendation is also based on the relative infrequent occurrence of the green sea turtle at the Reef Runway shallow-water recovery site compared to the other candidate shallow-water recovery sites.

There are no rare or sensitive benthic species or biological communities associated with the expanded Reef Runway shallow-water recovery site whose existence would be jeopardized by recovery vessel mooring, temporary seafloor berthing of the *Ehime Maru*, diving, or diving-support actions involved with crewmember recovery operations. Adherence to the project's Incident Action Plan would minimize, if not negate, any impacts to marine resources resulting from an oil or fuel release.

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APPENDIX J, PART 2

Marine Species List
Ehime Maru Shallow Water Site Inspection
Kevin Foster
U.S. Fish and Wildlife Service
Honolulu, Hawaii

Date: 4/25/01

Dive 1: Survey Area - Center transect in a south to north direction, from outer (seaward) boundary toward inner (landward) boundary.

Start Depth: 80 Feet
Finish Depth: 72 Feet
Time In: 10:00am
Time Out: 10:30am

Habitat Notes: Easterly Current, about 2 - 3 knots. Escarpment at seaward boundary (30-degree slope)...bottoms out at about 95 feet. Top of escarpment at 80 feet. Slope of reef landward of escarpment is about 5 degrees. Coral coverage ranges from 5 - about 25 percent (Visual/Qualitative Estimate).

Marine Species Observed

Common Name	Scientific Name (Genus/species)
Sponge	*Phorbas* sp.
Sponge	*Clathria* (Microciona) sp.
Christmas tree worm	*Spirobranchus giganteus*
Urchin	*Diadema* sp.
Urchin	*Echinothrix diadema*
Urchin	*E. calamaris*
Urchin	*Chondrocidaris gigantea*
Urchin	*Echinostrephus aciculatus*
Urchin	*Tripneustes gratilla*
Mussel	*Arca* sp.
Nudibranch	*Phyllidia varicosa*
Crab	*Trapezia ferruginea*
Coral	*Pocillopora meandrina*
Coral	*Porites lobata*
Coral	*P. compressa*
Coral	*Monitpora* sp.
Green Algae	*Neomeris annulata*
Red Algae	*Liagora* sp.

Dive 2: Survey Area - Inner (landward) boundary near center transect line.

Start Depth: 68 Feet
Finish Depth: 72 Feet
Time In: 12:10am
Time Out: 12:31am

Habitat Notes: Rubble/sand bottom. Coral Coverage about 15 percent (Visual/Qualitative Estimate). Current less than 1 knot.

Marine Species Observed

Common Name	Scientific Name (Genus/species)
Sponge	*Phorbas* sp.
Sponge	*Clathria* (Microciona) sp.
Christmas tree worm	*Spirobranchus giganteus*
Urchin	*Echinothrix diadema*
Urchin	*Chondrocidaris gigantea*
Urchin	*Echinostrephus aciculatus*
Urchin	*Tripneustes gratilla*
Oyster	*Pinctada radiata*
Mussel	*Arca* sp.
Crab	*Trapezia ferruginea*
Coral	*Pocillopora meandrina*
Coral	*Porites lobata*
Coral	*P. compressa*
Coral	*Monitpora* sp.
Green Algae	*Neomeris annulata*
Red Algae	*Asparagopsis taxiformis*
Seagrass	*Halophila discipiens* (Possibly Alien Species)
Gastropod	*Smaragdia bryanae* (endemic gastropod) *observe grazing evidence and capsule (reproductive case). The gastropod was collected from the seagrass *H. discipiens*.

Date: 5/2/01

Dive 1: Survey Area - Seaward Boundary, Western Quadrant. (21 degrees, 17.62 minutes North Latitude and 157 degrees 89.73 minutes West Longitude)

Start Depth: 90 Feet
Finish Depth: 82 Feet
Time In: 9:44am
Time Out: 10:01am

Habitat Notes: Current less than 1 knot. Rubble/Sand bottom. Pinnacle (20 percent coral Visual/qualitative Estimate).

Marine Species Observed

Common Name	Scientific Name (Genus/species)
Sponge	*Phorbas* sp.
Sponge	*Clathria* (Microciona) sp.
Christmas tree worm	*Spirobranchus giganteus*
Urchin	*Echinothrix diadema*
Urchin	*Chondrocidaris gigantea*
Urchin	*Tripneustes gratilla*
Coral	*Pocillopora meandrina*
Coral	*Porites lobata*
Coral	*P. compressa*
Coral	*Monitpora* sp.

Date: 5/2/01

Dive 1: Survey Area - Seaward Boundary, Western Quadrant.

Start Depth: 100 Feet
Finish Depth: 90 Feet
Time In: 12:05pm
Time Out: 12:24pm

Habitat Notes: Current less than 1 knot. Rubble/Sand bottom…transition to 100 percent sand bottom at 100 feet. Slope 3 - 4 percent. Expansive flat to moderately sloping area. Excellent location for the Ehime Maru mission.

Marine Species Observed

Common Name	Scientific Name (Genus/species)
Seagrass	*Halophila discipiens* (Possibly Alien Species)
Gastropod	*Smaragdia bryanae* (endemic gastropod) *observe grazing evidence and capsule (reproductive case). The gastrod was collected from the seagrass *H. discipiens*.