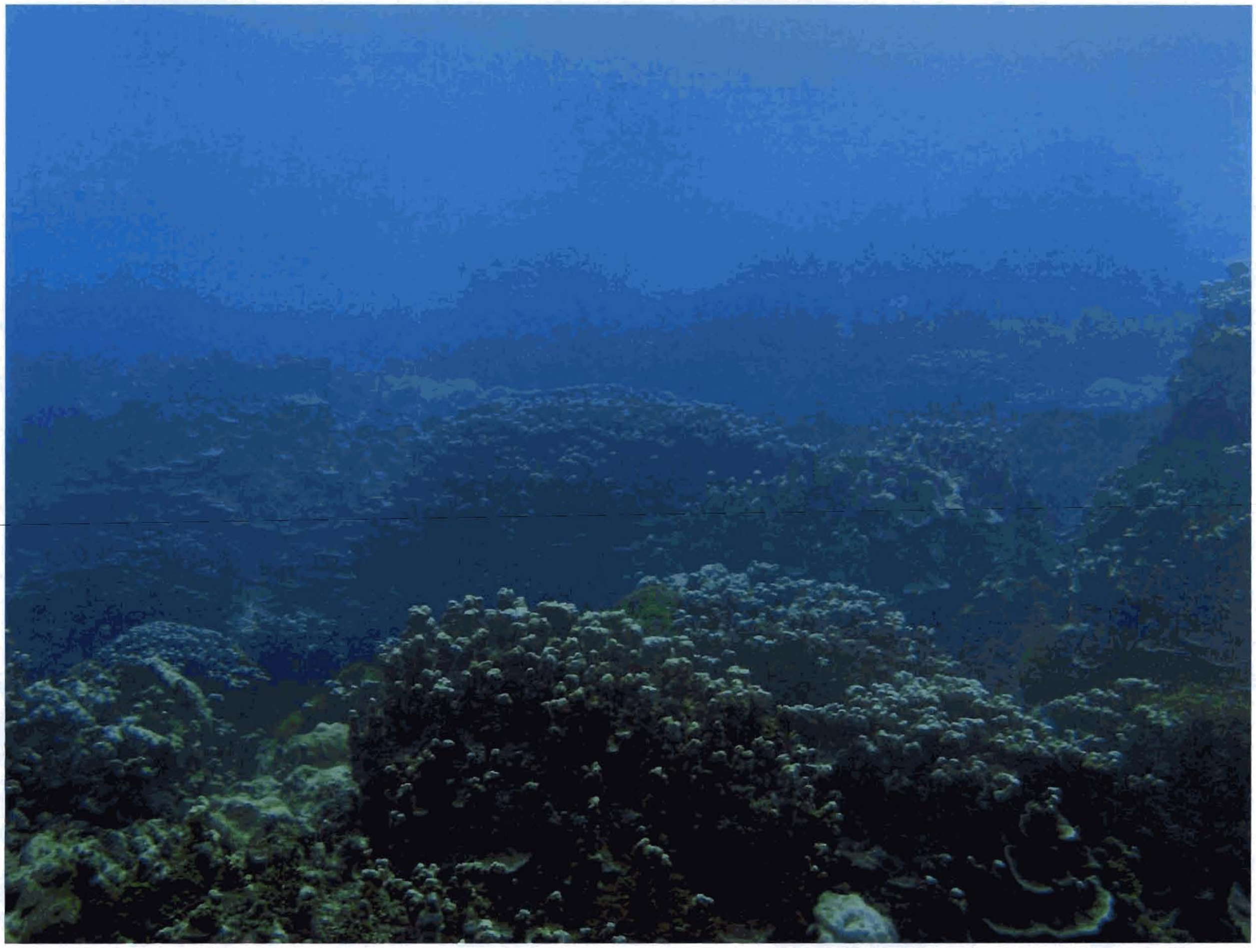

Photograph by Kevin Foster, USFWS

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KILO WHARF EXTENSION PROJECT
MARINE ASSESSMENT AND IMPACT ANALYSIS
APRA HARBOR
GUAM

FEBRUARY 2007

REVISED DRAFT

KILO WHARF EXTENSION PROJECT MARINE ASSESSMENT AND IMPACT ANALYSIS APRA HARBOR GUAM

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INTRODUCTION

Authority, Purpose and Scope

This draft report assesses anticipated impacts to fish and wildlife resources resulting from implementation of plans by the U.S. Navy (Navy) to extend or replace Kilo Wharf, in Apra Harbor on the island of Guam. This report has been prepared by the U.S. Fish and Wildlife Service (Service) under the authority of the National Environmental Policy Act of 1969 [42 U.S.C. 4321 et seq.; 83 Stat. 852], as amended (NEPA). The basic report format is similar to that used for Fish and Wildlife Coordination Act (FWCA) section 2(b) reports. The purpose of the report is to document the existing fish and wildlife resources at the proposed project sites and to ensure that fish and wildlife conservation receives equal consideration with other proposed project objectives. The report includes an assessment of the significant fish and wildlife resources at the proposed project sites and an evaluation of potential impacts associated with the proposed project design alternatives. Recommendations for fish and wildlife mitigation measures will be developed and summarized in a subsequent report. Habitat Equivalency Analysis will be used to scale appropriate compensatory mitigation actions that may be required to replace unavoidable project-related resource losses.

Navy Region Marianas is planning to extend the existing ammunition wharf, known as Kilo wharf, at the Apra Harbor Naval Complex in the Territory of Guam. The purpose of the proposed action is to modify the existing wharf to accommodate a new class of ammunition ship that would require greater berthing space. Currently, the Navy relies upon two Kilauea-class T-AE ammunition ships to transport ammunition to and from Guam at Kilo Wharf. In 2008, a larger class ammunition vessel, T-AKE, will replace the T-AE vessel. The proposed action is necessary to provide berthing, shore-side utilities, and cargo handling operations associated with the new T-AKE class vessel, as well as other vessels that may berth at Kilo Wharf.

The existing wharf, constructed in 1989, is approximately 400 feet (ft) (121.9 meters [m]) in length and includes about 6,000 square yards (yds^2) (5,017 square meters [m^2]) of cargo support area. Large concrete dolphins, located on either side of the wharf, provide additional but limited berthing up to 641 ft in length. The new T-AKE vessel is about 689 feet ft (210 m) in length and will require about 800 ft (243.9 m) of berthing space. Kilo Wharf would need to be lengthened by 400 ft (122 m) in order to accommodate the T-AKE vessel. Additional wharf-related improvements associated with the new T-AKE vessel include: placing utilities throughout the length of the wharf; increasing power capacity; enhancing the fire protection system; installing new security lighting for night-time operations; replacing the existing lighting protection system; and installing new telecommunications and fiber optic systems.

Coordination with Federal and Territorial Resource Agencies

Service biologists have participated in numerous discussions of this proposed project with the Navy and relevant resource agencies. Development of this report has been closely coordinated with staff of the National Marine Fisheries Service (NMFS), U.S. Environmental Protection Agency (USEPA), Territory of Guam Division of Aquatic and Wildlife Resources (DAWR), and Guam Environmental Protection Agency (GEPA). A high degree of ongoing collaboration among these agencies has been maintained in order to address all resource agency concerns in a consolidated manner and help streamline the environmental review process associated with the proposed project for the Navy. This close coordination was bolstered when the Service, NMFS, DAWR, and GEPA personnel cooperated in the collection of the biological and other field data that serves as the basis for this report. Copies of this report are being provided to the NMFS, USEPA, DAWR, GEPA, and the Guam Coastal Management Program.

DESCRIPTION OF THE PROJECT AREA

The Mariana Archipelago is located in the western Pacific Ocean, approximately 3,300 miles (mi) (5,311 kilometers [km]) west of the State of Hawaii and about 1,500 mi (2,414 km) east of the Philippine Islands. The archipelago, which is about 497 mi (800 km) in length, is politically divided into the Territory of Guam, an unincorporated territory of the U.S. (Figure 1) and the Commonwealth of the Northern Mariana Islands. Guam is the southernmost and largest of all the islands that comprise the Mariana Archipelago.

Guam, which is about 30 mi (48.3 km) long and between 4 (6.4 km) and 12 mi (19.3 km) wide, is approximately 212 square miles (mi^2) (549 km^2) in area. The highest elevation on Guam is Mount Lamlam at 1,332 ft (406 m). The proposed project area at Kilo Wharf is located at 13.44619 North Latitude and 144.62996 West Longitude (Figure 2).

The seasons in Guam include tropical dry and wet periods. From January through June, northeast trade winds provide cool and dry conditions throughout Guam. From July through December, warm and wet conditions prevail. During the winter, the average ocean surface water temperature is 27° Celsius (C), and about 30° C during the summer season. Rainfall averages approximately 71 inches (in) (180 centimeters [cm]) per year. During the past 57 years, about 19 typhoons have passed near or over Guam, causing various degrees of damage to the interior and coastal coral reefs. Of these, several have caused substantial damage, including: Super Typhoon Pamela - 1976 (160 miles per hour [mph]), Typhoon Omar – 1992 (150 mph), and Super Typhoon Paka – 1997 (170 mph) (NOAA NWS, Guam Forecast Office).

Apra Harbor is about 197 ft (60 m) deep at its deepest point. The harbor has been significantly altered since World War II. Glass Breakwater was constructed on the barrier reef north of the harbor, and this resulted in substantially reduced circulation with the surrounding ocean (Paulay *et al*, 2003). The reefs on the harbor side of the breakwater (*e.g.*, Family Beach, Diver's Beach, Seaplane Ramp, and off Cabras Island) support habitats dominated by a high diversity of algae. The eastern end of Outer Apra Harbor, which includes Piti Channel, Jade Shoals, Sasa Bay, and the Naval Wharf complex supports a diverse community of coral reef organisms (Eldredge and Paulay 1996). Similarly, the southern boundary of Apra Harbor, from Gabgab beach and Kilo Wharf to Orote Island, supports a rich community of coral reef organisms. Also, Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*) sea turtles are known of to occur in Apra Harbor (NMFS-USFWS 1998a and NMFS-USFWS 1998b).

Coral Reef Resources

Marine communities in Guam are comprised of thousands of plants and animals that are part of the greater coral reef ecosystem, which includes areas that may be dominated by live coral colonies, coralline algae, seagrass, macro-algae, and sand (Paulay *et al.*, 2003; Paulay *et al.*, 2002; Eldredge and Paulay 1996). Coral reefs are unique in that they are geological structures built by living communities. Coral polyps deposit calcium carbonate skeletons and grow upward as they continue to deposit new skeletal material from below. Many other organisms also deposit skeletons or shells on the reef. When corals or these other organisms die, their skeletal remains become part of the reef framework, largely as a result of the cementing action of coralline algae. New corals settle on top of dead ones to continue the overall growth of the reef. Thus, the reef can be viewed as a thick framework of calcium carbonate rock covered with a fragile, thin veneer of life. The reef surface and underlying framework form an important complex of holes, tunnels, and elevated projections that provide a wide range of shelter, foraging, and reproductive habitats for numerous species of fishes, invertebrates, and other organisms.

The most ubiquitous type of coral reef at Guam is the fringing reef (Figure 3) (Randall and Holloman, 1974; Randall, 1979). Fringing reefs are geologically young structures that extend a modest distance from the shoreline and represent the general growth pattern of the coral community around high islands. The fringing reefs on exposed shorelines at Guam are relatively high-energy environments that have evolved to support complex communities of plants and animals. The area between Kilo Wharf and Orote Island is exposed to oceanic waves that 'wrap-around' the end of Glass Breakwater, move through the harbor entrance channel, and break on this stretch of fringing reef. The fringing reefs that occur within deeply embayed areas such as Apra Harbor, are generally low-energy environments that support unique species assemblages (Paulay *et al.*, technical report [N68711-97-LT-7001]).

Guam's fringing reefs and shores are important because they provide extensive habitat that supports a wide variety of ecological functions. From a biological perspective, these functions include nesting, recruitment, foraging, resting, and sheltering from predators for highly diverse assemblages of coral reef species, including the federally listed threatened green sea turtle and endangered hawksbill sea turtle. Maintenance of coral reef habitats that support these ecological functions is dependent on protecting the thin, top layer of living coral, which requires clean, well-oxygenated, tropical seawater for maximum health. Although corals are fragile and can be broken by storm waves, healthy reefs can continually heal themselves from wave damage and other natural impacts.

Healthy coral reef habitats also include intact assemblages of marine plants, including encrusting coralline algae, macroalgae, turf algae, and sea grass. Coralline algae cements debris together and contributes to forming algal ridges. Calcareous green algae contribute to the production of marine sediments. Turf algae are important forage material for herbivorous reef fish and macro-invertebrates. Sea grass roots hold marine sediments in place. Many marine plant species also serve as forage and shelter for species of macro-invertebrates and reef fishes.

Healthy fringing reefs provide other important ecological functions by acting as buffers for island shorelines from oceanic swells and storm events. Wave energy is reduced and dispersed over the reef flat, protecting shorelines from erosion. This protection typically helps maintain upland areas for human inhabitants and a wide variety of native terrestrial organisms, including coastal vegetation, land snails and other invertebrates, sea turtles and other reptiles, sea birds, shorebirds, waterfowl, and bats.

Other ecological functions provided by healthy fringing reefs include the maintenance of intact marine communities in the near shore environment that interact with pelagic or terrestrial species through complex predator, prey, or symbiotic relationships common in tropical ecosystems. Also, healthy coral reef resources directly benefit the residents of Guam by supporting human activities such as subsistence harvest/fishing, recreational activities, tourism, and cultural practices.

Coral distribution is limited by numerous factors, such as alteration of habitat, sedimentation, water quality, predator outbreaks, and typhoons. Dredging can destroy coral tissue and entire coral colonies by direct contact. Sediments that become suspended in the water column may settle on coral polyps and smother them. Suspended sediments may also abrade polyps and planktonic larvae and render them non-viable. Contaminants re-suspended in the water column by dredging may chemically alter coral gametes and larvae, preventing normal fertilization and development. Apra Harbor and many other locations on Guam's shoreline have been altered to various degrees during military and commercial construction activities related to harbors, boat ramps, wharfs, docks, aids to navigation, shoreline revetments, and coastal roads.

Guam coral reefs remain vulnerable to sedimentation from upland sources as a result of un-controlled agriculture, fire, and human development activities (Wolanski *et al.*, 2003, Wolanski *et al,*. 2002; Rongo, 2004; Minton, 2005). Also, terrigenous sediments have the capacity to transport contaminants from land-based sources of pollution onto coral reefs (Fabricus, 2005).

The indigenous crown-of-thorns sea star (*Acanthaster planci*) is a corallivorous echinoderm observed on Guam coral reefs. It is not well understood whether periodic population outbreaks of this species can be attributable to natural or human influences. However, it is well documented that outbreaks may significantly degrade coral reefs (Chesher, 1969; Randall 1973).

Typhoons are a common weather phenomenon in Guam that can have devastating consequences for coral reefs (Randall and Eldredge, 1977). Certain coral reef species are limited or absent from windward exposed reefs due to large storm-generated waves (Kerr *et al.*, 1993).

FISH AND WILDLIFE RESOURCE CONCERNS AND PLANNING OBJECTIVES

Of primary concern is the potential for the proposed project to impact federally listed and other fish and wildlife species and their habitats from dredging and filling in the marine environment. Specific planning objectives are to maintain and enhance the existing significant habitat values at the proposed project sites by (1) obtaining basic biological data for the proposed project sites, (2) evaluating and analyzing the impacts of proposed-project alternatives on fish and wildlife species and their habitats, (3) identifying the proposed-project alternative least damaging to fish and wildlife resources, and (4) recommending mitigation measures as a result of an assessment of project-related negative impacts to fish and wildlife resources that include: avoidance of unnecessary impacts; minimization of unavoidable impacts; and compensation for unavoidable negative impacts consistent with environmental laws and established policies.

Under the authority of the Endangered Species Act of 1973 [16 U.S.C. 1531 *et seq.*; 87 Stat. 884], as amended (ESA), the Department of the Interior and the Department of Commerce share responsibility for the conservation, protection and recovery of federally listed endangered and threatened species. Authority to conduct consultations has been delegated by the Secretary of the Interior to the Director of the Service and by the Secretary of Commerce to the Assistant Administrator of NMFS. Section 7(a)(2) of the ESA requires Federal agencies, in consultation with and with the assistance of the Service or NMFS, to insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitats. The Biological Opinion is the document that states the opinion of the Service or NMFS as to whether the Federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. Critical habitat has not been designated for sea turtles in Apra Harbor.

The Service's Mitigation Policy (U.S. Fish and Wildlife Service 1981) outlines internal guidance for evaluating impacts affecting fish and wildlife resources. Federally listed threatened or endangered species are subject to the Endangered Species Act. The Mitigation Policy complements the Service's participation under NEPA and other authorities, such as the FWCA. The Service's Mitigation Policy was formulated with the intent of protecting and conserving the most important fish and wildlife resources while facilitating balanced development of this nation's natural resources. The policy focuses primarily on habitat values and identifies four resource categories and mitigation guidelines.

The resource categories are the following:

a. Resource Category 1: Habitat to be impacted is of high value for the evaluation species and is unique and irreplaceable on a national basis or in the eco-region section.

b. Resource Category 2: Habitat to be impacted is of high value for the evaluation species and is relatively scarce or becoming scarce on a national basis or in the eco-region section.

c. Resource Category 3: Habitat to be impacted is of high to medium value for the evaluation species and is relatively abundant on a national basis.

d. Resource Category 4: Habitat to be impacted is of medium to low value for the evaluation species.

The coral reef ecosystem fronting the Kilo Wharf project site is comprised of the habitats of major concern. Although corals are very small and sensitive organisms, healthy coral colonies are fundamentally important in providing the basic foundation for habitats that supports diverse communities of other highly specialized marine organisms. Corals contribute the bulk of the calcareous raw materials that form and maintain the basic structural framework of the reef. Coral colonies add significantly to the submarine topographic relief in which a large number of fish and invertebrate species find shelter and food. Coral polyps themselves are an important food source for some fishes and other marine life. The institutional significance of U.S. coral reefs has been established through their designation as Special Aquatic Sites [40 CFR Part 230 §230.44/FR v.45n.249] and as a Federal Trust Resource [Executive Order 13089 on Coral Reef Protection]. Such sites possess special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values and contribute to the general overall environmental health or vitality of an entire ecosystem of a region. Corals, macro-invertebrates, algae and reef fish were selected as the evaluation species because it is believed the proposed project may result in broad negative impacts and reduction of ecological functions for each species group.

Coral reefs are relatively scarce on a national basis and are currently in a world-wide state of decline (Crosby *et al.*, 1995; U.S. Coral Reef Task Force, 2000, Waddell (ed.), 2005). In Guam, coral reefs are subjected to relatively frequent adverse impacts, and the extent of healthy and productive coral reefs has declined on a local basis over the past 40 years (Birkeland, 1997; Richmond, 1997; Porter *et al*,. 2005). Furthermore, coral reef ecosystems are under pressure from a variety of anthropogenic sources that have resulted in the decline of species abundance, diversity and health (NOAA, 2002; Turgen *et al.*, 2002; Wilkinson, 2002). The Service considers coral reef habitats in Apra Harbor to be Resource Category 2 habitats. The Service's resource goal for Category 2 habitat is no net loss of in-kind habitat values. Under this designation, the Service will recommend ways to mitigate losses, through measures to avoid or minimize significant adverse impacts. If losses are unavoidable, measures to immediately rectify, reduce, or eliminate losses over time by the replacement of in-kind habitat values will be recommended for incorporation into the project description as necessary compensation.

EVALUATION METHODOLOGY

Marine Biological Assessment

In 2006, a marine biological assessment was conducted at Kilo Wharf to evaluate potential impacts to fish and wildlife resources based on the proposed project design criteria provided by the Navy. Sixteen survey sites were assessed to gauge potential project-related impacts to four alternatives that include: (1) western extension (preferred alternative), (2) west-east extension, (3) pullback, and (4) outboard. Selection of a diverse assemblage of organisms offers an evaluation at the community level to assess a site's relative contribution to the overall coral reef resources that occur within Apra Harbor. Therefore, the distribution and relative abundance of algae, corals, other macro-invertebrates, and reef fishes were compiled. Also, Global Positioning System (GPS) data were collected to identify the location of each survey transect.

Service ecologists Kevin Foster and Antonio Bentivoglio, NMFS biologist Steve Kolinski, Guam DAWR biologist Brent Tibbats, and GEPA biologist Mike Gawel conducted the marine survey work for this project in January 2006. Mr. Foster collected macro-invertebrate data, Dr. Kolinski collected coral and sea turtle data, Mr. Gawel collected marine plant data, and Mr. Bentivoglio and Mr. Tibbats collected reef fish data at all survey sites. All marine survey work was conducted between 9:00 am and 5:00 pm. SCUBA gear was used to evaluate each of the sixteen survey sites and the duration of each dive was between 50 to 60 minutes. Mr. Foster and Dr. Kolinski provided all photographs that appear in this report. Mr. Foster collected all GPS data illustrated in this report.

Survey sites were randomly selected with consideration towards project construction designs. Prior to the marine assessment field work, sixteen survey sites were randomly selected (7 inside and 9 outside) as proposed dredge and fill sites using GIS software. During field work, biologists navigated to each survey station using pre-registered Latitude/Longitude points stored in a Garmin 76S global positioning system device. At each survey station, a weight (l pound), tethered to a surface buoy, was dropped to mark the location. Reef fish biologists descended to the reef substrate first, and checked the depth of the weight as it rested on the reef. Afterwards, using a compass and depth gauge, they followed the reef contour in a general direction away from the existing Kilo wharf structure. Benthic (coral, algae, and macro-invertebrate specialists) biologists followed along on the transects laid down on the reef previously by the reef fish biologists.

Algae

A total of thirty-two 25-m transects were sampled for algae during this study, two transects at each survey station. A 0.5-m^2 quadrat, with 49 evenly spaced points was used to sample the substrate on each transect. Of these 49 points, 20 were randomly selected for each quadrat sample. A quadrat sample was taken every 5 m along each transect. The quadrat was placed on the reef a total of 5 times on each transect and 10 times at each survey station. A total of 100 points were described on each transect, with a total of 200 points described at each survey station. Green (Chlorophyta), brown (Phaeophyta), and red (Rhodophyta) macro-algae were recorded to the genus and species levels. If a point could not be identified to the species or genus level, it was placed into more general functional groups, such as turf algae, which consisted of all unidentifiable upright algal species of less than 1 cm. Other functional marine plant groups included crustose coralline algae and blue green algae (Cyanophyta). Other non-algal functional groups, such as invertebrates, were also recorded and included in order to calculate percent (%) substrate cover. Data are reported as percentages (*i.e.*, 1 – 100%) for each transect (T1 = Transect 1 and T2 = Transect 2).

Corals

Two 25-m meter transects were laid down on the reef, end to end with a 5-m gap in between the first 25-m transect tape and the second 25-m transect tape. The first and second 10-m coral transects were performed along the first 25-m transect, with a 5-m gap between the first and second 10-m transects. The third and fourth 10-m transects were performed on the second 25-m transect, with a 5-m gap between the third and fourth 10-m transects. All visible scleractinian, alcyonacean and helioporacean colonies having centers located within 0.5 m of each side of the four 10-m line transects were identified, counted and visually sized into one of eight categories (0 to < 2 cm greatest diameter, 2 to < 5 cm, 5 to < 10 cm, 10 to < 20 cm, 20 to < 40 cm, 40 to < 80 cm, 80 to < 160 cm, and > 160 cm) at each station (using SCUBA). Colonies completely separated by fission were noted, counted and sized by apparent genotype. Unattached fragments were identified and considered as separate individuals. A digital image of benthic substrate was collected at a distance of 0.5 m above the substrate every 0.5 m along each 10-m transect for determining percent coral cover (20 to 21 images per transect) on the reef substrate. General images of habitat along each transect were also collected. Mean colony densities, densities of fragments and "recent" visible sexual recruits, percentages of large colonies parted by fission (colonies 10 cm and greater), diversity and equability were determined using data from the separate transects at a site as replicates. Recent sexual recruits were defined as observed colonies < 5 cm in greatest diameter that did not appear to result from processes of fission or fragmentation. Sexual recruits within this size range might be considered to initially have settled within the previous 5 years under favorable conditions (Kolinski 2004, in review, unpub. data). Percent coral cover was measured through Point Count analysis of benthic substrate images using 50 randomly selected points per frame. Point Count randomly spreads 50 points over an image of given size and looks at percentage values of each species or group compared to the total 50 points. At these sites, the scale to which the measurements applied was 'm^2'. The Shannon index of diversity was determined for mean colony numbers at each survey site, with data from the separate transects at each site used as replicates. The Shannon index was calculated as:

$$H' = \Sigma\, p_i \, ln(p_i) \quad \text{where } p_i \text{ is the proportion of all species } i$$

This index uses the natural log of the proportion of each species observed to represent both *numbers of species* and *numbers of colonies* present. The Shannon index ranges from 0 (low diversity) to S (equal to one individual of each species present). The related index value of equability was also calculated. Equability varies from 0 to 1 with communities where all species are equally abundant having index of 1. Equability is calculated as:

$$J = H'/Hmax = \Sigma\, p_i \, ln(p_i)/ln\,(s) \qquad \text{where s = number of species}$$

Mean percent species cover for the Shannon index was indirectly estimated using size category data with the following formula and correction factors:

$X_i = \pi \times (0.5 \times \text{minimum size for category})^2 \times$ number of category colonies; 0 to < 2 cm = 1.

$Y_i = 0.167 \times X_i + 0.167 \times (0.9 \times X_i) + 0.167 \times (0.8 \times X_i) + 0.167 \times (0.7 \times X_i) + 0.167 \times (0.6 \times X_i) + 0.167 \times (0.5 \times X_i)$; X_i determined only for colonies < 160 cm.

> Y_i represents equal probability of 50 to 100 % of each colony, in 10 % increments, falling within 0.5 m of either side of a transect line.

$Y_j = 0.167 \times (0.5 \times X_i) + 0.167 \times (12000\ cm^2) + 0.167 \times (14000\ cm^2) + 0.499 \times (16000\ cm^2)$; X_i determined only for 160 cm colonies.

> Y_j modifies area values for 160 cm colonies as full area of 160 cm diameter circle can not fall within a 1 m wide transect.

Species cover = $\sum Y_i + Y_j$ for each species on a transect.

This formula provided a means to account for species not detected in the image analysis and was used specifically for estimating percent-cover-based diversity. Data from all transects at a site were combined for graphical presentation of size distributions. Rugosity was measured for each 10-m transect, excluding sites dominated by reef walls.

Macro-invertebrates

Two 25-m transects were laid down on the reef, end to end with a 5-m gap in between the first 25-m transect tape and the second 25-m transect tape. Macro-invertebrates were evaluated over four 10-m transects. The first and second 10-m invertebrate transects were performed along the first 25-m transect, with a 5-m gap between the first and second 10-m transects. The third and fourth 10-m transects were performed on the second 25-m transect, with a 5-m gap between the first and second 10-m transects. Quantitative measurements of specific target marine invertebrates were recorded within 0.5 m on each side of the four 10-m belt transects. A 1-m^2 area was measured at 1-m intervals, for a total of 10 times per transect and 40 times per survey station. Measurements were collected using a 1-m collapsible measuring stick. These data were enumerated to sample populations of mobile (*e.g.*, sea urchin) or sessile (*e.g.*, giant clam) species. Target species included the following: cnidarians (zoanthids and sea anemones), echinoderms (sea urchins, sea cucumbers, and sea stars), mollusks (bivalves, nudibranchs, gastropods, and cephalopods), and crustaceans (hermit crabs, lobsters, large crabs, guard crabs, and shrimp). Afterwards, qualitative surveys were conducted to record observations of macro-invertebrate species within a larger area surrounding each 10-m belt transect. This was accomplished by swimming in a zigzag search pattern and recording species presence within an area that extended 5 m from each side of the line on all four belt transects.

Reef Fishes

Larger reef fish (>10 cm) were recorded in a "swim-out leg" during deployment of each 25-m belt transect. Subsequently, smaller fish (<10 cm) were recorded during a "swim-back leg." During the "swim-out leg" of the transect, each diver recorded size-class-specific (Total Length, [TL]) counts of all fishes greater than 10 cm within visually estimated but defined belt widths (*i.e.*, within 2 m on each side of the line), while small and cryptic fish (*i.e.*, < 10 cm) were counted during the "swim-back leg." Each fish was identified to genus and species. The result was that each diver obtained a density estimate of all fishes greater than 10 cm TL within a 25-m long x 4-m wide (100-m^2) area on an initial ("swim-out") leg, followed by a density estimate of fishes $\leq$ 10 cm TL within a 25-m long x 2-m wide (50-m^2) area on the subsequent ("swim back") leg, on each of two transects, at each dive station, conditions permitting. Therefore, two transects worth of data provided totals for 200 m^2 and 100 m^2 of area that were searched for large, relatively vagile and small, site-attached reef fishes, respectively.

Size classes were recorded as:

> A = 5-10 cm, B = 10-15 cm, C = 15-20 cm
> (fish 5 cm and under were recorded to nearest cm; fish over 20cm were recorded to the nearest cm).

Reef fish species diversity was described by calculating Shannon diversity values for various species. Equability is calculated as:

$$J = H'/Hmax = \Sigma\, p_i\, ln(p_i)/ln\,(s) \qquad \text{where s = number of species}$$

This simple measure of diversity does not account for the relative contribution of individuals representing each species. The Shannon diversity value is an expression derived using both the number of species observed and numbers seen of each species within belt transects. Belt transect observations, for which numbers of each species encountered were recorded, were used to derive H'.

Typically, divers located the depth contours at each survey station with a hand-held fathometer. GPS data were collected at the 0-m mark of Transect 1 and at the 25-m mark of Transect 2, or at the beginning and end of each survey station. After these data were collected, both the fathometer and GPS unit were secured in dry bags attached to a floating dive flag. Divers towed the float while conducting each survey.

DESCRIPTION OF FISH AND WILDLIFE RESOURCES

Quantitative data for marine plants, corals, other macro-invertebrates, and reef fishes are presented in Tables 4–7 and illustrated in Appendix 1 (Figures 1–3). Observations of sea turtles and available forage habitat are presented Table 8. GPS data that were collected for each survey transect are presented in Table 9. Photos of marine organisms and habitat appear in Appendix 2, Figures a–p. Survey stations were numbered in the order each was surveyed. However, in this report, the results are not presented in the same order. Rather, station-specific information is presented for various reef zones that were surveyed in areas east and west of the existing Kilo Wharf and between Orote Island and Orote Peninsula.

Existing Conditions East of Kilo Wharf

The area east of Kilo Wharf consists of several habitats which include reef flat, reef crest, and reef slope. Relief on the reef flat is low. Small rocks, crevices and small boulders offer opportunities for fish and invertebrates to shelter and forage. *Codium* sp., a green alga, is commonly observed across the reef flat and a variety of snails forage on patches of algae. Small branching corals, *Pocillopora damicornis*, occur throughout the survey area and offer hiding places for crabs and shrimp. Structurally, the reef crest and slope are complex, high relief areas with many holes, crevices and interstitial space for a variety of marine organisms to shelter. *Porites rus* is the dominant coral observed across these habitats. A variety of fish, invertebrates and marine plants compete for space within this band of highly three-dimensional coral reef. Similar to the reef crest, the reef slope offers much three-dimensional structure and provides forage and shelter habitat for reef fish and macro-invertebrates.

Reef Flat

Survey Station 9

At a depth of 5 ft (1.5m), the marine benthos was comprised of small pockets of sand (T1=5%, T2=1%) and rubble (T2=2%) (Table 4b). Observations of marine plants and other benthic species consisted of the green algae *Codium fastigiata* (T1=53%, T2=74%) and *Halimeda opuntia* (T1=1%); the brown algae *Dictyota bartayresii* (T1=1%), *Padina tenuis* (T1=1%, T2=3%), *Turbinaria ornata* (T2=1%), and *Sargassum cristaefolium* (T2=1%); the red algae *Galaxaura fasciculata* (T1=5%) and *Galaxaura* sp (cf. *G. acuminata*) (T1=4%, T2=1%); turf (thick) (T1=19%, T2=15%); and invertebrates (T1=2%).

One-hundred-twelve scleractinian corals (11 species) were recorded within four 10-m^2 transects on the harbor reef flat (rugosity = 1.1 ± 0.1 S.D.) at 1.5 m depth (Table 5i, Figure 1i). Two additional species (*Acropora* sp and *Leptoria phrygia*) were observed in the area. The Shannon index of diversity was 1.42 (equability = 0.59) based on colony densities and 1.09 (equability = 0.46) based on cover. *Pocillopora damicornis* and *Leptastrea purpurea* (both brooding species) dominated colony numbers; *P. damicornis* dominated live coral cover. Coral numbers and cover were low, with fairly high variability between transects and species. Seventy-nine percent of colonies were less than 20 cm in greatest diameter with 40% less than 5 cm. Size trends varied among species. Five of the 11 species (45%) displayed evidence of recent (past five years) larval recruitment which appeared low. Larval recruitment may be limited by the overall dominance in the area of thick turf and macro-algae cover. Fragments were noted for four (36%) species, with highest numbers evident in *P. damicornis*. Only 4% of large colonies (2% ± 4 S.D. of all colonies) were completely parted by fission. Size, density, coverage and rugosity data suggest that coral habitat complexity and reproductive potential are low. Coral community development may be limited by physical factors such as storm wave and wave refraction exposure at shallow depths, in addition to historical and wharf proximity impacts.

Twenty-eight species from twenty families of non-coral macro-invertebrates were recorded at this station (Table 6a). Boring sea urchins, *Echinostrephus acciculatus* (0.45 m^2) and *Echinometra mathaei* (0.1 m^2), were numerous on the reef flat (Table 6b, Figure 2i). Mobile urchins, *Echinothrix calamaris* (0.3 m^2) and *Diadema setosum* (0.1 m^2) congregated in small crevices and between coral colonies. Mobile asteroids, *Acanthaster planci* (0.025m^2), *Linckia multifora* (0.15 m^2), and *L. laevigata* (0.1 m^2) appeared as occasional observations. Mobile mollusks, *Trochus niloticus* (0.1 m^2), *Lambis truncata* (0.025m^2), and *L. lambis* (0. 025m^2) appeared to be grazing on turf and macroalgae-covered pavement. One species of giant clam (sessile bivalve), *Tridacna maxima* (0.025 m^2), was represented at this site. A corallivorous snail, *Coralliophila violacea* (0.125 m^2), was observed attached to several *Porites* coral colonies. Occasional observations of mobile sea cucumbers (benthic detritivores), *Holothuria atra* (0.125 m^2), *Thelenota ananas* (0.025 m^2), and *Bohadschia vitiensis* (0.025 m^2) were also recorded.

Twenty fish species representing 11 families were seen at this station (Table 7, Fig. 3a-c, and Fig. 4a-c, Shannon diversity H` = 1.92). The surgeon fishes *Acanthurus nigrofuscus*and *Ctenochaetus striatus* and the damselfish *Chrysiptera brownriggii* were the most frequently observed species. *A. nigrofuscus* was the largest single contributor to the estimate of biomass (71.4 percent).

Benthic Community Ecological Functions: Marine plant species from the genera *Codium* and *Turbinaria* have been documented as important forage for green sea turtles (Chelonia mydas). Also, several marine snails from the genera *Trochus* and *Lambis* were observed foraging within macro algae and turf algae patches. Coral species diversity and abundance was low at this site. However, corals at this site function as important shelter for marine snails and echinoderm species from the genera, *Trochus, Conus, Lambis, Echinothrix, Holothuria* and *Thelenota* and forage for the marine snail *Coralliophila.* Corals also function as wave diffusers and assist in deflecting high wave energy from the shoreline. Omnivorous mobile urchins, such as *Echinothrix calamaris and Diadema setosum*, primarily graze on algae and to some degree other plant and animal materials. Mobile urchins function by keeping fast growing macroalgae in check. Controlling macroalgae allows other organisms, such as crustose coralline algae and corals to become established and expand into the community. Holothurians (sea cucumbers) also function as omnivores and scour the reef for organic materials and detritus. Boring urchins (*e.g., Echinometra mathaei* and *Echinostrephus asciculatus*) were numerous and function by altering the physical structure of the shallow reef environment. Boring urchins contribute to the creation of 'sub-habitats' for small reef fish, other macro-invertebrate species, and algae by drilling small holes, crevices, and channels in the reef. This habitat also supports unique species of bivalves, such as the giant clam (*Tridacna maxima*).

Survey Station 11

At a depth of 5 ft (1.5 m), the marine benthos was comprised of small pockets of sand (T1=2%, T2=1%) (Table 4c). Observations of marine plants and other benthic species consisted of the blue-green alga *Microcoleus lyngbyaceus* (T1=1%) and unidentified red slime (T1=1%); the green algae *Caulerpa racemosa* (T1=1%), *Codium edulis* (T1=43%, T2=27%), *Halimeda* sp (cf. *H. micronesica*) (T1=2%, T2=10%), *Halimeda opuntia* (T1=4%, T2=2%), *Neomeris annulata* (T1=1%, T2=1%), and *Valonia ventricosa* (T1=1%); the brown algae *Dictyota bartayresii* (T1=2%), *Padina tenuis* (T2=1%), and *Turbinaria ornata* (T1=1%, T2=2%); the red algae *Galaxaura fasciculata* (T1=2%, T2=1%), and *Galaxaura* sp (cf. *G. acuminata*) (T1=4%, T2=2%);

encrusting coralline (T1=7%, T2=6%), branching coralline algae (T1=1%, T2=5%); turf (thick) (T1=19%, T2=37%); and invertebrates (T1=7%, T2=4%).

A total 161 scleractinian corals (17 species) were recorded within four 10-m^2 transects along topographically complex (rugosity = 1.4 ± 0.1 S.D.) harbor reef flat at 1.5 m depth (Table 5k, Figure 1k). Three additional scleractinian (*Hydnophora microconos*, *Montastrea curta* and *Platygyra sinensis*) and one calcium carbonate accreting hydrozoan (*Millepora* sp.) species were noted within the area. The Shannon index of diversity was 2.14 (equability = 0.76) based on colony densities and 1.78 (equability = 0.63) based on cover. *Pocillopora damicornis* (a brooding species) was the dominant coral in terms of colony numbers and cover. Coral numbers and coverage were low. Cover varied substantially between transects. Seventy-three percent of colonies were less than 20 cm in greatest diameter with 22% less than 5 cm. Size trends varied for commonly encountered species. Fragmentation was evident for *P. damicornis* and *Porites rus*, suggesting some relevance of this mechanism of reproduction and dispersal to the population dynamics of these species in this area. Eight of the 17 (47%) species displayed evidence of recent (past five years) recruitment that appeared larval in nature. Recruitment, in general, was low; however, benthic area was dominated by thick turf and macroalgae cover. Eleven percent of large colonies (5% ± 2 S.D. of all colonies) were completely parted by fission. Fission appeared proportionately high in *Pocillopora danae*. High topographic complexity and limited reproductive potential are suggested by the variables measured.

Twenty species from 13 families of non-coral macro-invertebrates were recorded at this site (Table 6a). Giant clams, *Tridacna maxima* (0.225 m^2), were firmly anchored to the reef (Table 6b, Figure 2k). Mobile mollusks, *Trochus niloticus* (0.1 m^2) and *Lambis lambis* (0. 025m^2) were occasionally observed. Boring urchins, *Echinostrephus acciculatus* (0.325 m^2) and *Echniometra mathaei* (0.2 m^2), were abundant and had modified the limestone reef pavement, providing boring-path habitat for other invertebrates, reef fish, and algae. Mobile urchins, *Echinothrix calamaris* (0.225 m^2) and *Diadema setosum* (0.2 m^2) were observed to occupy crevices and the base of small rocks. Sea cucumbers, *Actinopyga mauritiana* (0.025 m^2) and *Holothuria atra* (0.05 m^2), were also recorded.

Twenty-three fish in nine families were seen at this site (Table 7, Fig. 3a-c, and Fig. 4a-c, Shannon diversity H` = 2.24). *Acanthurus nigrofuscus* and the parrotfish *Chlorurus sordidus* were frequently observed and provided a large contribution to the total biomass estimate. Other fish that were common in terms of numbers and biomass werethe damselfish *Chrysiptera brownriggii,* the wrasse *Cheilinus fasciatus,* and the surgeonfishes *Ctenochaetus striatus* and *Zebrasoma veliferum*.

Benthic Community Ecological Functions: Similar to survey station 9, marine plant species from the genera *Codium, Caulerpa,* and *Turbinaria* were observed at this site and are known to function as important forage for green sea turtles (*Chelonia mydas*). Marine snails from the genera *Trochus* and *Lambis* were observed foraging within macro algae and turf algae patches. Corals were observed to function as important shelter for marine snails and echinoderm species from the genera, *Trochus, Conus, Lambis, Echinothrix, Holothuria* and *Thelenota*. Corals also function as wave diffusers that assist in deflecting high wave energy from the shoreline. Omnivorous mobile urchins, such as *Echinothrix calamaris and Diadema setosum*, were observed grazing on algae. Holothurians (sea cucumbers) also function as omnivores and scour the reef for organic materials and detritus. Boring urchins (*e.g., Echinometra mathaei* and *Echinostrephus asciculatus*) were numerous and contribute substantially to the community at this location. Boring urchins were observed to alter the reef structure, forming 'sub-habitats' for small reef fish, other macro-invertebrate species, and algae by drilling small holes, crevices, and channels in the reef.

Reef Crest

Survey Station 12

At a depth of 12 ft (3.7 m), the marine benthos was comprised of a sparse amount of sand habitat (T1=5%) (Table 4c). Observations of marine plants and other benthic species consisted of the blue-green alga *Microcoleus lyngbyaceus* (T1=3%, T2=2%) and unidentified blue-green slime (T1=4%, T2=2%); the green algae *Caulerpa filicoides* (T1=1%), *Halimeda* sp. (cf. *H. micronesica*) (T1=11%, T2=4%), and *Halimeda opuntia* (T1=5%, T2=23%); the brown algae *Dictyota bartayresii* (T1=2%, T2=3%), *Dictyota* sp. (T1=3%), and *Lobophora variegata* (T1=1%); red algae encrusting coralline (T1=10%, T2=6%) and branching coralline algae (T1=2%, T2=1%); turf (thick) (T1=15%, T2=1%); and invertebrates (T1=41%, T2=55%).

A total 419 scleractinian corals (20 species), 16 alcyonacean corals (*Sinularia*) and one helioporacean corals (*Heliopora coerulea*) were recorded within four 10 m^2 transects in topographically complex (rugosity = 1.5 ± 0.1 S.D.) harbor reef crest habitat at 3.7 m depth (Table 51, Figure 11). One additional scleractinian species (*Diploastrea heliopora*) was observed in the area. The Shannon index of diversity was 1.37 (equability = 0.45) based on colony numbers and 0.67 (equability = 0.22) based on cover. *Porites rus* (a brooding and broadcast spawning species) was the dominant species, accounting for over 64% of mean colony densities and 76% of mean live cover. Variability in numbers and coverage was high among species, less so among transects. Overall coral densities and cover were high. Forty percent of colonies were ≥20 cm in greatest diameter with 20% less than 5 cm. Size trends were fairly similar for commonly encountered species. Eleven of the 22 species (50%) displayed evidence of recent (past five years) recruitment that appeared larval in nature. Fragment numbers of *P. rus* and *P. cylindrica* were similar/greater than observations of mean numbers of recent sexual recruitment for these species. Eleven percent of large colonies (7% ± 4 S.D. of all colonies) were completely parted by fission. Fission was observed in *Porites cylindrica. P. lobata* and *P. rus*. Large colonies of *Sinularia*, *P. lobata* and *P. rus* were observed in clusters, suggesting high reproductive potential for these species. Size, densities, cover, diversity and rugosity suggest high coral habitat complexity.

Twenty-four species from 21 families of non-coral macro-invertebrates were recorded at this station (Table 6a). Several size classes (1 in/25millimeters (mm), 3 in/76 mm, 5 in/127 mm) of giant clams, *Tridacna maxima* (0.225 m^2), were observed at this site, suggesting recent recruitment (Table 6b, Figure 21). Mobile mollusks, *Trochus niloticus* (0.05 m^2), and *Cypraea tigris* (0. 025 m^2) and a species of boring urchin, *Echniometra mathaei* (0.2 m^2), were observed at this site. The mobile urchin, *Echinothrix calamaris* (0.075 m^2) was occasionally observed.

Fifty-five fish species in 18 families were seen at this site (Table 7., Fig. 3a-c, and Fig. 4a-c, Shannon diversity H` = 2.65). The parrotfish *Chlorurus sordidus* was the most commonly seen fish (23.1% of all fish observed), and was the largest single contributor to the estimate of total biomass (39.0%). Other fish frequently observed at the site were the surgeonfishes *Ctenochaetus striatus* and *Acanthurus nigrofuscus,* the butterflyfish *Chaetodon trifascialis* and the damselfish *Plectroglyphidodon lacrymatus*). *A. nigrofuscus,*and the parrotfishes *Scarus schlegeli, Calotomus carolinus* and *S. psittacus* together made up an additional 42.0% of the biomass estimate. At this site, both numerical observations and biomass estimates suggest that the fish community is composed primarily of mobile herbivores and invertebrate predators.

Benthic Community Ecological functions: Marine plant species of calcareous green macroalgae from the genera *Halimeda* were observed and contribute to the formation of sand habitats at this site. Large colonies of corals from the genera *Porites* and *Sinularia* function as forage and shelter habitat for reef fish, macro-invertebrates and create interstitial space to support the growth of calcareous algae. Large coral colonies also function as important wave diffusers that deflect high wave energy from the shoreline. The mobile urchin, *Echinothrix calamaris* was observed grazing on algae. The boring sea urchin, *Echinometra mathaei*, was observed forming grooves in the reef substrate, which were occupied by an unidentified turf algae and marine snails from the genera, *Trochus*.

Survey Station 7

At a depth of 23 ft (7.0 m), the marine benthos was completely occupied by marine organisms (Table 4b). Observations of marine plants and other benthic species consisted of the blue-green alga *Microcoleus lyngbyaceus* (T1=4%,); the green algae *Halimeda* sp (cf. *H. micronesica*) (T1=16%, T2=18%) and *Halimeda opuntia* (T1=11%, T2=9%); the brown algae *Dictyota bartayresii* (T2=2%), *Dictyota* sp. (T1=1%); red encrusting coralline algae (T1=4%, T2=1%); turf (thick) (T1=3%); and invertebrates (T1=62%, T2=69%).

Two-hundred-forty-six scleractinian corals (9 species) were recorded within four 10-m^2 transects along topographically complex (rugosity = 1.5 ± 0.1 S.D.) sunken reef crest at 7.0 m depth (Table 5g, Figure 1g). Four additional species (*Diploastrea heliopora*, *Fungia paumotensis*, *Pocillopora meandrina* and *Porites cylindrica*) were observed in the area. Diversity was low (Shannon index of diversity = 0.35, equability = 0.16 based on colony densities; Shannon index of diversity = 0.05, equability = 0.02 based on cover). *Porites rus* (a brooder and broadcast spawning species) was the dominant species, accounting for over 93% of mean density and coverage by live corals. Coral numbers and cover were high, with little variation between transects. Fifty-seven percent of colonies were ≥20 cm in greatest diameter with 4% less than 5 cm. *P. rus* spanned the range of size categories. Only *P. rus* displayed evidence of recent (past five years) recruitment which was low. Larval recruitment may be limited by a lack of substrate availability (live coral and macro-algae dominate benthic cover in the area). Average fragment numbers exceeded evidence of recent larval recruitment, suggesting a relatively important role of fragmentation in the population dynamics of *P. rus* in this area. Eleven percent of large colonies (10% ± 6 S.D. of all colonies) were completely parted by fission. Size, density, cover and rugosity data suggest high coral habitat complexity and reproductive potential for *P. rus* in this area.

Thirty-eight species from 27 families of non-coral macro-invertebrates were recorded at this station (Table 6a). A corallivorous snail, *Coralliophila violacea* (1.925 m^2), was the dominant mollusk observed attached to several *P. rus* coral colonies (Table 6b, Figure 2g). The asteroids, *Echinaster luzonicus* (0.05 m^2), *Linckia multifora* (0.075 m^2), and *Fromia milleporella* (0.1 m^2) appeared as occasional observations. The monotypic *P. rus* habitat supported few holothurians, and sea urchins were absent from this station. Therefore, densities for these functional groups were not recorded.

Thirty-seven reef fish species in 13 families were observed at this station (Table 7, Fig. 3a-c, and Fig. 4a-c, Shannon diversity H` = 2.41). Large numbers of fish were seen at this station. The most frequently observed fish were the butterfly fish *Chaetodon trifascialis,* the parrotfish *Scarus globiceps* and the damselfish *Amblyglyphidodon curacoa,* which together represented 65.3% of all individuals recorded. Aggregations of *C. trifascialis* accounted for a large proportion of the total number of fish seen (41.7%). The biomass estimate for this station was composed of robust-bodied parrotfishes with *S. globiceps, S. schlegeli, Chlorurus sordidus* and *Calotomus carolinus* representing 81.4% of the biomass estimate. Both numerical observations and biomass estimates reflected the existence of a fish community composed of mobile herbivores and selective invertebrate predators.

Benthic Community Ecological functions: Sediment forming calcareous green macroalgae from the genera *Halimeda* was observed. Large colonies of corals from the genera *Porites* function as important forage and shelter habitat for reef fish, macro-invertebrates and create interstitial space to support the growth of calcareous algae. The large *Porites rus* colonies also function as significant wave diffusers that destabilize large waves, thus minimizing erosion impacts to the shoreline. These coral colonies were especially important to the corallivorous snail, *Coralliophila violacea* which was observed in large densities foraging on *P. rus* colonies.

Reef Slope

Survey Station 8

At a depth of 28 ft (8.5 m), the marine benthos was completely occupied by marine organisms (Table 4b). Observations of marine plants and other benthic species consisted of the blue-green algae *Microcoleus lyngbyaceus* (T1=2%, T2=1%) and unidentified red slime (T2=1%); the green algae *Caulerpa filicoides* (T2=2%), *Caulerpa serrulata* (T2=2%), *Halimeda* sp (cf. *H. micronesica*) (T1=2%, T2=12%), *Halimeda opuntia* (T1=9%, T2=5%), and *Valonia ventricosa* (T1=1%); the brown alga *Turbinaria ornata* (T2=1%); the red alga *Galaxaura* sp (cf. *G. acuminata*) (T2=2%), encrusting coralline (T1=8%, T2=4%) and branching coralline algae (T2=2%); turf (thick) (T1=11%, T2=18); and invertebrates (T1=68%, T2=49%).

A total of 380 scleractinian corals (23 species) were recorded within four 10-m^2 transects along topographically complex (rugosity = 1.5 ± 0.04 S.D.) harbor reef ledge/slope at 8 m depth (Table 5h, Figure 1h). One additional species, *Lobophyllia hemprichii*, was observed in the area. The Shannon index of diversity was 1.20 (equability = 0.38) based on coral densities and 0.45 (equability = 0.14) based on cover. *Porites rus* (a brooder and broadcast spawning species) was the dominant species, accounting for over 70% of colony densities and cover. Variability in overall numbers and cover between transects was low. Colony densities and cover were high. Forty percent of colonies were ≥20 cm in greatest diameter with 13% less than 5 cm. *P. rus*, *P. lobata*, *Cosinaraea exesa* (aggregate distribution) and *Diploastrea heliopora* were represented by large colonies. Ten of the 23 species (43%) displayed evidence of recent (past five years) recruitment that appeared larval in nature. *P. rus* was the only species noted to fragment, with fragment numbers exceeding that of recent larval recruits. Ten percent of large colonies (7% ± 2 S.D. of all colonies) were completely parted by fission. Fission was prominent in *P. lobata*, *P. rus* and *Psammocora haimeana* (limited colony numbers). Size, density, cover, distribution and rugosity data suggested high coral habitat complexity and reproductive potential for *P. rus*, *P. lobata*, and *C. exesa* in this area.

Fifty-two species from 41 families of non-coral macro-invertebrates were recorded at this station (Table 6a). A corallivorous snail, *Coralliophila violacea* (1.425 m^2), was the dominant mollusk observed attached to *P. rus* coral colonies (Table 6b, Figure 2h). Giant clams, *Tridacna maxima* (0.1 m^2) and the top-shell snail, *Trochus niloticus* (0.05 m^2) were also observed at this station. The asteroids, *Echinaster luzonicus* (0.1 m^2) and *Linckia multifora* (0.075 m^2), were occasionally observed. The dominant mobile sea urchin observed at this station was *Diadema setosum* (0.125 m^2). The boring urchins, *Echinostrephus acciculatus* (0.025 m^2) and *Echinometra mathaei* (0.05 m^2), were also observed. The reef slope habitat supported but one species of holothuroid (*Pearsonothuria graeffei*), which was observed off the transect line and, therefore, not included in the estimates for abundance.

Forty-five fish species in 15 families were seen at this station (Table 7, Fig. 3a-c, and Fig. 4a-c, Shannon diversity H` = 2.54). Aggregations of the butterflyfish *Chaetodon trifascialis* accounted for a large proportion of the observations at this location (42.2%). Other frequently observed fish included the parrotfish *Chlorurus sordidus*; the surgeonfish *Ctenochaetus striatus*; and the damselfishes *Plectroglyphidodon lacrymatus* and *Amblyglyphidodon curacao* (32.0%). The biomass estimate for this station was dominated by the robust-bodied parrotfishes *C. sordidus, S. psittacus, S. schlegeli, S. globiceps,* and *Calotomus carolinus*, which together made up 82.85% of the biomass estimate. The numerical observations and biomass estimates at this station were reflective of a fish community composed of mobile herbivores and selective invertebrate predators.

Benthic Community Ecological Functions: Large patches of the green macroalgae, *Codium edulis* were observed at this site and functions as important forage for green sea turtles (*Chelonia mydas*). Large colonies of corals from the genera *Porites* function as important forage and shelter habitat for reef fish, macroinvertebrates and create interstitial space to support the growth of calcareous algae. The large *Porites rus* colonies also function as significant wave diffusers that destabilize wave energy and reduce shoreline erosion. These coral colonies were especially important to the corallivorous snail, *Coralliophila violacea* which was observed in large densities and foraging on *P. rus* colonies. Corals also function as important shelter for marine snails and echinoderm species from the genera, *Trochus*, *Conus*, *Lambis*, *Echinothrix*, *Holothuria* and *Thelenota*. The mobile urchin, *Diadema setosum*, was observed grazing on algae. Boring urchins (*e.g., Echinometra mathaei* and *Echinostrephus asciculatus*) created small holes and grooves in the reef that were observed to be occupied by small reef fish, other macro-invertebrate species, and algae.

Existing Conditions West of Kilo Wharf

Nearshore, the reef flat is generally low relief habitat with small branching corals, small rocks and boulders, and crevices of various sizes. The green alga, *Codium* sp., covers a large extent of this area. Mollusks, boring urchins, and mobile urchins are common throughout the area. Further west of the wharf, the reef flat is colonized by larger forms of branching (*Pocillopora*) and boulder-like (*Porites*) coral colonies. The reef crest and slope close to the wharf support a small variety of corals, mollusks, holothurians, and reef fish. However, overall species diversity and abundance on the reef crest and reef slope increases dramatically west-ward of Kilo Wharf. Large *Porites rus* colonies are the dominant species, forming a highly complex, three-dimensional habitat that supports a complex coral reef community. The reef ledge, about 45-ft contour, is primarily composed of sand and turf algae. Few coral species are distributed throughout the reef ledge. Also, a low variety of mollusks, sea stars and holothurians can be observed foraging across the reef ledge substrate.

Reef Flat

Survey Station 1

At a depth of 9 ft (2.7 m), the marine benthos was comprised of rock (T1=17%, T2=3%), sand (T1=1%), and rubble habitat (T1=2%) (Table 4a). Observations of marine plants and other benthic species consisted of the blue-green algae *Microcoleus lyngbyaceus* (T2=2%) and unidentified red slime (T2=1%); the green algae *Codium edulis* (T1=9%, T2=52%), *Halimeda* sp (cf. *H. micronesica*) (T1=8%, T2=3%), and *Neomeris annulata* (T1=1%, T2=1%); the brown algae *Dictyoa bartayresii* (T1=2%, T2=2%), *Lobophora variegata* (T2=1%), and *Padina tenuis* (T1=2%, T2=1%); the red algae *Actinotrichia fragilis* (T2=1%), *Galaxaura fasciculata* (T2=2%); encrusting coralline algae (T2=8%); turf (thick) (T1=22%) and turf (thin-silt covered) (T1=36%); and invertebrates (T2=23%).

One-hundred-sixty-three scleractinian coral colonies (16 species) were recorded within four 10-m^2 transects set across harbor reef flat with relatively low rugosity (rugosity = 1.2 ± 0.1 S.D.) at 2.7 m depth (Table 5a, Figure 1a). Six additional coral species (*Acropora nana*, *Favia stelligera*, *Goniastrea retiformis*, *Hydnophora microconos*, *Pocillopora danae* and *P. elegans*) were noted within the area. The Shannon index of diversity was 1.60 (equability = 0.58) based on colony numbers and 1.53 (equability = 0.55) based on colony coverage. *P. damicornis*, a brooding species, dominated colony numbers and cover. Variability in colony abundance was low among transects but relatively high between species. Coral coverage was low for all species. Ninety-one percent of colonies were less than 20 cm in greatest diameter with 44% less than 5 cm. Size trends were similar for commonly encountered species. One percent (± 1 S.D.) of *P. damicornis*, 3% (± 6 S.D.) of *P. meandrina* and < 1% of *Porites lobata* colonies were identified as unattached fragments. The majority of recent recruitment of species appeared larval in nature. Nineteen percent of large colonies (5% ± 1 S.D. of all colonies) were completely parted by fission. Fission was proportionally high in *Acanthastrea echinata* and *P. eydouxi*; however, sample size of these species was low. Size, density and coverage data suggest coral habitat complexity and reproductive potential are low. Coral community development may be limited by physical factors such as storm wave and wave refraction exposure at shallow depths, in addition to historical and wharf proximity impacts.

Twenty-six species from 19 families of non-coral macro-invertebrates were recorded at this station (Table 6a). The giant clam *Tridacna maxima* (0.15 m^2) was the dominant bivalve observed (Table 6b, Figure 2a). The boring sea urchins *Echinostrephus acciculatus* (0.7 m^2) and *Echinometra mathaei* (0.1 m^2) appeared in large abundance due to exposure to high-energy waves. The mobile urchin *Diadema setosum* (0.375 m^2) was observed scavenging the reef flat. The asteroids *Echinaster luzonicus* (0.025 m^2), *Linckia multifora* (0.1 m^2), and *L. laevigata* (0.025 m^2), were occasionally observed. A diverse assemblage of holothuroids, including *Holothuria whitmaei* (0.025 m^2), *Stichopus chloronotus* (0.025 m^2), *Bohadschia argus* (0.075 m^2), and *B. vitiensis* (0.025 m^2) were represented at this station. Among crustaceans, the red-spotted guard crab, *Trapezia ferruginea* (0.1 m^2), was observed to be associated with *P. eydouxi* and *P. meandrina* coral colonies.

Twenty-four fish species in 12 families were observed in roving diver surveys at this site (Table 7, Fig. 3a-c, and Fig. 4a-c, Shannon diversity H` = 2.73). Parrotfish were both numerically important and, because of their robust body shape, also were dominant in estimated biomass (45 *Chlorurus* *sordidus* and 18 *Scarus psittacus* were recorded within belt transects). Other frequently observed fish were the damselfishes *Chrysiptera brownriggii* and *Abudefduf vaigiensis,* and the wrasse *Thalassoma quinquevittatum.* Among the parrotfishes observed at the station, the two numerically dominant species together represented an estimated 0.41 tons/ha (76%) of the total biomass of all fish at this location. Other fish that contributed to the total fish biomass were the Moorish idol *Zanclus cornutus,* the butterflyfish *Chaetodon ulietensis and* the triggerfish *Sufflamen bursa.* These observations suggest a fish community primarily composed of mobile herbivores and selective invertebrate predators.

Benthic Community Ecological Functions: The green macro- algae, *Codium edulis,*was observed at this site and is documented as important forage for green sea turtles (*Chelonia mydas*). Though coral species diversity and abundance were low at this site, corals function as important shelter for marine snails and echinoderm species from the genera *Trochus*, *Conus*, *Lambis*, *Diadema*, *Holothuria* and *Bohadschia*. Corals also function as wave diffusers that assist in deflecting high wave energy from the shoreline. Corals were also observed to support a species of guard crab from the genus *Trapezia*. The mobile urchins, *Diadema setosum*,was observed grazing on algae. Several species of holothurians from the genera *Holothuria*, *Bohadschia* and *Stichopus* were observed foraging on the reef. Boring urchins (*e.g., Echinometra mathaei* and *Echinostrephus asciculatus*) were numerous and created many small holes, and channels in the reef that were occupied by small fish, other macroinvertebrates and turf algae. The reef flat habitat at this site also supports a species of giant clam, *Tridacna maxima,*which is considered a rare and unique species.

Survey Station 2

At a depth of 8 ft (2.4 m depth), the marine benthos was comprised of a sparse amount of rock habitat (T1=1%) (Table 4a). Observations of marine plants and other species consisted of blue-green unidentified blue-green slime (T2=1%); green algae *Codium edulis* (T1=34%, T2=3%), *Halimeda* sp. (cf. *H. micronesica*) (T1=10%, T2=8%), *Halimeda opuntia* (T2=3%); brown algae *Dictyoa bartayresii* (T1=2%, T2=1%), *Turbinaria ornata* (T2=1%); red algae *Galaxaura fasciculata* (T1=1%), *Polysiphonia* sp. (T1=2%), encrusting coralline (T2=1%), turf (thin-silt covered) (T1=47%, T2=78%); and invertebrates (T1=2%, T2=5%).

A total 170 scleractinian coral colonies (19 species) were recorded within four 10 m^2 transects set across relatively low rugosity harbor reef flat (rugosity = 1.2 ± 0.1 S.D.) at 2.4 m depth (Table 5b, Figure 1b). Two additional coral species (*Acropora humilis* and *Leptoria phrygia*) were observed in the area. The Shannon index of diversity was 1.72 (equability = 0.58) based on colony numbers and 2.59 (equability = 0.9) based on coverage. *Pocillopora damicornis*, a brooding species, dominated colony numbers and coverage. Colony numbers varied considerably between transects and species. Coral coverage was low for all species. Ninety-three percent of colonies were less than 20 cm in greatest diameter with 54 % less than 5 cm. Size trends were similar for commonly encountered species (Figure 2-1). Sixty-three percent of *Pocillopora verrucosa* colonies were observed as unattached fragments; no other species were noted to have fragmented. Ten of the 19 species (52 %) displayed evidence of recent (past five years) recruitment that appeared larval in nature. Ten percent of large colonies (3% ± 2 S.D. of all colonies) were completely parted by fission. Fission was proportionately high in *Astreopora listeri* (only one colony observed) and *P. damicornis*. Size, density and coverage data suggest coral habitat complexity and reproductive potential are low. Coral community development may be limited by physical factors such as storm wave and wave refraction exposure at shallow depths, in addition to historical and wharf proximity impacts.

Twenty-nine species from 21 families of non-coral macro-invertebrates were recorded at this site (Table 6a). The giant clam, *Tridacna maxima* (0.125 m^2), was the primary mollusks observed (Table 6b, Figure 2b). The zone of boring urchins, *Echinostrephus acciculatus* (0.55 m^2) and *Echinometra mathaei* (0.075 m^2), is extended from Survey Station 1 into this area. The mobile urchin, *Diadema setosum* (0.175 m^2), was also observed scavenging the reef flat. The asteroids, *Echinaster luzonicus* (0.075 m^2), *Linckia multifora* (0.175 m^2), and *L. laevigata* (0.075 m^2), were occasionally observed. The holothuroids, *Holothuria whitmaei* (0.025 m^2), *Bohadschia argus* (0.225 m^2), and *Pearsonothuria graeffei* (0.025 m^2) were represented at this site.

Thirty-four species representing 15 families were observed at this location (Table 7., Fig. 3a-c, and Fig. 4a-c, Shannon diversity H\` = 2.54). Numerically, a mix of parrotfish (Scaridae) and damselfish (Pomacentridae) were dominant. Eighteen juvenile *Ptereleotris evides* (dartfish, family Ptereleotridae) were observed at this site. Three parrotfish species (*Scarus psittacus, Chlorurus sordidus* and *Scarus globiceps*) together contributed 0.23 tons/ha (27 percent) of the total estimated biomass of all fish. Other fish species that contributed to the total estimates biomass of fish were *Aulostomus chinensis* and *Acanthurus triostegus*. These observations also suggest a fish community composed of mobile herbivores, a few demersal (territorial) grazers, and selective invertebrate predators.

Benthic Community Ecological Functions: The green macroalgae, *Codium edulis,*was observed at this site and is documented as important forage for green sea turtles (*Chelonia mydas*). Though coral species diversity and abundance were low, corals function as important shelter for marine snails and echinoderm species from the genera *Trochus*, *Conus*, *Lambis*, *Diadema*, *Holothuria,* and *Bohadschia*. Corals also function as wave diffusers that assist in deflecting high wave energy from the shoreline. The mobile urchins, *Diadema setosum,*was observed grazing on algae. Several species of holothurians from the genera *Holothuria*, *Bohadschia* and *Stichopus* were observed foraging on the reef. Boring urchins (*e.g., Echinometra mathaei* and *Echinostrephus asciculatus*) were numerous and created many small holes, and channels in the reef that were occupied by small fish, other macroinvertebrates and turf algae. The reef flat habitat at this site also supports a species of giant clam, *Tridacna maxima,*which is considered a rare and unique species on Guam.

Survey Station 6

At a depth of 5 ft (1.5 m), the marine benthos was completely occupied by marine organisms (Table 4b). Observations of marine plants and other species consisted of blue-green algae *Microcoleus lyngbyaceus* (T1=1%), unidentified yellow-brown (T1=1%, T2=1%), unidentified red slime (T1=1%, T2=4%), unidentified blue-green slime (T2=2%); green algae *Codium edulis* (T1=4%), *Dictyosphaeria versluysii* (T1=2%), *Halimeda* sp. (cf. *H. micronesica*) (T1=1%, T2=1%), *Halimeda opuntia* (T1=1%, T2=5%); brown algae *Dictyoa bartayresii* (T1=4%, T2=1%), *Dictyota* sp. (T1=2%, T2=2%), *Turbinaria ornata* (T1=1%); red algae encrusting coralline (T1=7%, T2=14%), branching coralline (T1=4%), turf (thick) (T1=43%, T2=36%); and invertebrates (T1=28%, T2=33%).

A total of 337 scleractinian corals (41 species) were recorded within four 10 m^2 transects along relatively low rugosity (rugosity = 1.20 ± 0.04 S.D.) harbor reef flat at 1.5 m depth (Table 5f, Figure 1f). Coral diversity was high with a Shannon index of 3.03 (equability = 0.82) based on colony densities and 2.53 (equability = 0.68) based on cover. *Pocillopora damicornis* (a brooder), *Goniastrea retiformis* (hermaphroditic broadcast spawner) and *Porites lutea* (gonochoric broadcast spawner) dominated colony densities and cover. Colony densities overall were high. Coral cover was moderate. Transect variability in coral cover was higher than that for overall colony densities. Variation among species was high. Sixty-five percent of colonies were less than 20 cm in greatest diameter with 17% less than 5 cm. *Porites lutea* was represented by colonies greater than 160 cm in greatest diameter. Size trends varied among species. Fourteen of the 41 species (34 %) displayed evidence of recent (past five years) recruitment of apparent larval origin. Representative colonies of four species were noted as fragments. Complete colony fission was observed in 15 species, but less than 1% of large colonies (0.6% ± 0.3 S.D. of all colonies) were completely parted by fission. A single colony of *Goniastrea edwardsii* was noted to possess a growth anomaly. Size, density, and diversity data suggest fair coral habitat complexity and high reproductive potential for common species.

Forty species from twenty-six families of non-coral macro-invertebrates were recorded at this site (Table 6a). Giant clams, *Tridacna maxima* (0.225 m^2) were commonly observed (Table 6b, Figure 2f). Mobile mollusks, *Trochus niloticus* (0.175 m^2) and *Lambis lambis* (0.025 m^2) and the corallivore, *Coralliophila violacea* (0.075 m^2) were observed. Boring urchins, *Echinostrephus acciculatus* (0.425 m^2) and *Echinometra mathaei* (0.175 m^2), continue to appear in large numbers throughout this site, similar to survey stations 1 and 2. The asteroids, *Acanthaster planci* (a corallivore) (0.05 m^2), *Echinaster luzonicus* (0.2 m^2), *Linckia multifora* (0.075 m^2), and *L. laevigata* (0.15 m^2), were observed throughout the site. The holothuroids, *Holothuria atra* (0.175 m^2), *Holothuria whitmaei* (0.125 m^2), *Stichopus chloronotus* (0.025 m^2), *Bohadschia argus* (0.45 m^2) were well represented at this site. The red-spotted guard crab, *Trapezia ferruginea* (0.15 m^2), was observed to be associated with *Pocillopora damicornis* coral colonies.

Thirty-eight reef fish species in 12 families were recorded at this site (Table 7., Fig. 3a-c, and Fig. 4a-c, Figure Shannon diversity H` = 2.26). *Chlorurus sordidus, Acanthurus nigrofuscus* were the two most frequently encountered species (36.2% of all fish seen). These two species together were the largest component of the biomass estimate (81.4%). Other frequently observed fish included *Ctenochaetus striatus* and *Chrysiptera brownriggii.*

Benthic Community Ecological Functions: The green macroalgae, *Codium edulis,* was observed at this site and serves as important forage for green sea turtles (*Chelonia mydas*). Coral species diversity and abundance were high and function as important shelter for marine snails and echinoderms. Corals at this site also function as significant wave diffusers that reduce wave energy from the shoreline. Corals were observed to support a species of guard crab from the genus *Trapezia*. The corallivorous snail, *Coralliophila violacea* was observed in large densities and actively foraging on colonies of *Porites* coral. The mobile urchin, *Diadema setosum*, was observed grazing on algae. Several species of holothurians from the genera *Holothuria*, *Bohadschia* and *Stichopus* were observed foraging on the reef. Boring urchins (*e.g., Echinometra mathaei* and *Echinostrephus asciculatus*) were abundant and created many small holes, and channels in the reef that were occupied by small fish, other macro-invertebrates and turf algae. This site also supports a species of giant clam, *Tridacna maxima,* considered a rare and unique species on Guam.

Survey Station 15

At a depth of 8 ft (2.4 m), the marine benthos was completely occupied by marine organisms (Table 4c). The marine community consisted of blue-green algae *Microcoleus lyngbyaceus* (T1=1%, T2=1%), unidentified yellow-brown (T2=4%), unidentified red slime (T2=1%), unidentified blue-green slime (T2=2%); green algae *Codium edulis* (T1=2%), *Dictyosphaeria versluysii* (T1=2%), *Halimeda* sp. (cf. *H. micronesica*) (T2=2%), *Halimeda opuntia* (T1=6%, T2=2%), *Neomeris annulata* (T1=1%); brown algae *Dictyota* sp. (T1=3%), *Lobophora variegata* (T1=1%, T2=1%), *Turbinaria ornata* (T1=3%, T2=2%); red algae encrusting coralline (T1=14%, T2=10%), branching coralline (T2=1%), turf (thick) (T1=36%, T2=33%); and invertebrates (T1=31%, T2=40%).

Three-hundred-sixty-seven scleractinian (38 species) and 11 alcyonacean (*Sinularia*) corals were recorded within three 10 m^2 transects along topographically complex (rugosity = 1.3 ± 0.1 S.D.) harbor reef flat at 2.4 m depth (Table 5o, Figure 1o). Four additional scleractinian species (*Acropora robusta*, *Montipora hoffmeisteri*, *Pavona duerdeni* and *Platygyra sinensis*) were observed in the area. Diversity was high, with a Shannon index of 2.80 (equability = 0.76) based on colony densities and 2.15 (equability = 0.86) based on cover. *Porites lobata* (gonochoric broadcast spawning coral), *Pocillopora damicornis* (a brooder) and *Goniastrea retiformis* (hermaphroditic broadcast spawner) dominated colony densities and cover. Colony densities and cover were high. Fifty percent of colonies were ≥20 cm in greatest diameter, with 19% less than 5 cm. Size trends varied among species. Fourteen of the 39 species (36%) displayed evidence of recent (last five years) recruitment that appeared of larval origin. Thirty percent of *Porites rus* and 2 % of *P. damicornis* mean colony numbers were observed as fragments. Overall recruitment appeared high for the region. Complete fission was observed in 10 species (7% of larger colonies; 4 % ± 4 S.D. for all colonies) and was proportionally highest in affected species represented by low sample numbers. Size, density, cover and rugosity data suggest high coral habitat complexity and reproductive potential for representative species in the area.

Fifty-one species from 35 families of non-coral macro-invertebrates were recorded at this site (Table 6a). The sessile bivalve, giant clam *Tridacna maxima* (0.125 m^2), and mobile snails, *Trochus niloticus* (0.05 m^2) and *Lambis chiragra* (0.025 m^2) were occasionally observed (Table 6b, Figure 2o). Boring urchins, *Echinostrephus acciculatus* (0.2 m^2) and *Echinometra mathaei* (0.025 m^2), and the mobile urchin, *Diadema setosum* (0.125 m^2) were also occasionally observed. The asteroids, *Acanthaster planci* (0.025 m^2), *Echinaster luzonicus* (0.075 m^2), *Linckia multifora* (0.1 m^2), and *L. laevigata* (0.05 m^2), were broadly distributed throughout the survey site. The holothuroids, *Actinopyga mauritiana* (0.05 m^2), *Holothuria atra* (0.05 m^2), *Stichopus chloronotus* (0.225 m^2), and *Bohadschia argus* (0.025 m^2) appeared to be grazing at turf algae or rubble covered habitat. The rusty guard crab *Trapezia rufopunctata* (0.15 m^2) and the red-spotted guard crab *Trapezia ferruginea* (0.05 m^2) were observed to occupy *Pocillopora eydouxi* coral colonies.

Fifty-five reef fish species from 18 families were seen at this site (Table 7, Fig. 3a-c, and Fig. 4a-c, Figure , Shannon diversity H` = 3.05). *Acanthurus nigrofuscus* was both the most abundant species (accounting for 19.9% of all individuals recorded) and the largest contributor to the biomass estimate (29.4% of total biomass estimate for all fish). *Ctenochaetus striatus, Chlorurus sordidus, Chaetodon ornatissimus* and *Balistapus undulatus* were other important fish species fish at this site.

Benthic Community Ecological Functions: Green macroalgae species from the genera *Codium* and *Turbinaria,*were observed and are also known to serve as important forage for green sea turtles (*Chelonia mydas*). Coral species diversity and abundance were high and function as important shelter for marine snails and echinoderms. Corals at this site also function as significant wave diffusers that reduce wave energy and minimize shoreline erosion impacts. Corals were also observed to support species of guard crabs from the genus *Trapezia*. The mobile urchin, *Diadema setosum*, was observed grazing on algae. Several species of holothurians from the genera *Actinopyga*, *Holothuria*, *Bohadschia* and *Stichopus* were observed foraging on the reef. Boring urchins (*e.g., Echinometra mathaei* and *Echinostrephus asciculatus*) were common and many bore holes and channels were observed to be occupied by small fish, other macroinvertebrates and turf algae. This site also supports a species of giant clam, *Tridacna maxima,* a rare and unique species on Guam.

Reef Crest

Survey Station 5

At a depth of 20 ft (6.1 m), the marine benthos was comprised of a modest amount of sand habitat (T1=2%) (Table 4a). The marine community consisted of blue-green algae *Microcoleus lyngbyaceus* (T1=1%, T2=1%); green algae *Halimeda* sp. (cf. *H. micronesica*) (T1=29%, T2=16%), *Halimeda opuntia* (T1=2%, T2=2%), *Neomeris annulata* (T1=1%); brown algae *Dictyota bartayresii* (T1=2%); red algae *Amphiroa* sp (T1=4%); and invertebrates (T1=53%, T2=81%).

A total 378 scleractinian corals (14 species) were recorded within four 10 m^2 transects along topographically complex (rugosity = 1.4 ± 0.1 S.D.) harbor sunken reef crest/slope at 6.1 m depth (Table 5e, Figure 1e). Eight additional coral species (*Ctenactis echinata*, *Diploastrea heliopora*, *Fungia fungites*, *Goniastrea edwardsii*, *G. pectinata*, *Pocillopora setchelli*, *Porites australiensis* and *Platygyra pini*) were observed in the area. Coral diversity was low, with a Shannon index of 0.34 (equability = 0.13) based on colony densities and 0.04 (equability = 0.02) based on coverage. *Porites rus* (a brooding and broadcast spawning species) was the dominant species, accounting for over 95 % of colony densities and cover. Overall coral numbers and cover were high, but varied between transects and species. Fifty-two percent of colonies were ≥20 cm in greatest diameter with 5 % less than 5 cm. *Porites rus* spanned the range of size categories. Seven of the species (50 %) displayed evidence of recent (past five years) recruitment of apparent larval origin. Larval recruitment may be limited by high benthic cover of live coral and macroalgae in this area. Nine percent of recorded *P. rus* were fragments, suggesting some importance of this reproduction and dispersal mechanism to the population dynamics of this species in this area (exceeding noted evidence of recent sexual recruitment). Eight percent of large colonies (7 % ± 5 S.D. of all colonies) were completely parted by fission. Size, density, cover and rugosity data suggest high coral habitat complexity and reproductive potential for *P. rus* in this area.

Twenty-one species from 18 families of non-coral macro-invertebrates were recorded at this site (Table 6a). The mobile snail, *Cypraea tigris* (0.025 m^2) was occasionally observed (Table 6b, Figure 2e). The mobile urchins, *Echinothrix diadema* (0.125 m^2) and *Diadema setosum* (0.05 m^2) were occasionally observed. New recruits of the asteroid, *Echinaster luzonicus* (0.25 m^2), along with *Linckia multifora* (0.3 m^2), and *L. laevigata* (0.05 m^2), were commonly observed. Overall, holothuroids were not well represented, with infrequent observations of *Bohadschia argus* (0.025 m^2) at this site.

Thirty-eight reef fish species from 13 families were observed at this site. (Table 7, Fig. 3a-c, and Fig. 4a-c, Shannon diversity H` = 2.67). *Amblyglyphidodon curacoa, Abudefduf vaigiensis* and *Plectroglyphidodon lacrymatus* were the most frequently seen species (47.4%). The small damselfish *Amblyglyphidodon curacoa* (Pomacentridae) was the most often recorded (22.3%), adults of this species often school well above the substrate where they feed on plankton. All of the commonly seen fish were small bodied and did not contribute significantly to the total estimates of biomass. *Myripristis berndti, Chlorurus sordidus* and *Naso vlamingii* were the largest contributors to the estimate of total biomass (58.5%) in roughly equivalent amounts (0.12 to 0.9 tons/ha). At this site, both numerical observations and biomass estimates suggest a fish community composed of a mix of herbivores, omnivorous schooling planktivores and invertebrate predators.

Benthic Community Ecological functions: Calcareous green macro-algae from the genera *Halimeda* were observed and likely contribute to the formation of sand sub-habitats. Sand habitats were observed to support a variety of marine snail species. Large colonies of corals from the genera *Porites* function as important forage and shelter habitat for reef fish, macroinvertebrates and create interstitial space that support the growth of calcareous algae. Large *Porites rus* colonies also function as wave diffusers that minimize erosion impacts to the shoreline. Mobile urchins, *Diadema setosum* and *Echinothrix diadema*, was observed grazing on algae.

Survey Station 14

At a depth of 21 ft (6.4 m), the marine benthos was completely occupied by marine organisms (Table 4c). Observations of marine plants and other species consisted of blue-green algae *Microcoleus lyngbyaceus* (T1=1%), unidentified yellow-brown (T2=1%); green algae *Caulerpa filicoides* (T2=2%), *Halimeda* sp. (cf. *H. micronesica*) (T1=11%, T2=29%), *Halimeda opuntia* (T1=18%, T2=1%), *Tydemania expeditionis* (T1=1%); red algae encrusting coralline (T1=6%, T2=5%), branching coralline (T1=2%), turf (thick) (T1=18%, T2=3%); and invertebrates (T1=43%, T2=59%).

One-hundred-ninety-five scleractinian (10 species) and five alcyonacean (*Sinularia*) corals were recorded within four 10 m^2 transects along topographically complex (rugosity = 1.6 ± 0.1 S.D.) harbor sunken reef crest at 6.4 m depth (Table 5n, Figure 1n). One additional scleractinian species, *Ctenactis albitentaculata*, was observed in the area. Diversity was low, with a Shannon index of 0.60 (equability = 0.25) based on colony densities and 0.11 (equability = 0.04) based on cover. *Porites rus* (a brooder and broadcast spawner) was the dominant species, accounting for 88 % of mean colony numbers and 97 % of mean live coral cover. It spanned the range of size categories (with the exception of the 0 to < 2 cm). Variability in overall numbers and cover between transects was relatively low, but high among species. Nine percent of mean *P. rus* colonies were noted as fragments, suggesting some importance of this reproductive and dispersal process in this species' dynamics. Fragments for other species were not observed. Three of the 11 species (27 %) displayed evidence of recent (past five years) larval recruitment. Recent larval recruitment appears low; however, substrate availability was limited by high live coral, macroalgae and thick turf algae cover. Only 1 % of large colonies (0.7 % ± 0.1 S.D. of all colonies) were completely parted by fission. Fission was observed in *P. rus* and *P. lobata*. Large colonies of *Porites lobata* and *P. rus* were observed in clusters, suggesting high reproductive potential for these species in this area. Size, densities, cover and rugosity data suggest high coral habitat complexity.

Twenty species from 19 families of non-coral macro-invertebrates were recorded at this site (Table 6a). *Coralliophila violacea* (1.275 m^2), was the dominant mollusk observed attached to *Porites rus* coral colonies (Table 6b, Figure 2n). Several size classes of giant clams, *Tridacna maxima* (0.3 m^2) were commonly observed throughout the survey site. Tiger cowry snails, *Cypraea tigris* (0.05 m^2) were occasionally observed. This site supported one of the highest densities of *Echinaster luzonicus* (0.45 m^2) with many new recruits observed. The mobile urchin, *Diadema setosum* (0.3 m^2) was commonly observed. The holothuroids, *Holothuria atra* (0.025 m^2), *Holothuria edulis* (0.025 m^2), and *Bohadschia vitiensis* (0.025 m^2) were observed to be foraging.

Fifty-one fish species representing 14 families were recorded at this site. This site had the most diverse fish community as indicated by the Shannon diversity value (Table 7, Fig. 3a-c, and Fig. 4a-c, Shannon diversity H` = 2.65). This site also had the highest number of fish recorded of any site. *Plectroglyphidodon lacrymatus, Abudefduf vaigiensis* and *Scolopsis lineate* were the most common fish and together made up 42.8% of all fish observed. The mobile herbivores *Naso vlamingii, Scarus globiceps* and *Chlorurus sordidus* together made up 37.5% of the total biomass estimate for fish. A large *Gymnothorax javanicus* (moray eel, family Muraenidae) was observed at this site which probably accounts for a disproportionate share of the biomass estimate. Numerical observations and biomass estimates suggest a fish community composed primarily of herbivores and selective invertebrate predators.

Benthic Community Ecological functions: The green macro-algae species, *Codium edulis,* was observed and considered as important forage for green sea turtles (*Chelonia mydas*). Also, calcareous green macro algae from the genera *Halimeda* were observed and contribute to the formation of sand sub-habitats. Sand habitats have been observed to support a variety of marine invertebrates. Large colonies of corals from the genera *Porites* function as important forage and shelter habitat for reef fish, macroinvertebrates and create interstitial space that support the growth of calcareous algae. Large *Porites rus* and *P. lobata* colonies function as wave energy diffusers and minimize erosion impacts to the shoreline. Also, a corallivorous snail, *Coralliophila violacea* was observed in large densities, foraging on *Porites* coral. The mobile urchin, *Diadema setosum* was observed grazing on algae. This site also supports one species of giant clam, *Tridacna maxima,* that is considered rare and unique for Guam fauna. Also, several species of holothurians from the genera *Holothuria* and Bohadschia were observed foraging.

Reef Slope

Survey Station 3

At a depth of 30 ft (9.1 m), the marine benthos was comprised of rock (T1=1%, T2=2%), sand (T1=22%, T2=6%), and rubble habitat (T1=2%, T2=1%) (Table 4a). The marine community consisted of blue-green algae *Microcoleus lyngbyaceus* (T2=1%), unidentified red slime (T1=1%), unidentified blue-green slime (T2=1%); green algae *Caulerpa filicoides* (T2=6%), *Halimeda* sp. (cf. *H. micronesica*) (T1=1%, T2=25%), *Halimeda opuntia* (T1=35%, T2=2%), *Neomeris annulata* (T1=1%, T2=1%); brown algae *Dictyota bartayresii* (T2=1%); red algae encrusting coralline (T1=3%, T2=1%), turf (thick) (T1=21%, T2=44%); and invertebrates (T1=13%, T2=8%).

Eighty-eight scleractinian (16 species) and two alcyonacean corals (*Sinularia*) were recorded within four 10 m^2 transects established along harbor reef slope/vertical wall at approximately 9.1 m depth (Table 5c, Figure 1c). Four additional coral species (*Diploastrea heliopora*, *Galaxea* *fascicularis*, *Montipora verrucosa* and *Pavona varians*) were observed in the area. The Shannon index of diversity was 1.97 (equability = 0.69) based on colony numbers and 1.07 (equability = 0.39) based on coverage. *Porites lobata* (a gonochoric broadcast spawner) and *P. rus* (a brooder and broadcast spawning species) dominated colony densities and coverage, which overall were very low. Ninety percent of colonies were less than 20 cm in greatest diameter with 43 % less than 5 cm. Size trends were varied for commonly observed species. Recent (last five years) recruitment was evident for 10 species, appeared larval in nature and was low. Fragments, if generated, were not observed due to slope. Eight percent of large colonies (2 % ± 5 S.D. of all colonies) were completely parted by fission. Fission was proportionately high in *Porites lobata* and *P. lutea*. Size, density and coverage data suggest coral reproductive potential is low. Coral community development may be limited by physical factors such as storm wave exposure in addition to historical and wharf proximity impacts.

Twenty-six species from 20 families of non-coral macro-invertebrates were recorded at this site (Table 6a). The boring urchin, *Echinostrephus acciculatus* (0.175 m^2), was commonly observed at this site (Table 6b, Figure 2c). Several species of asteroids, *Echinaster luzonicus* (0.025 m^2), *Linckia laevigata* (0.025 m^2), and *Fromia milleporella* (0.025 m^2) were observed. The holothuroids, *Holothuria whitmaei* (0.025 m^2), *Bohadschia argus* (0.225 m^2), and *Pearsonothuria graeffei* (0.025 m^2) were observed.

Thirty-eight species in 14 families were recorded at this site (Table 7, Fig. 3a-c, and Fig. 4a-c, Shannon diversity H` = 2.03). *Chaetodon trifascialis, Pomacentrus vaiuli, Acanthurus nigrofuscus* and *Plectroglyphidodon johnstonianus* were the most frequently recorded fish within belt transects. The butterflyfish *Chaetodon trifascialis* (Chaetodontidae) was both numerically dominant (26 percent of all individual fish observed) and was the largest single species contributing to the total estimated biomass of fish at this site (26.8 percent). Three other species (*Acanthurus nigrofuscus, Scarus schlegeli* and *Acanthurus lineatus*) together made up 57.1 percent of the remaining biomass estimate for this site. Both numerical observations and biomass estimates reflect a fish community composed of mobile herbivores, demersal grazers, and invertebrate predators (*Chaetodon trifascialis* is a selective coral polyp feeder).

Benthic Community Ecological Functions: Calcareous green macroalgae from the genera *Halimeda* was observed and contribute to the formation of sand sub-habitats. Few corals were observed at this site and future development was determined to be limited, likely as a result of previous wharf construction, ongoing vessel operations combined with high wave energy. One species of boring urchin (*e.g.,Echinostrephus asciculatus*) created small holes in the reef that were observed to be occupied by small reef fish, other macro-invertebrate species, and algae. Also, several species of holothurians from the genera *Holothuria, Bohadschia*, and *Pearsonothuria* were observed foraging.

Reef Ledge

Survey Station 10

At a depth of 45 ft (13.7 m), the marine benthos was primarily comprised of sand habitat (T1=59%, T2=43%) (Table 4b). The marine community consisted of red algae turf (thick) (T1=38%), turf (sandy and green) (T2=57%); and invertebrate (T1=3%).

Twenty-one scleractinian corals (7 species) were recorded within four $10m^2$ transects along harbor slope ledge habitat with low topographic complexity (rugosity = 1.0 ± 0.0 S.D.) fronting wharf structure at 13.7 m depth (Table 5j, Figure 1j). Four additional species (*Fungia* cf *granulosa*, *Hydnophora microconos*, *Lobophyllia hemprichii* and *Porites lutea*) were observed in the area. The Shannon index of diversity was 1.72 (equability = 0.88) based on colony numbers and 1.65 (equability = 0.85) based on cover. Colony densities and cover were exceedingly low. *Porites lobata* was the most abundant species encountered. No colony exceeded 20 cm in greatest diameter. Twenty-four percent of colonies were less than 5 cm in diameter and appeared as recent (past five years) recruits of larval origin. No colony fragments or complete fission were observed along transects. Coral habitat complexity and reproductive potential appeared absent. The lack of coral community development may be attributed to limited suitability of substrate available for recruitment and recurrent sediment exposure and/or scour.

Eighteen species from fourteen families of non-coral macro-invertebrates were recorded at this site (Table 6a). *Lambis lambis* (0.05 m^2), a mobile snail, was one of a few species of mollusks recorded at this location (Table 6b, Figure 2j). *Culcita novaeguineae* (0.025 m^2), a corallivorous asteroid, was recorded on a sand patch in close proximity to *Porites* coral colonies. *Thelenota ananas* (0.025 m^2), a large holothuroid, was observed amongst a patch of brown algae (*Padina* sp).

Twelve fish species in eight families were recorded at this site (Table 7, Fig. 3a-c, and Fig. 4a-c, Shannon diversity H` = 0.80). *Acanthurus blochii* was the single largest contributor both in number (71.4 percent) and in estimated biomass (96.3 percent). Other frequently observed fish were *Lethrinus harak* and *Sufflamen bursa*. These observations also suggest a fish community composed of mobile herbivores, piscivores and selective invertebrate predators.

Benthic Community Ecological Functions: Calcareous green macroalgae from the genera *Halimeda* was observed and contributes to the formation of sand sub-habitats. Few corals were observed at this site and future development was determined to be limited, likely as a result of previous wharf construction, ongoing vessel operations combined with high wave energy. One species of boring urchin (*e.g.,Echinostrephus asciculatus*) created small holes in the reef that were observed to be occupied by small reef fish, other macroinvertebrate species, and algae. Also, several species of holothurians from the genera *Holothuria, Bohadschia*, and *Pearsonothuria* were observed foraging.

Survey Station 13

At a depth of 47 ft (14.3 m), the marine benthos was primarily comprised of sand habitat (T1=83%, T2=29%) (Table 4c). Observations of marine plants and other species consisted of blue-green algae unidentified red slime (T2=1%); green algae *Caulerpa filicoides* (T2=2%), *Halimeda* sp. (cf. *H. micronesica*) (T2=3%), *Halimeda opuntia* (T1=2%, T2=15%), *Neomeris annulata* (T2=1%); red algae encrusting coralline (T2=2%), turf (thin) (T1=12%, T2=43%); and invertebrates (T1=6%, T2=1%).

One hundred scleractinian corals (18 species) were recorded within four 10 m^2 transects along harbor reef slope ledge habitat with low topographic complexity (rugosity = 1.1 ± 0.1 S.D.) at 14.3 m depth (Table 5m, Figure 1m). Three additional scleractinian species (*Goniastrea pectinata*, *Pocillopora eydouxi* and *Scolymia* cf *australis*) were noted in the area. The Shannon index of diversity was 1.87 (equability = 0.65) based on colony densities and 2.03 (equability = 0.70) based on cover. Coral densities and cover were low. *Porites lobata* (a gonochoric broadcast spawning species) was the most abundant species encountered. Ninety-six percent of colonies were less than 20 cm in greatest diameter with 40 % less than 5 cm. No colony fragments were observed. Recent (past five years) recruitment of apparent larval origin was displayed by only four of the 18 species (22 %). Available substrate for settlement was limited (mainly sand). Four percent of large colonies (1 % ± 2 S.D. of all colonies) were completely parted by fission. Coral habitat complexity and reproductive potential appeared nearly absent. The lack of coral community development may be attributed to limited suitability of substrate available for recruitment and recurrent sediment exposure.

Eighteen species from 13 families of non-coral macro-invertebrates were recorded at this site (Table 6a). *Holothuria atra* (0.025 m^2), *H. edulis* (0.025 m^2), and *Bohadschia vitiensis* (0.025 m^2) were among the observable holothuroids at this location (Table 6b, Figure 1m). Observations of other macro-invertebrate species occurred during the REA swim, while off of the survey transect, and therefore, were factored into estimates of abundance.

Twenty-five fish representing 13 families occurred at this site (Table 7., Fig. 3a-c, and Fig. 4a-c, Shannon diversity H` = 2.41). The most common fish numerically were *Chlorurus sordidus* and *Acanthurus nigrofuscus* which together accounted for 30.8% of all fish observed. The two most important contributors to the fish biomass estimate for this site were *Acanthurus nigricauda* and *Chlorurus sordidus*, which together contributed 57.6% of the total estimated biomass of fish at this site. Other commonly seen fish at this site were *Parapercis clathrata, Pomacentrus vaiuli* and *Parupeneus barberinus*. At this site, both numerical observations and biomass estimates suggest a fish community composed primarily of mobile herbivores.

Benthic Community Ecological Functions: Calcareous green macroalgae from the genera *Halimeda* was observed and contributes to the formation of sand habitats. Coral functions were absent at this site. Future coral growth potential appears unlikely due to the resuspension of sediment associated with ongoing vessel operations. Several species of holothurians from the genera *Holothuria* and *Bohadschia* were observed foraging on sand habitat and on patches of algae.

Survey Station 4

At a depth of 50 ft (15.2 m), the marine benthos was comprised of sand habitat (T1=3%, T2=30%) (Table 4a). Observations of marine plants and other species consisted of consisted of blue-green algae *Microcoleus lyngbyaceus* (T1=3%, T2=11%), unidentified red slime (T1=2%); green algae *Caulerpa filicoides* (T2=1%), *Halimeda* sp. (cf. *H. micronesica*) (T2=3%), *Halimeda opuntia* (T1=18%, T2=25%), *Neomeris annulata* (T2=1%), *Udotea argentea* (T2=1%); brown algae *Dictyota* sp. (T1=1%), *Lobophora variegata* (T1=1%); red algae encrusting coralline (T1=24%, T2=15%), turf (thick) (T1=19%, T2=10%); and invertebrate (T1=26%, T2=6%).

One-hundred-nineteen scleractinian corals (15 species) were recorded within four 10 m^2 transects along fairly steep harbor reef slope ledge at 15.2 m depth (Table 5d, Figure 1d). The Shannon index of diversity was 1.87 (equability = 0.69) based on colony numbers and 1.04 (equability = 0.38) based on coverage. *Porites rus* (a brooder and broadcast spawner) and *P. lobata* (gonochoric broadcast spawner) dominated colony numbers; *P. rus* and *P. lutea* (a gonochoric broadcast spawner) were dominant in coral cover, which was low. Seventy-four percent of colonies were less than 20 cm greatest diameter with 28 % less than 5 cm. Recent (past five years) larval recruitment was evident for 10 of the 15 species (67 %) but was low. Limited fragment numbers of *P. rus* and *P. lobata* were also identified within transect areas. Although larger colonies were identified, none appeared to have fully undergone fission. Density and coverage data suggest limited reproductive potential for corals in this area.

Twenty-two species from 21 families of non-coral macro-invertebrates were recorded at this survey station (Table 6a). The marine snails, *Trochus niloticus* (0.05 m^2) and *Cypraea tigris* (0.05 m^2) were observed at this site (Table 6b, Figure 2d). The asteroid *Echinaster luzonicus* (0.025 m^2) was observed on a patch of green calcareous algae, *Halimeda* sp. The holothuroid, *Bohadschia argus* (0.025 m^2), was also recorded.

Thirty-seven species in 15 families were seen at this site (Table 7., Fig. 3a-c, and Fig. 4a-c, Shannon diversity H` = 2.87). Overall relatively few fish were seen. *Chaetodon trifascialis, Cheilinus fasciatus* and *Acanthurus nigrofuscus* were the most frequently seen species (together representing 42.5 percent observed). The butterflyfish *Chaetodon trifascialis* was the most frequently observed fish (22.2 percent of all fish). *Acanthurus nigrofuscus, Zebrasoma veliferum* and *Naso vlamingii* were the largest contributors to estimated biomass. At this site, both numerical observations and biomass estimates suggest a fish community composed of mobile herbivores, demersal grazers, and invertebrate predators.

Benthic Community Ecological Functions: Two species of calcareous green macroalgae *Halimeda* sp. (cf. *H. micronesica*) and *H. opuntia*, function as sand habitat builders. Several large species of coral, *Porites rus* and *P. lutea*, functioned as shelter for the marine snails, *Trochus niloticus* and *Cypraea tigris* and provided interstitial space for the growth of calcareous algae. One species holothuria, *Bohadschia argus*, was observed foraging on sand habitat and at patches of algae.

Existing Conditions in the channel between Orote Island and Orote Peninsula

The channel between Orote Island and Orote Peninsula is primarily dominated by soft corals (*Sinularia* sp.). Giant clams, boring urchins, mobile urchins, secretive urchins, and holothurians are commonly observed in this area. The green calcareous algae (*Halimeda opuntia*) was commonly observed at this location.

Ocean Exposed Coral Reef flat (channel)

Survey Station 16

At a depth of 4 ft (1.2 m), the marine benthos was comprised of rock, (T1=1%, T2=2%), sand (T1=14%, T2=13%), and rubble habitat (T1=7%, T2=8%) (Table 4d). Observations of marine plants and other species consisted of green algae *Halimeda opuntia* (T1=2%, T2=7%); red algae encrusting coralline (T1=8%, T2=2%); and invertebrates (T1=68%, T2=68%).

Three-hundred-thirty-four scleractinian (22 species) and 84 alcyonacean (*Sinularia*) corals were recorded within four 10 m^2 transects along topographically complex (rugosity = 1.3 ± 0.1 S.D.) ocean exposed reef flat at 1.2 m depth (Table 5p, Figure 1p). One additional scleractinian coral (*Diploastrea heliopora*) and one helioporacean (*Heliopora coerulea*) coral were noted within the area (note, limited time available for area assessment). Level of diversity varied according to measured parameter, with a Shannon index of 2.20 (equability = 0.70) based on colony densities and 1.08 (equability = 0.35) based on cover. *Sinularia* and *Porites lobata* (both gonochoric broadcast spawners) dominated coral densities and cover. *Porites rus* (a brooder and broadcast spawner) and *Leptastrea purpurea* (a brooder) also dominated colony densities. Large aggregations of *Porites cylindrica* were observed but not covered by transect measurements. Variability in overall numbers and cover between transects was relatively low, but high among species. Seventy-one percent of colonies were less than 20 cm in greatest diameter with 41% less than 5%. Size trends varied between common species. Thirteen of the 23 species (57%) displayed evidence of recent (past five years) recruitment of apparent larval origin. Representative colonies of five species were noted as fragments. Overall recruitment appeared high. Eight percent of large colonies (3% ± 1 S.D. of all colonies) were completely parted by fission. Fission was proportionately high in *Goniastrea pectinata* (limited sample size), *Pavona varians* and *Porites lobata*. Size, density, cover and rugosity data suggest high coral habitat complexity and reproductive potential for representative species.

Twenty-one species from 18 families of non-coral macro-invertebrates were recorded at this survey station (Table 6a). Several mollusks were observed at this site, including: giant clams, *Tridacna maxima* (0.075 m^2), top-shell snails, *Trochus niloticus* (0.025 m^2), and the finger conchs *Lambis truncata* (0.025 m^2) and *L. lambis* (0.025 m^2) (Table 6b, Figure 2p). The asteroid *Linkia laevigata* (0.025 m^2) was reported. The boring urchin, *Echinostrephus acciculatus* (0.025 m^2), was observed. Congregations of the mobile urchins, *Echinothrix calamaris* (0.525 m^2) and *Diadema setosum* (0.7 m^2), were observed under small rock overhangs and in crevices in the reef flat. The secretive urchin, *Eucidaris metularia* (0.025 m^2), was observed in a soft coral (*Sinularia*) community. Holothuroids observed at this location included: *Holothuria atra* (0.1 m^2), *Stichopus chloronotus* (0.025 m^2) *Bohadschia argus* (0.025 m^2), and the synaptid, *Euapta godeffroyi* (0.125 m^2).

Seventy-eight species from twenty-one families were seen at this site (Shannon diversity H` = 2.49). *Platybelone argalus* (a schooling needlefish, family Belonidae), *Chlorurus sordidus* and *Ctenochaetus striatus* were the most frequently observed species and accounted for 48.9% of all individuals observed. By estimated weight, *Chlorurus sordidus, Chaetodon ornatissimus, Novaculichthys taeniourus* and *Lutjanus fulvus* together contributed 63.2% of the total biomass estimate. This site exhibited a diverse fish community with a wide range of feeding guilds including piscivores, generalist and selective invertebrate predators, and herbivores.

Benthic Community Ecological Functions: One species of calcareous green macroalgae, *Halimeda opuntia,* was observed and functions as a sand habitat builder. Coral species diversity and abundance were high and function as important shelter for marine snails and echinoderms. Numberous congregations of mobile urchins, *Diadema setosum* and *Echinothrix calamaris* were observed grazing on algae. Several species of holothurians from the genera *Euapta*, *Holothuria*, *Bohadschia* and *Stichopus* were observed foraging. One species of boring urchin, *Echinostrephus asciculatus,* was common and vacated burrows were observed to be occupied by small fish, other macro-invertebrates and turf algae. This site also supports a species of giant clam, *Tridacna maxima,* a rare and unique species on Guam.

Sea Turtles and Related Habitat

Nine sea turtle observations were recorded between January 19 and 23, 2006, while conducting habitat assessments at the proposed Kilo Wharf development sites and adjacent areas in Apra Harbor, Guam. Turtles were sighted within and/or near proposed development areas on each of the five survey days (average = 1.5 turtles per day^{-1} ± 0.5 S.D.). Observations included five green

(*Chelonia mydas*), one hawksbill (*Eretmochelys imbricata*) and three unidentified turtle sightings. At least 10 species of algae and a Cyanophyte identified as green turtle forage in other parts of the world (Balazs 1980, Forbes 1996, Hirth 1997, Uzcategui et al. 2005, Tsuda 1998) were identified, some in high percentages, in habitat areas that were assessed (Table 8). A sea grass, *Halophila* sp., which was present at one of the sites may also be utilized by turtles (Hirth 1997). Various invertebrate and algae groupings noted as forage by hawksbill turtles (including sponges, coelenterates, bryozoa, mollusks, urochordates, algae such as *Codium* and sea grass; Witzell 1983) were also observed. Local fishermen reported having observed utilization of habitat adjacent to the Kilo Wharf for turtle resting (Dan Narcis, Guam Environmental Protection Agency; Gerry Davis, NOAA Fisheries Service, pers. com.). Green turtle nesting activity has been noted on beach habitat lining inner Orote Peninsula near the Kilo Wharf (Tibbatts 2001). Hawksbill nesting within Apra Harbor historically has occurred in Sumay Cove (G. Davis, NOAA Fisheries Service, pers. com.).

DESCRIPTION OF ALTERNATIVES EVALUATED

In November, 2004, the U.S. Navy (Navy) informed the federal natural resource trustees (Service and NMFS) about plans to extend the existing ammunition wharf at Apra Harbor. At a June, 2005 meeting with the Service, NMFS, and EPA, the Navy released information that described several proposed alternatives for the extension and these included: (a) a 400-foot extension to the west; (b) a 400-foot extension to the east; (c) a 285-foot extension to the west and a 115-foot extension to the east; (d) an 821-foot extension perpendicular to the existing wharf; and (e) an 860-foot parallel pullback of the existing wharf, with a new breakwater and shore protection. In December 2005, consultants (Helbert Hastert and Fee [HHF]) transmitted maps that illustrated four alternatives (*i.e.*, West, West/East, Pullback, and Outboard) to extend the existing Kilo Wharf. In January, 2006, the Navy confirmed that the four alternatives identified in these maps were currently under consideration as viable alternatives to extend the existing wharf and should be evaluated by the natural resource agencies during the upcoming marine investigation.

At the conclusion of the field work surveys of the marine habitats at each of the four alternative sites in January 2006, the Service, NMFS, DAWR and GEPA met with Navy representatives at the DAWR office in Mangilao, Guam. During the course of this meeting, the resource agencies learned that the West extension is the Navy's preferred alternative to modify Kilo Wharf.

In February, 2006, at a meeting with the Navy, the Service, NMFS, DAWR, and GEPA discussed possible mitigation actions to offset ecological functions anticipated to be lost or degraded as a result of the proposed project. In addition, plans to coordinate the use of Habitat Equivalency Analysis were discussed as a means to appropriately scale potential mitigation projects. During March and April 2006, the Service and the Navy coordinated the exchange of various documents and information that related to the proposed construction project operations, which aided in the development of the Service's coordinated impact analysis. During this period, the Navy removed the Pull-back alternative from consideration, while retaining the West, West/East, and Outboard alternatives. Also, the Service hosted a meeting that included representatives from the Navy, consultants to the Navy, NMFS, GEPA, and DAWR to discuss project dredging-related sediment impacts to coral reef resources.

In June, 2006, the Service transmitted to the Navy a draft copy of the Kilo Wharf Expansion Project, Marine Assessment and Impact Analysis, Apra Harbor, Guam. Comments on the draft report were received from the Navy and incorporated into the report, where possible. In

December, 2006, the Service received new information from the Navy, indicating that the proposed West Extension and West/East Extension alternatives would be expanded in scope and that the Outboard alternative would be dropped from further consideration. In order to preserve the analyses included in the June 2006 draft report, an appendix (Appendix 5) is attached to this report that captures the stated alternatives, as they appeared during that iteration. The following description of the West Extension and West/East Extension alternatives is the latest account of planned activities, as provided by the Navy.

Alternative 1, Western Extension (Preferred)

Kilo Wharf would be extended in a westerly direction by about 400 ft (121.9 m) long and about 127 ft (38.7 m) wide, extending the existing wharf by about 50,800 ft^2 (4,719.5 m^2) (Appendix 3, Fig. 1 & 4) (Appendix 4). The approximate dredge area is about 54,900 ft^2 (5 099.04 m^2) or 1.26 acres (0.510 hectares). The approximate fill area or footprint of the new wharf extension is about 3,478,651 cubic feet (ft^3) (106,150 cubic meters (m^3)) or 2.13 acres (ac) (0.86 hectares [ha]). The approximate fill volume is about 3,859,893 ft^3 (2,951,100 m^3). The depth of the coral reef flat is currently between 5 and 8 feet deep and this would be increased to a depth of -56 feet. Approximately 70,000 cubic yards (yd^3) (53,519 m^3) of coral reef materials would be removed from the dredge site. A 1:1 slope would be dredged landward and outside of the western caisson extension footprint.

Prior to dredging activities, the deck and western breasting dolphin would be demolished and removed. The dolphin is about 40 ft by 40 ft or 1,600 ft^2 (148.6 m^2) or 0.04 ac (0.016 ha) in area. Similar to Kilo Wharf, the dolphin was constructed of concrete caissons and reaches depths of about 45 ft (13.7 m) below mean sea level (MLS), and about 18 ft (5.5 m) above MLS.

Dredging would be conducted using mechanical excavating equipment (*e.g.*, clamshell or crane) from a construction barge platform, approximately 260 ft long and 66 ft wide. Dredged materials would be placed on barges, known as dredge scows. The largest material dredge scow is about 220 ft long and about 50 ft wide, with a 4,000 yd^3 load capacity. Scows would not employ anchors, but would be tied off to the side of the construction barge. Dredged materials would be offloaded at the operational end of Kilo Wharf or Uniform Wharf at Inner Apra Harbor using a barge-mounted or land-based crane and bucket. Blasting methods are not considered under this alternative.

Approximately four main anchors and wire anchor lines would be used to moor the construction barge in place during project construction-related activities. Main anchors are 15 ft long and 10 ft wide, and weigh about 5 tons (4,535 kilograms), each. Piggy back anchors, additional small sized anchors (about 100 pounds each), would be attached to the existing anchor wire and in close proximity to the main anchor to stabilize the barge, if needed. Of the four main anchors, two would be deployed along the reef slope in the direction of the harbor bottom, and two would be placed on the reef flat, landward of the construction barge's operational position.

Factors that will be considered in the placement of construction barge anchors include: anchor design, barge size, wind/wave climate, and anchor position in relation to the elevation of the barge deck. Anchors will generally be deployed between 200 ft and 1,000 ft from the construction barge to achieve a stabilized state, allowing crane operations to occur. However, certain areas will likely require modified anchor geometry.

The construction barge main anchors and line would likely be deployed by a shallow draft tug using a heavy-duty winch to deploy or retrieve anchor and line during high tide conditions. Also, a tug may need to under-run an anchor in order to retrieve it. In addition, there is a small chance that a tug and anchor barge (drafts ranging between 3 to 12 ft) would be used in combination to set and retrieve anchors. Finally, a construction barge's position may be secured by tethering it to several Deadman units on the shoreline, in the event a tug or anchor barge could not be used to deploy construction barge anchors.

Dredged materials would be disposed of at an upland confined disposal facility (CDF) for dewatering, at either the primary site at the Orote Airfield CDF, or at Field 5 (east of Kilo Wharf) or at Field 3 (southeast of Kilo Wharf). After the dewatering process is completed, suitable dried materials may be reused by the Navy or others as potential landfill cover, construction fill, beach replenishment, rip-rap or other approved use.

An additional mooring island, constructed of pre-cast concrete, will be placed on the reef to stabilize vessels berthed at Kilo Wharf during the wharf extension period. The mooring island will be constructed on the reef flat, approximately 200 feet due west of the existing western mooring island, west of Kilo Wharf. The total construction period would range between 3 and 6 months. The footprint of the mooring island would be about 20 ft by 30 ft or 600 ft^2 (55.74 m^2) or 0.01 ac (0.004 ha) in area. Prior to placement of the mooring island, dredging would be required to sculpt the reef in a manner that would stabilize the mooring island in position. An area, approximately 30 ft by 40 ft or 1,200 ft^2 (111.48 m^2) or 0.026 ac (0.01 ha) in size would be dredged. The dredge depth is estimated to be – 5 feet. Approximately 210 yd^3 of coral reef materials would be removed from the site. The mooring island would not be removed after construction and may be used to stabilize vessels during future Kilo wharf vessel operations.

Two existing mooring islands, about 20 ft by 30 ft or 600 ft^2 (55.74 m^2) in size, located to the east and west of Kilo wharf, would be restored to prevent future erosion and scouring. Armor rocks (size unknown) would be placed around the existing mooring islands, resulting in a 3 ft^2 overfill. The overall footprint, including mooring island and armor rock overfill, would be extended to 23 ft by 33 ft or 759 ft^2 (70.5 m^2), or an additional 159 ft^2 (15 m^2) or 0.0037 ac (0.0015 ha) for each existing mooring island. Though specific refurbishment details are not yet available, it is possible that armor rocks would be set in place around the mooring island by either barge-mounted cranes or heavy equipment (*e.g.*, back-hoes) from a landward position.

Wharf extension construction-related activities are expected to occur over a 36-month period. Construction will generally occur between Monday and Friday for a 10-hour period. However, it is feasible for construction activities to occur at night, in the event ammunition operations are carried out during the daylight period. Ordnance operations would be performed at the eastern end of the wharf, during construction of the western extension section of the wharf. Vessels would be oriented in a bow-east facing position while tied off at the dock, and may drop a bow anchor to stabilize it in place.

Wharf improvements would include a variety of utility and infrastructure upgrades. Electrical power upgrades, including a 13.8 kilovolt (kV) circuit, would be installed along existing alignments from the Orote Power Plant to Kilo Wharf. A new transformer substation would be installed on the wharf to support ammunition vessel-related operations. New lighting would be added throughout the wharf to improve security. Telecommunications fiber optic systems would be added on the landside portion of Kilo Wharf and would be installed along the existing electrical alignment.

Alternative 2, West/East Extension

A total of 76,000 yd^3 (58,106 m^3) of coral reef materials would be dredged from the footprint of the proposed west/east extension (Appendix 3, Fig. 2 & 5) (Appendix 4). The removal of coral reef materials would be distributed over two construction sites: 53,500 yd^3 (38,228 m^3) from the eastern extension area and 22,500 yd^3 (14,527 m^3) from the western extension area. Coral reef materials would be dredged down to a depth of -56 feet. Dredged materials would be removed from an area approximately 96,700 ft^2 (8,984.02 m^2) or 2.22 ac (0.898 ha) in area, permanently modifying the coral reef habitat to the west and east of the existing wharf. From the existing Kilo Wharf, the wharf would extend about 285 ft (86.9 m) to the west and about 115 ft (35.0 m) to the east. The approximate width of the wharf for both western and eastern extensions would be about 127 ft (38.7 m). This would extend the existing footprint of the wharf by about 36,195 ft^2 (3,362.6 m^2) or 0.83 ac (0.33 ha) to the west and about 14,605 ft^2 (1,356.9 m^2) or 0.34 ac (0.137 ha) to the east. The approximate fill volume is about 4,506,151 ft^3 (127,600 m^3).

The existing deck and mooring dolphins would be demolished and removed first. Afterwards, the western extension section of the wharf would be constructed and ordnance operations would be carried out at the eastern end of Kilo Wharf. Similarly, ordnance operations would be performed at the newly constructed western end of the wharf, during construction of the eastern extension section of the wharf. The time-frame to carry out construction-related activities at the western and eastern sites is: between 16 and 20 months for the western site, and between 12 and 18 months for the eastern site. Vessels docking at Kilo Wharf during the construction period would be oriented in a bow-east position.

Two newly constructed mooring islands would be placed on the reef to stabilize vessels berthed at Kilo Wharf during the wharf extension period. They would be constructed and placed on the reef in a manner similar to the description provided in the western extension alternative. One new mooring island would be placed on the reef flat approximately 200 feet due east of the existing eastern mooring island, located east of Kilo Wharf; and one would be placed 200 feet due west of the existing western mooring island, located west of Kilo Wharf. Also, existing western and eastern mooring islands would be restored and other wharf improvements, including utility and infrastructure upgrades would be carried out.

PROJECT IMPACTS

The dimensions for each of the proposed project features and associated construction activities are site-dependent. Estimates of direct habitat impact by project construction-related activities are described below for each alternative (West, West/East, and Outboard) (Appendix 3, Figures 1 – 3). Additionally, indirect project construction-related sedimentation and suspended sediment impacts to coral reef resources beyond the project site are anticipated for each alternative (Appendix 3, Figures 4 – 6).

General Impacts

Dredging and filling-related activities associated with the proposed project will permanently alter habitat features and destroy coral reef organisms that occur within the project footprint and construction area of operation, for each proposed alternative. These organisms include functional groups of coral, algae, invertebrates and fish. Also, it is anticipated that wind-driven surface currents will transport suspended dredged sediment to areas down-current of the proposed dredge sites, and that some of this sediment will settle-out and smother sessile organisms (*e.g.*, corals, giant clams, macro-algae and turf algae) (U.S. Navy, 1986[1]; G. Davis Pers. Comm., 2006). It is also expected that dredging-related sedimentation and suspended sediment will disrupt or reduce coral reproduction processes, such as: (1) gamete production, (2) egg fertilization, (3) embryo development and larval survival, (4) larval settlement and metamorphosis, (5) recruitment survival, and (6) juvenile growth and survival (Fabricius 2004, Richmond 1997, Richmond 1993, Hodgson 1990, Babcock and Davies 1991) and (7) reduce adult coral fecundity (Kojis and Quinn 1984) over a broad area. Finally, the recovery of coral reef organisms within project areas that will be subjected to long-term exposure to re-suspended sediment mobilized by propeller turbulence should be anticipated.

All proposed alternatives have the potential to impact both green and hawksbill sea turtles in Apra Harbor directly and indirectly. Direct impacts include loss of resting habitat and foraging resources from dredging and filling. The loss of foraging resources, including sponges, coelenterates, bryozoa, mollusks, urochordates, and macro-algae may also occur as a result of the indirect impacts of sedimentation over varying periods of time. Although sea turtle nesting habitat is not expected to be directly impacted, contamination of harbor waters from project-related activities could degrade nearby potential nesting habitat. Measures to protect sea turtles from project-related impacts will be recommended in a subsequent mitigation report and addressed through ESA section 7 consultation.

Other indirect impacts to coral reef resources may include: introductions of alien species and exposure to petroleum products. Discharged vessel ballast water is a primary pathway for the introduction of alien species that could displace indigenous coral reef organisms (Godwin *et al.* 2004), and harbors are particularly vulnerable marine environments for this type of impact. Also, exposure to petroleum products, accidentally released into the harbor, may negatively impact coral reef organisms (Te 1991, Rinkevich and Loya 1983, Loya and Rinkevich 1980).

Descriptions of anticipated site-specific impacts are provided below. Tables 1 through 3 present summaries of project-related impacts to various habitats for each of the alternatives under consideration.

Western Extension Alternative (Preferred)

About 70,000 yd^3 (53,519 m^3) of coral reef materials will be dredged from the fringing reef, west of Kilo Wharf and this will permanently modify an area of coral reef habitat that is about 3.39 ac (1.372 ha) in size (Table 1 and Appendix 3 - Figure 1). The areas of coral reef habitat that could

[1] Current Measurement and Numerical Circulation Model Study for Kilo Wharf Extention Apra Harbor, Guam (Helber, Hastert and Fee, 2005) and Marine Ecosystem Impact Analysis Kilo Wharf Extension Outer Apra Harbor, Guam (Helber, Hastert and Fee, 2006) contained insufficient analyses of surface current-transported sediments beyond the identified dredge sites to merit considering their inclusion in this report.

be permanently affected by dredging operations are as follows: reef flat and crest (1.99 ac), reef slope (0.47 ac), and reef ledge (0.93 ac) habitat. The Kilo Wharf western extension will be constructed on about 1.17 ac (0.473 ha), within the 3.39-ac dredge site.

Barges and tugs will likely be used to perform dredging and filling activities for the western extension alternative; dredging and placement of the new mooring island; and refurbishment activities associated with the existing mooring island. Tug operations will involve the deployment and retrieval of anchors and anchor wire to secure construction barges in place. Anchor placement will have direct physical impacts to coral reef resources. Likewise, coral reef resources will be vulnerable to the effects of scouring and abrasions from anchor wires that are influenced by tides, currents, swells, and vessel movement. Because barges will be moved multiple times over the course of the construction period, we expect anchor-related impacts to occur over a broad area. It is anticipated that construction barges will be anchored at several different sites for dredging and filling to construct the west extension, install the new mooring island, and refurbish the existing mooring islands.

We anticipate that anchor deployment and retrieval impacts may occur up to 25 ft (7.62 m) from final placement on the reef (K. Foster, Pers. Comm). Also, we anticipate up to 25 ft (7.26 m) of impacts to coral reef resources to occur on either side of the anchor cable (K. Foster, Pers. Comm). Therefore, we anticipate about 4.16 ac (1.68 ha) of coral reef resources, distributed over several habitat zones: reef flat and crest (0.80 ac), reef slope (0.59 ac), reef ledge (0.05 ac), and harbor bottom (2.72 ac), will be affected by construction barge and tug operations.

Construction of a new mooring island would permanently modify about 0.03 ac (0.012 ha) of reef flat habitat, due to dredging-related activities. Within the dredged area, fill-related placement of the new mooring island would result in the permanent loss of about 600 ft^2 (55.74 m^2) or 0.01 ac (0.004 ha) of reef flat habitat.

Armor rock overfill at the two existing mooring islands would impact about 0.0037 ac (0.0015 ha) or a total of about 0.008 ac (0.003 ha) of reef flat habitat that would be permanently lost.
The total area that may be exposed to dredging-induced elevated turbidity levels is about 13.37 acres (5.4 hectares) (Table 1 and Appendix 3 - Figure 4), based upon monitoring and observations conducted during the original construction of Kilo Wharf (U.S. Navy, 1986; G. Davis Pers. Comm., 2006). The proposed time-frame to perform wharf extension construction activities could be as much as 36 months. Coral reproduction processes would likely be degraded during the time of exposure to elevated levels of fine sediments in the water column.

Also, we anticipate about 1.34 acres (about 10% of the affected 13.37 acres) of reef flat habitat may be subject to fine sediments settling out on the reef flat and remaining in place for a period of up to ten years (Rongo, 2004). Therefore, we anticipate lethal and sub-lethal injuries to affected coral reef organisms, due to smothering, abrasions, and scouring, resulting from long periods of exposure to sediments.

Summary of Impacts to Benthic Ecological Functions:

Planned project construction-related activities associated with the Western Extension Alternative would result in the loss of a variety of benthic ecological functions and seriously degrade functions to adjacent coral reef communities. Specific construction activities, such as dredge and fill, construction barge placement (anchor and cable), new mooring island construction, existing mooring island refurbishment, and suspended sediment and sedimentation associated with construction dredge and fill activities would result in negative impacts to coral reef resources and functions over a broad area, about 22.336 acres (Table 1), along the southern shore of Apra Harbor. Existing intact functions documented at reef flat, crest, slope, and ledge habitats within the project area would be lost and include: (1) formation of sand habitat by calcareous algae; (2) the provision of forage for federally listed threatened green sea turtles (*Chelonia mydas*) by green macro-algae; (3) provision of shelter for marine snails and echinoderms, forage for corallivorous snails, and interstitial space for calcareous algae by coral structure; (4) diffusion of wave energy and minimization of shoreline erosion by coral structure; (5) complex symbiotic relationships between corals and crustaceans; (6) checks on macro-algae proliferation through grazing by mobile sea urchins, which allows other functions to occur; (7) cleansing of benthic sediment by detritivorous holothurians, (8) creation of sub-habitat structures, occupied by species of reef fish, macro-invertebrates and algae by the actions of boring sea urchins; and (9) provision of habitat that supports rare and unique bivalve species, including giant clams.

Table 1. Summary of project-related impacts to coral reef habitat for the Western Extension Alternative.

Construction Activity	Habitat Type	Type of Injury	Injury Affects	Duration of Injury	Acreage
(1) Wharf Dredging	Reef flat/crest	Dredge	BS and BC[1]	Permanent	1.99
	Reef slope	Dredge	BS and BC	Permanent	0.47
	Reef ledge	Dredge	BS and BC	Permanent	0.93
				Subtotal	3.39
(2) Barge/Tug Operations	Reef flat/crest	Anchor/Wire	BS and BC	100 years*	0.80
	Reef slope	Anchor/Wire	BS and BC	100 years*	0.59
	Reef ledge	Anchor/Wire	Calc. Algae[2]	5 years**	0.05
	Harbor Bottom	Anchor/Wire	Infauna[3]	1 year***	2.72
				Subtotal	4.16
(3) New Mooring Island	Reef flat	Dredge	BS and BC	Permanent	0.03
(4) Existing Mooring Islands	Reef flat	Fill	BS and BC	Permanent	0.046
(5) Wharf Dredging	Reef flat/slope	Sup.Seds.[5]	Degraded CRP[4]	36 Months	13.37
(6) Wharf Dredging	Reef flat	Sedimentation	BS and BC	10 years	1.34
				Total	22.336

[1] BS and BC = BS - Benthic Substrate (Sand/Rocks etc.,) and BC – Biological Community (Algae, Coral, Macroinvertebrates, and Reef Fish)
[2] Calc. Algae = (Calcareous Algae, such as *Halimeda*). [3] Infauna = crustaceans, mollusks, and marine worms. [4] Degraded Coral Reproduction Processes [5] Suspended Sediments* Approximate time for *Porites rus* colony to recover. ** Approximate time for *Halimeda* sp meadow to recover. *** Approximate time for Infauna to recolonize benthic habitat.

West/East Extension Alternative

About 76,000 yd^3 (58,106 m^3) of coral reef materials will be dredged from the fringing reef located west and east of Kilo Wharf and this will permanently modify about 4.47 ac (1.809 ha) of coral reef habitat (Table 2 and Appendix 3 – Figure 2). The areas of coral reef habitat that would be permanently modified by dredging operations are as follows: reef flat and crest (2.39 ac), reef slope (0.67 ac), and reef ledge (1.41 ac) habitat. Within this dredged area, approximately 2.25 ac (0.911 ha) will be filled.

Because barges will be moved multiple times over the course of the construction period, it is expected that anchor-related impacts will occur over a broad area. It is anticipated that the construction barges will be anchored at several different sites for dredging and filling to construct the west and east extensions, install the new mooring islands, and refurbish the existing mooring islands. Anchor deployment and retrieval impacts are anticipated to occur up to 25 ft (7.62 m) from final placement on the reef. Also, it is expected that up to 25 ft (7.26 m) of impacts to coral reef resources will occur on either side of the wire. Therefore, we anticipate about 6.78 ac (2.74 ha) of coral reef resources, distributed over several habitat zones: reef flat and crest (1.43 ac), reef slope (1.16 ac), reef ledge (0.05 ac), and harbor bottom (4.14 ac) will be affected by construction barge and tug operations.

Construction of the two new mooring islands would modify about 0.052 ac (0.022 ha) of reef flat habitat. Within the dredged area, placement of the new mooring islands would fill an area about 1,200 ft^2 (111.48 m^2) or 0.027 ac (0.008 ha) in size.
Armor rock overfill at the two existing mooring islands would impact about 0.016 ac (0.01 ha) of reef flat habitat that would be permanently lost.

The total area that may be exposed to dredging-induced elevated suspended sediment is about 18.38 ac (7.43 ha). The proposed time-frame to perform wharf extension construction activities could be up to about 38 months. Therefore, we anticipate turbidity levels to disrupt coral reproduction processes during this period, over the affected area.

Also, it is anticipated that about 1.83 ac (about 10 % of the affected area of 18.38 ac) of reef flat habitat may be vulnerable to sedimentation from fine sediment settling out on the reef (Table 2 and Appendix 3 – Figure 5). If left in place, settled sediment would likely smother, abrade, and scour coral reef organisms that occur within this area.

Summary of Impacts to Benthic Ecological Functions:

Planned project construction-related activities associated with the West-East Extension Alternative would result in greater impacts to coral reef resources and ecological functions over a broader area, 31.536 acres (Table 2), as compared to the preferred West Extension Alternative. Construction activities include dredge and fill, construction barge placement (anchor and cable), new mooring island construction, and existing mooring island refurbishment. Also, dredge and fill-related activities will result in mobilizing and transporting suspended sediment downwind/current of the project site. We also anticipate suspended sediment to settle out over coral resources and degrade or disrupt ecological functions within affected areas. Existing intact functions documented at reef flat, crest, slope, and ledge habitats within the project area would be lost and include: (1) formation of sand habitat by calcareous algae; (2) provision of forage for federally listed threatened green sea turtles (*Chelonia mydas*) by green macro-algae; (3) provision of shelter for marine snails and echinoderms, forage for corallivorous snails, and interstitial space for calcareous algae by coral structure; (4) diffusion of wave energy and minimization of shoreline erosion by coral structure; (5) complex symbiotic relationships between corals and crustaceans; (6) checks on macro-algae proliferation through grazing by mobile sea urchins, which allows other functions to occur; (7) cleansing of benthic sediment by detritivorous holothurians; (8) creation of sub-habitat structures, occupied by species of reef fish, macro-invertebrates and algae by boring sea urchins; and (9) provision of habitat that supports rare and unique bivalve species, including giant clams.

Table 2. Summary of project-related impacts to coral reef habitat for the West/East Extension Alternative.

Construction Activity	Habitat Type	Type of Injury	Injury Affects	Duration of Injury	Acreage
(1) Wharf Dredging	Reef flat/crest	Dredge	BS and BC[1]	Permanent	2.39
	Reef slope	Dredge	BS and BC	Permanent	0.67
	Reef ledge	Dredge	BS and BC	Permanent	1.41
				Subtotal	4.47
(2) Barge/Tug Operations	Reef flat/crest	Anchor/Wire	BS and BC	100 years*	1.43
	Reef slope	Anchor/Wire	BS and BC	100 years*	1.16
	Reef ledge	Anchor/Wire	Calc. Algae[2]	5 years**	0.05
	Harbor Bottom	Anchor/Wire	Infauna[3]	1 year***	4.14
				Subtotal	6.78
(3) New Mooring Islands	Reef flat	Dredge	BS and BC	Permanent	0.03
(4) Existing Mooring Islands	Reef flat	Fill	BS and BC	Permanent	0.046
(5) Wharf Dredging	Reef flat/slope	Susp.Sed.	Degraded CRP[4]	38 Months	18.38
(6) Wharf Dredging	Reef flat	Sedimentation	BS and BC	10 years	1.83
				Total	31.536

[1] BS and BC = BS - Benthic Substrate (Sand/Rocks etc.,) and BC – Biological Community (Algae, Coral, Macroinvertebrates, and Reef Fish)
[2] Calc. Algae = (Calcareous Algae, such as *Halimeda*).[3] Infauna = crustaceans, mollusks, and marine worms. [4] Degraded Coral Reproduction Processes.
[5]Suspended Sediments. * Approximate time for *Porites rus* colony to recover. ** Approximate time for *Halimeda* sp meadow to recover.
*** Approximate time for Infauna to recolonize benthic habitat.

Each alternative under consideration is anticipated to result in permanent and temporary impacts. Table 3 shows a summary comparison of these impacts in relation to the various reef habitats at the proposed project site.

Table 3. Comparison summary of anticipated project-related impacts to coral reef habitat for both proposed alternatives under consideration.

		Type of Impact		
Alternative	Habitat Type	Permanent (ac)	Temporary (ac)	Total (ac)
Western Extension	Reef flat/crest	2.066	0.80	2.866
	Reef Slope	0.47	0.59	1.06
	Reef Ledge	0.93	0.05	0.98
	Reef flat/slope	0.0	14.71	14.71
	Harbor bottom	0.0	2.72	2.72
	Subtotal	3.466	18.87	22.336
West/East Extention	Reef flat/crest	2.466	1.43	3.896
	Reef Slope	0.67	1.16	1.83
	Reef Ledge	1.41	0.05	1.46
	Reef flat/slope	0.0	20.21	20.21
	Harbor bottom	0.0	4.14	4.14
	Subtotal	4.546	26.99	31.536

SUMMARY

This report documents existing fish and wildlife resources at the proposed Kilo Wharf project site and evaluates alternative project plans to extend the wharf in relation to anticipated project-related impacts to these resources. The proposed action is necessary to provide berthing and operations support for the new T-AKE vessel that may berth at Kilo Wharf in 2008. Federal and territorial resource agencies cooperated closely in the development of this report, including the collection of field data that serves as the basis for the biological resource summary contained within this report.

Fringing coral reefs are the dominant form of reef habitat on Guam and these reefs support thousands of species of animals and plants. It is well documented that complex biological communities on Guam enable a variety of ecological functions. However, these coral reefs are exceedingly vulnerable to natural and anthropogenic influences that may degrade or completely alter entire communities.

A diverse assemblage of marine organisms was evaluated at the community level to assess the relative contribution to coral reef resources that occur around Kilo Wharf and within the channel near Orote Island. The distribution and relative abundance of algae, corals, other macro-invertebrates, and reef fishes were then compiled, along with a decription of observed benthic ecological functions, for sixteen survey stations. Various methods were employed to calculate species diversity and to describe the coral reef community within the areas anticipated to be affected by the proposed project.

Information obtained from the Navy describes two alternatives to extend the existing wharf, including the Western and West/East extension alternatives. For each alternative, the existing

environment around Kilo Wharf will be significantly altered by construction-related dredge and fill activities. Additionally, significant indirect impacts to resources beyond the immediate project site are anticipated.

The Western Extension Alternative is anticipated to result in fewer impacts to coral reef resources and less loss of coral reef ecological functions than the West/East Extension Alternative. Adverse impacts to coral reef species and ecological functions anticipated to result from the proposed project include the unavoidable direct and indirect loss or degradation of organisms, functions, and reef habitat. The proposed project has the potential to impact listed species, including sea turtles and marine mammals, and other rare federally protected species, including corals and giant clams. Measures to protect listed species will be addressed through consultation under section 7 of the ESA.

Recommendations for measures to avoid or minimize impacts and to off-set unavoidable impacts to fish and wildlife resources will be developed by the resource agencies and transmitted to the Navy in a follow-up report. Habitat Equivalency Analysis (HEA), will be used to scale anticipated resource losses and relative mitigation requirements designed to off-set these losses. The federal and territorial resource agencies will continue to coordinate with the Navy to identify appropriate mitigation projects. Likewise, the resource agencies will continue to collaborate on several levels including: (a) Future field work and other data collection efforts to evaluate potential mitigation sites; (b) Development of performance criteria and recovery goals at potential mitigation sites; (c) Identification of actions to achieve recovery goals; and (d) Identification of methods to monitor potential mitigation projects.

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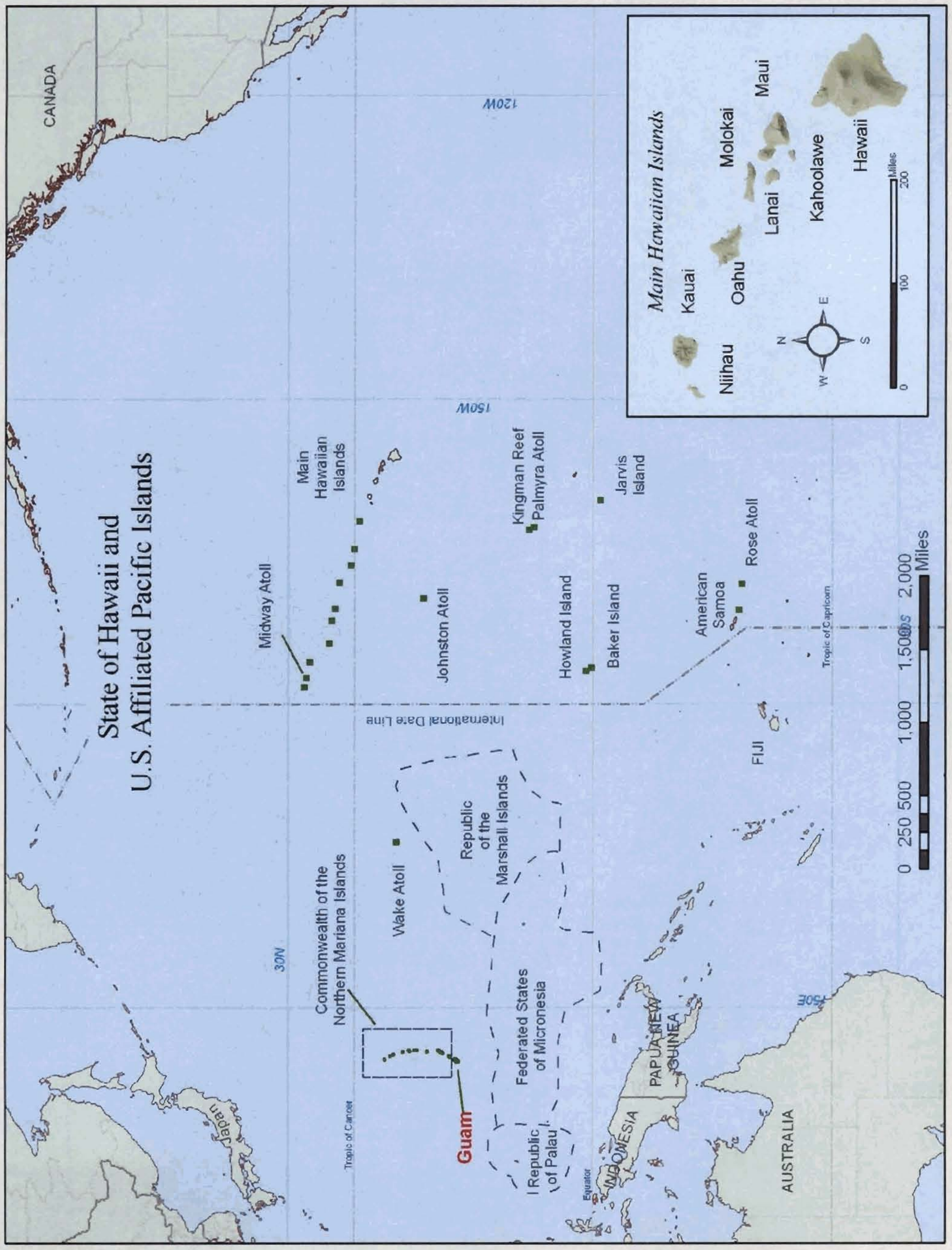


Figure 1. Pacific Area Map

Figure 2. Apra Harbor, Guam

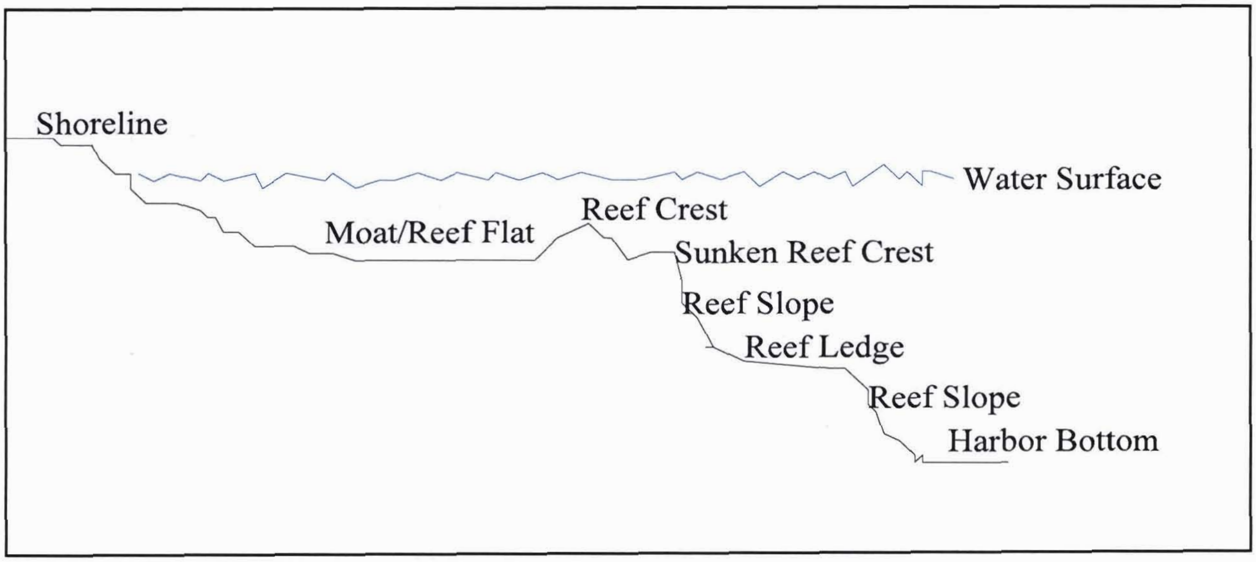


Figure 3. Stylized Fringing Coral Reef Habitat Profile, Apra Harbor, Guam

Table 4a. Marine plant species observed at 16 survey stations at the Kilo Wharf and Orote Channel, Apra Harbor, Guam, January 19 - 23, 2006. (Data reported as %)

SURVEY STATION	1	1	2	2	3	3	4	4	5	5
TRANSECT	1	2	1	2	1	2	1	2	1	2
DATE	J19	J19	J19	J19	J19	J19	J20	J20	J20	J20
Rock	17	3	1		1	2				
Sand	1				22	6	3	30	2	
Rubble	2				2	1				
Cyanophyta										
Microcoleus lyngbyaceus		2				1	3	11	1	1
Unid red slime		1			1		2			
Unid blue-green slime			1			1				
Chlorophyta										
Avrainvillea sp.										
Caulerpa filicoides						6		1		
Codium edulis	9	52	34	3		1				
Halimeda sp. (cf. H micronesica)	8	3	10	8	1	25	3		29	16
Halimeda opuntia				3	35	2	18	25	2	2
Neomeris annulata	1	1			1	1	1			
Udotea argentea								1		
Phaeophyta										
Dictyota bartayresii	2	2	2	1		1			2	
Dictyota sp.?								1		
Lobophora variegata		1					1			
Padina tenuis	2	1								
Turbinaria ornata				1						
Rhodophyta										
Actinotrichia fragilis		1								
Amphiroa sp.									4	
Galaxaura fasciculata		2	1							
Polysiphonia sp.			2							
encrusting coralline		8		1	3	1	24	15	7	
Turf, thick, Rhodophyta	22				21	44	19	10		
Turf, thin, silt covered	36		47	78						
Hard Coral		1	2		8	2	7	2	48	81
Sponge				5	5	6	19	4	5	
Sinularia		22								
TOTAL	100	100	100	100	100	100	100	100	100	100

Table 4b. Marine plant species observed at 16 survey stations at the Kilo Wharf and Orote Channel, Apra Harbor, Guam, January 19 - 23, 2006. (Data reported as %)

SURVEY STATION	6	6	7	7	8	8	9	9	10	10
TRANSECT	1	2	1	2	1	2	1	2	1	2
DATE	J20	J20	J21	J21	J21	J21	J21	J21	J21	J21
Rock		1								
Sand							5	1	59	43
Rubble								2		
Cyanophyta										
Microcoleus lyngbyaceus	1		4		2	1				
Unid yellow-brown	1	1								
Unid red slime	1	4				1				
Unid blue-green slime		2								
Chlorophyta										
Caulerpa filicoides						2				
Caulerpa serrulata						2				
Codium edulis	4						53	74		
Dictyosphaeria versluysii	2									
Halimeda sp. (cf. H micronesica)	1	1	16	18	2	12				
Halimeda opuntia	1	5	11	9	9	5	1			
Phaeophyta										
Dictyota bartayresii	4	1		2			1			
Dictyota sp.?	2	2		1						
Padina tenuis							1	3		
Turbinaria ornata	1					1		1		
Sargassum cristaefolium								1		
Rhodophyta										
Galaxaura fasciculata							5			
Galaxaura sp.(cf. G acuminata)						2	4	1		
encrusting coralline	7	14	4	1	8	4	9	2		
branching coralline	4					2				
Turf, thick, Rhodophyta	43	36	3		11	18	19	15	38	
Turf, sandy and green										57
Coral	21	28	57	66	68	44	2		2	
Sponge	5	3	5	3		5			1	
Tridacna	1	1								
Holothurian	1	1								
TOTAL	100	100	100	100	100	99	100	100	100	100

Table 4c. Marine plant species observed at 16 survey stations at the Kilo Wharf and Orote Channel, Apra Harbor, Guam, January 19 - 23, 2006. (Data reported as %)

SURVEY STATION	11	11	12	12	13	13	14	14	15	15
TRANSECT	1	2	1	2	1	2	1	2	1	2
DATE	J22	J22	J22	J22	J22	J22	J22	J22	J23	J23
Sand	2	1	5		83	29				
Cyanophyta										
Microcoleus lyngbyaceus	1		3	2			1		1	1
Unid yellow-brown								1		4
Unid red slime	1					1				1
Unid blue-green slime			4	2					1	2
Chlorophyta										
Avrainvillea sp.										
Caulerpa filicoides			1			2		2		
Caulerpa racemosa	1									
Codium edulis	43	27							2	
Dictyosphaeria versluysii									2	
Halimeda sp. (cf. H micronesica)	2	10	11	4		3	11	29		2
Halimeda opuntia	4	2	5	23	2	15	18	1	6	2
Neomeris annulata	1	1				1				1
Tydemania expeditionis							1			
Valonia ventricosa	1									
Phaeophyta										
Dictyota bartayresii	2		2	3						
Dictyota sp.?				3					3	
Lobophora variegata			1						1	1
Padina tenuis		1								
Turbinaria ornata	1	2							3	2
Rhodophyta										
Galaxaura fasciculata	2	1								
Galaxaura sp.(cf. G acuminata)	4	2								
encrusting coralline	7	6	10	6		2	6	5	14	10
branching coralline	1	5	2	1			2			1
Turf, thick, Rhodophyta	19	37	15	1			18	3	36	33
Turf, thin, silt covered					12	43				
Hard Coral	6	4	17	52		3	43	59	28	38
Sponge	1	1	6	3	3	1			3	2
Sinularia			18							
Lambis	1									
Halophila ovalis *(present nearby)					*					
TOTAL	100	100	100	100	100	100	100	100	100	100

Table 4d. Marine plant species observed at 16 survey stations at the Kilo Wharf and Orote Channel, Apra Harbor, Guam, January 19 - 23, 2006. (Data reported as %)

DIVE NUMBER	16	16
TRANSECT	1	2
DATE	J23	J23
Rock	1	2
Sand	14	13
Rubble	7	8
Chlorophyta		
Halimeda opuntia	2	7
Rhodophyta		
branching coralline	8	2
Hard Coral	36	56
Sponge	18	11
Sinularia		1
Lobophytum	12	
Snail	1	
Acanthaster	1	
TOTAL	100	100

Table 5a. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 1.

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Acanthastrea									
A. echinata	0	2	0	0	0.05 ± 0.10	< 0.1	0	0	100
Acropora									
A. humilis	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
A. surculosa	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
A. sp.	2	0	0	1	0.08 ± 0.10	< 0.1	0	0.05 ± 0.06	0
Astreopora									
A. myriophthalma	4	0	0	0	0.10 ± 0.20	< 0.1	0	0	0
Favia									
F. matthaii	1	3	2	0	0.15 ± 0.13	< 0.1	0	0.08 ± 0.10	0
Leptastrea									
L. purpurea	4	0	1	0	0.13 ± 0.19	< 0.1	0	0.10 ± 0.20	0
Leptoria									
L. phrygia	0	0	2	0	0.05 ± 0.10	< 0.1	0	0.05 ± 0.10	0
Pavona									
P. varians	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
Platygyra									
P. pini	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
Pocillopora									
P. damicornis	19	21	19	33	2.30 ± 0.67	0.7 ± 0.7	0.28 ± 0.21	0.83 ± 0.35	12.3 ± 19.0
P. eydouxi	1	0	0	1	0.05 ± 0.06	< 0.1	0	0	50.0 ± 70.7
P. meandrina	4	0	1	4	0.23 ± 0.21	0.2 ± 0.3	0.03 ± 0.05	0.03 ± 0.05	0
Porites									
P. lobata	10	17	2	0	0.73 ± 0.78	< 0.1	0.03 ± 0.05	0.58 ± 0.69	0
P. lutea	1	1	1	0	0.08 ± 0.05	< 0.1	0	0.03 ± 0.05	0
P. sp. (lob)	2	0	0	0	0.05 ± 0.10	< 0.1	0	0.05 ± 0.10	0
Total	**49**	**44**	**30**	**40**	**4.08 ± 0.81**	**1.0 ± 0.7**	**0.33 ± 0.25**	**1.80 ± 0.75**	**18.8 ± 10.5**

Table 5b. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 2.

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Acropora									
A. tenuis	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
A. sp.	1	0	0	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Astreopora									
A. listeri	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	100
A. myriophthalma	0	3	0	0	0.08 ± 0.15	< 0.1	0	0	0
A. randalli	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
Favia									
F. matthaii	3	5	0	3	0.37 ± 0.12	0.1 ± 0.1	0	0.05 ± 0.06	0
F. pallida	1	0	0	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
F. sp.	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
Leptastrea									
L. purpurea	3	0	2	0	0.13 ± 0.15	< 0.1	0	0.13 ± 0.12	0
Pavona									
P. varians	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
Platygyra									
P. pini	2	0	0	0	0.05 ± 0.10	< 0.1	0	0.03 ± 0.05	0
Pocillopora									
P. damicornis	28	9	22	28	2.18 ± 0.90	0.8 ± 0.7	0	1.20 ± 0.50	13.1 ± 12.5
P. eydouxi	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
P. meandrina	1	1	1	4	0.18 ± 0.15	< 0.1	0	0.08 ± 0.10	0
P. verrucosa	0	8	0	0	0.20 ± 0.40	0.5 ± 1.1	0.13 ± 0.25	0	0
Porites									
P. lobata	17	6	0	12	0.88 ± 0.74	< 0.1	0	0.75 ± 0.65	0
P. lutea	0	2	1	0	0.08 ± 0.10	< 0.1	0	0.03 ± 0.05	0
P. sp.	0	1	0	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Total	**59**	**36**	**28**	**47**	**4.25 ± 1.35**	**1.6 ± 1.1**	**0.13 ± 0.25**	**2.30 ± 1.20**	**10.3 ± 8.2**

Table 5c. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 3.

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Acanthastrea									
A. echinata	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
Astreopora									
A. myriophthalma	1	2	4	0	0.18 ± 0.17	0.1 ± 0.1	0	0.05 ± 0.10	0
Favia									
F. matthaii	0	0	2	3	0.13 ± 0.15	< 0.1	0	0.05 ± 0.10	0
Goniastrea									
G. edwardsii	0	1	1	0	0.05 ± 0.06	< 0.1	0	0	0
Leptastrea									
L. bottae	0	1	0	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
L. purpurea	1	0	1	1	0.08 ± 0.05	< 0.1	0	0.08 ± 0.05	0
L. transversa	0	2	0	0	0.05 ± 0.10	< 0.1	0	0.05 ± 0.10	0
Montipora									
M. hoffmeisteri	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
M. sp.	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
Pavona									
P. duerdeni	0	0	0	1	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Pocillopora									
P. damicornis	0	0	0	2	0.05 ± 0.10	< 0.1	0	0.05 ± 0.10	0
Porites									
P. lobata	4	4	17	9	0.85 ± 0.61	< 0.1	0	0.58 ± 0.69	33.3 ± 57.7
P. lutea	0	0	1	1	0.05 ± 0.06	< 0.1	0	0	50.0 ± 70.7
P. rus	20	1	2	1	0.60 ± 0.93	1.5 ± 2.7	0	0.05 ± 0.10	0
P. sp.	1	0	0	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Sinularia									
S. sp.	0	0	0	2	0.05 ± 0.10	< 0.1	0	0	0
Stylocoeniella									
S. armata	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
Total	**27**	**13**	**29**	**21**	**2.25 ± 0.72**	**1.7 ± 2.6**	**0**	**0.98 ± 0.65**	**8.3 ± 16.7**

Table 5d. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 4.

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Acanthastrea									
A. echinata	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
Diploastrea									
D. heliopora	0	0	0	2	0.05 ± 0.10	0.3 ± 0.6	0	0	0
Favia									
F. matthaii	0	0	1	3	0.10 ± 0.14	< 0.1	0	0.03 ± 0.05	0
Galaxea									
G. fascicularis	3	1	0	0	0.10 ± 0.14	0.2 ± 0.3	0	0.03 ± 0.05	0
Leptastrea									
L. purpurea	1	0	0	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Montipora									
M. verrucosa	4	0	0	0	0.10 ± 0.20	< 0.1	0	0.03 ± 0.05	0
M. sp. (enc)	0	0	2	0	0.05 ± 0.10	< 0.1	0	0.05 ± 0.10	0
Plesiastrea									
P. versipora	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
Pocillopora									
P. damicornis	0	2	0	0	0.05 ± 0.10	< 0.1	0	0.05 ± 0.10	0
P. sp.	0	2	1	0	0.08 ± 0.10	< 0.1	0	0.08 ± 0.10	0
Porites									
P. lobata	12	7	3	1	0.58 ± 0.49	0.3 ± 0.5	0.03 ± 0.05	0.38 ± 0.49	0
P. lutea	0	0	6	0	0.15 ± 0.30	1.1 ± 2.3	0	0	0
P. rus	21	28	4	1	1.35 ± 1.31	2.4 ± 2.4	0.10 ± 0.14	0.05 ± 0.10	0
Psammorora									
P. haimeana	1	0	1	1	0.08 ± 0.05	< 0.1	0	0	0
Stylocoeniella									
S. armata	3	4	2	0	0.23 ± 0.17	< 0.1	0	0.10 ± 0.14	0
Total	**45**	**44**	**20**	**10**	**2.98 ± 1.75**	**4.3 ± 2.1**	**0.13 ± 0.19**	**0.83 ± 0.62**	**0**

Table 5e. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 5.

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Acropora									
A. sp.	1	0	0	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Favia									
F. sp.	0	0	0	1	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Galaxea									
G. fascicularis	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
Leptastrea									
L. purpurea	2	0	0	0	0.05 ± 0.10	< 0.1	0	0.05 ± 0.10	0
Montipora									
M. sp. (enc)	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
Pavona									
P. varians	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
Pocillopora									
P. danae	0	1	0	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Porites									
P. annae	3	0	0	0	0.08 ± 0.15	< 0.1	0	0	0
P. cylindrica	2	0	0	0	0.05 ± 0.10	< 0.1	0	0	50
P. lobata	2	1	0	0	0.08 ± 0.10	0.1 ± 0.2	0	0	0
P. lutea	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
P. rus	115	96	59	88	8.95 ± 2.33	38.2 ± 15.9	0.78 ± 0.26	0.20 ± 0.18	8.4 ± 4.8
Scolymia									
S. sp.	1	0	0	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Stylocoeniella									
S. armata	1	0	0	1	0.05 ± 0.06	< 0.1	0	0.03 ± 0.05	0
Total	**130**	**98**	**59**	**91**	**9.45 ± 2.91**	**38.3 ± 15.7**	**0.78 ± 0.26**	**0.48 ± 0.31**	**8.3 ± 4.8**

Table5f. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 6.

Species	Total no. colonies				No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
	T1	T2	T3	T4					
Acropora									
A. abrotanoides	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
A. digitifera	1	0	1	0	0.05 ± 0.06	0.4 ± 0.8	0	0	0
A. gemmifera	0	2	0	0	0.05 ± 0.10	< 0.1	0	0	0
A. humilis	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
A. monticulosa	0	0	2	0	0.05 ± 0.10	< 0.1	0	0	5.0
A. surculosa	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
A. sp. (br)	0	2	0	0	0.05 ± 0.10	< 0.1	0	0	0
A. sp. (enc)	0	0	0	1	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Astreopora									
A. myriophthalma	0	3	3	1	0.18 ± 0.15	0.7 ± 1.0	0	0	0
Coscinaria									
C. exesa	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	10.0
Cyphastrea									
C. chalcidicum	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
C. serailia	0	0	1	1	0.05 ± 0.06	< 0.1	0	0	5.0 ± 7.1
Favia									
F. matthaii	4	5	4	1	0.35 ± 0.17	0.1 ± 0.1	0	0	0.8 ± 1.4
F. stellata	1	3	0	1	0.13 ± 0.13	0.4 ± 0.7	0	0	0
Favites									
F. sp.	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0

Table 5f. Continued

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Galaxea									
G. fascicularis	0	0	0	19	0.48 ± 0.95	0.3 ± 0.5	0	0.13 ± 0.25	0
Goniastrea									
G. edwardsii	2	2	3	4	0.28 ± 0.10	< 0.1	0	0.05 ± 0.06	0
G. retiformis	14	10	8	4	0.90 ± 0.42	4.1 ± 3.5	0	0.08 ± 0.10	0.2 ± 0.5
Hydrophora									
H. microconos	2	1	1	0	0.10 ± 0.08	< 0.1	0	0	3.3 ± 5.8
Leptastrea									
L. purpurea	3	5	1	2	0.28 ± 0.17	< 0.1	0	0.10 ± 0.08	3.3 ± 5.8
L. transversa	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
Leptoria									
L. phrygia	3	3	2	1	0.23 ± 0.10	1.6 ± 1.3	0	0.03 ± 0.05	0
Montastrea									
M. sp.	0	0	1	2	0.08 ± 0.10	< 0.1	0	0	0
Montipora									
M. aequituberculata	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	10.0
M. tuberculosa	0	1	0	0	0.03 ± 0.05	0.3 ± 0.6	0	0	0
Pavona									
P. decussata	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
P. varians	1	2	0	1	0.10 ± 0.08	0.2 ± 0.2	0	0.03 ± 0.05	5.0 ± 7.1
Platygyra									
P. daedalea	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
P. pini	5	2	1	2	0.25 ± 0.17	< 0.1	0	0	5.0 ± 5.8
P. sinensis	0	0	2	2	0.10 ± 0.12	< 0.1	0	0	0
Pocillopora									
P. damicornis	18	13	11	18	1.50 ± 0.36	1.6 ± 1.2	0.05 ± 0.10	0.55 ± 0.65	1.0 ± 0.9
P. danae	2	6	3	0	0.28 ± 0.25	< 0.1	0.03 ± 0.05	0.05 ± 0.10	0
P. elegans	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
P. meandrina	1	0	1	1	0.08 ± 0.05	0.8 ± 0.6	0	0	0
P. sp.	0	0	0	4	0.10 ± 0.20	< 0.1	0.03 ± 0.05	0	0
P. setchelli	3	2	0	1	0.15 ± 0.13	< 0.1	0	0.05 ± 0.06	0
P. verrucosa	1	4	0	1	0.15 ± 0.17	< 0.1	0	0	1.1 ± 1.9
Porites									
P. lobata	5	5	11	2	0.58 ± 0.38	1.3 ± 0.9	0	0.20 ± 0.20	3.3 ± 4.7
P. lutea	3	5	6	14	0.70 ± 0.48	2.6 ± 2.5	0	0.03 ± 0.05	0.3 ± 0.5
P. rus	1	1	5	18	0.63 ± 0.81	0.9 ± 0.8	0.13 ± 0.13	0.03 ± 0.05	0
Psammocora									
P. obtusangula	10	0	0	1	0.28 ± 0.49	< 0.1	0	0.05 ± 0.10	0.6 ± 0.9
Total	**84**	**79**	**70**	**104**	**8.43 ± 1.44**	**15.6 ± 5.9**	**0.23 ± 0.13**	**1.45 ± 1.11**	**0.9 ± 0.4**

Table5g. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 7.

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Fungia									
F. fungites	0	0	2	0	0.05 ± 0.10	< 0.1	0	0	0
Goniastrea									
G. edwardsii	0	1	1	0	0.05 ± 0.06	< 0.1	0	0	0
G. fascicularis	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
G. pectinata	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
Pavona									
P. varians	1	0	1	0	0.05 ± 0.06	< 0.1	0	0	0
Porites									
P. lobata	2	2	0	1	0.13 ± 0.10	< 0.1	0	0	0
P. lutea	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
P. rus	53	50	69	59	5.78 ± 0.84	51.3 ± 13.3	0.53 ± 0.34	0.25 ± 0.13	10.8 ± 7.1
P. sp.	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
Total	**57**	**54**	**74**	**61**	**6.15 ± 0.88**	**51.4 ± 13.4**	**0.53 ± 0.34**	**0.25 ± 0.13**	**10.8 ± 7.1**

Table 5h. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 8.

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Acanthastrea									
A. echinata	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
Acropora									
A. sp. (br)	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
Astreopora									
A. gracilis	0	2	0	0	0.05 ± 0.10	< 0.1	0	0	0
A. myriophthalma	0	0	3	0	0.08 ± 0.15	< 0.1	0	0	0
Coscinaraea									
C. exesa	4	0	0	0	0.10 ± 0.20	0.7 ± 1.4	0	0	0
Cyphastrea									
C. sp.	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
Diploastrea									
D. heliopora	0	0	1	0	0.03 ± 0.05	1.1 ± 2.1	0	0	0
Favia									
F. sp.	2	0	0	0	0.05 ± 0.10	< 0.1	0	0.05 ± 0.10	0
Galaxea									
G. fascicularis	7	2	0	0	0.23 ± 0.33	< 0.1	0	0.10 ± 0.20	0
Goniastrea									
G. edwardsii	2	1	1	2	0.15 ± 0.06	< 0.1	0	0	0
G. pectinata	4	0	0	0	0.10 ± 0.20		0	0.03 ± 0.05	0
G. retiformis	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
Leptastrea									
L. purpurea	1	0	1	1	0.08 ± 0.05	< 0.1	0	0.08 ± 0.05	0
Montastrea									
M. valenciennesi	0	0	2	0	0.05 ± 0.10	< 0.1	0	0.03 ± 0.05	0
Pavona									
P. varians	2	0	2	2	0.15 ± 0.10	< 0.1	0	0.05 ± 0.10	0
Pocillopora									
P. damicornis	1	0	0	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
P. danae	0	0	0	2	0.05 ± 0.10	< 0.1	0	0	0
Porites									
P. cylindrica	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
P. lobata	2	2	16	13	0.83 ± 0.73	1.5 ± 1.0	0	0.05 ± 0.10	39.1 ± 43.2
P. lutea	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
P. rus	58	69	93	62	7.05 ± 1.57	27.3 ± 3.0	1.15 ± 1.17	0.35 ± 0.17	6.9 ± 3.7
Psammocora									
P. haimeana	2	0	0	0	0.05 ± 0.10	< 0.1	0	0	50.0
Stylocoeniella									
S. armata	8	0	2	2	0.30 ± 0.35	< 0.1	0	0.23 ± 0.39	0
Total	**95**	**78**	**121**	**86**	**9.50 ± 1.87**	**30.8 ± 1.2**	**1.15 ± 1.17**	**1.20 ± 0.92**	**9.8 ± 2.2**

Table 5i. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006.Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 9.

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Acropora									
A. surculosa	1	1	0	0	0.05 ± 0.06	0.6 ± 0.78	0	0	0
Favia									
F. matthaii	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	100
F. stellata	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
Leptastrea									
L. purpurea	7	7	3	10	0.68 ± 0.29	< 0.1	0	0.63 ± 0.30	0
Pocillopora									
P. damicornis	4	34	4	17	1.48 ± 1.42	1.4 ± 1.5	0.43 ± 0.42	0.13 ± 0.13	3.9 ± 7.9
P. danae	5	1	3	2	0.28 ± 0.17	< 0.1	0.03 ± 0.05	0.05 ± 0.06	0
P. meandrina	0	0	1	0	0.03 ± 0.05	< 0.1	0.03 ± 0.05	0	0
P. verrucosa	0	0	2	0	0.05 ± 0.10	< 0.1	0	0.03 ± 0.05	0
Porites									
P. lobata	5	0	1	0	0.15 ± 0.24	0.1 ± 0.2	0	0.10 ± 0.20	0
P. rus	0	1	0	0	0.03 ± 0.05	< 0.1	0.03 ± 0.05	0	0
P. sp. (lob)	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
Total	**22**	**47**	**14**	**29**	**2.80 ± 1.41**	**2.2 ± 1.9**	**0.50 ± 0.42**	**0.93 ± 0.43**	**4.3 ± 8.7**

Table 5j. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 10.

Species	Total no. colonies				No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
	T1	T2	T3	T4					
Astreopora									
A. listeri	0	0	1	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
A. myriophthalma	0	3	0	2	0.13 ± 0.15	< 0.1	0	0	0
Cyphastrea									
C. agassizi	0	2	0	1	0.08 ± 0.10	< 0.1	0	0	0
Favia									
F. lizardensis	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
F. matthaii	0	3	1	0	0.10 ± 0.14	< 0.1	0	0.05 ± 0.06	0
Montipora									
M. verrucosa	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
Porites									
P. lobata	0	4	1	1	0.15 ± 0.17	< 0.1	0	0.05 ± 0.06	0
Total	**1**	**12**	**3**	**5**	**0.53 ± 0.48**	**0.07 ± 0.15**	**0**	**0.13 ± 0.15**	**0**

Table 5k. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 11.

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Astreopora									
A. myriophthalma	0	0	0	1	0.03 ± 0.05	0.4 ± 0.9	0	0	0
Cyphastrea									
C. serailia	0	0	3	0	0.08 ± 0.15	< 0.1	0	0	0
Favia									
F. matthaii	0	1	4	1	0.15 ± 0.17	0.2 ± 0.2	0	0	0
F. stellata	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
Goniastrea									
G. edwardsii	0	0	3	0	0.08 ± 0.15	< 0.1	0	0	0
G. retiformis	0	2	11	2	0.38 ± 0.49	0.4 ± 0.7	0	0	0
Leptastrea									
L. purpurea	4	4	2	1	0.28 ± 0.15	< 0.1	0	0.28 ± 0.15	0
Leptoria									
L. phrygia	1	0	1	0	0.05 ± 0.06	0.7 ± 1.3	0	0	0
Platygyra									
P. pini	0	0	5	1	0.15 ± 0.24	< 0.1	0	0.03 ± 0.05	0
Pocillopora									
P. damicornis	15	15	11	10	1.28 ± 0.26	1.3 ± 0.7	0.15 ± 0.19	0.30 ± 0.16	9.8 ± 12.2
P. danae	2	2	3	3	0.25 ± 0.06		0	0.05 ± 0.06	25.0 ± 50.0
P. verrucosa	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
P. sp.	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
Porites									
P. lobata	1	5	9	12	0.68 ± 0.48	1.2 ± 1.2	0	0.10 ± 0.00	7.8 ± 9.7
P. rus	2	8	9	2	0.53 ± 0.38	< 0.1	0.23 ± 0.33	0.03 ± 0.05	0
P. sp. (lob)	0	0	0	1	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Stylocoeniella									
S. armata	0	0	0	1	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Total	**25**	**37**	**64**	**35**	**4.03 ± 1.67**	**4.2 ± 3.3**	**0.38 ± 0.45**	**0.83 ± 0.15**	**10.8 ± 6.1**

Table 51. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006.Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 12.

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Astreopora									
A. myriophthalma	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
Cyphastrea									
C. agassizi	3	0	0	0	0.08 ± 0.15	0.2 ± 0.5	0	0	0
C. microphthalma	0	0	0	6	0.15 ± 0.30	< 0.1	0	0.08 ± 0.15	0
Fungia									
F. fungites	9	0	0	0	0.23 ± 0.45	0.1 ± 0.2	0	0.20 ± 0.40	0
Goniastrea									
G. edwardsii	2	2	0	0	0.10 ± 0.12	< 0.1	0	0.03 ± 0.05	0
G. pectinata	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
G. retiformis	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
Heliopora									
H. coerulea	1	0	0	1	0.05 ± 0.06	< 0.1	0	0	0
Leptastrea									
L. purpurea	1	0	0	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
L. transversa	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
Montastrea									
M. valenciennesi	0	0	1	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Pavona									
P. varians	1	4	0	0	0.13 ± 0.19	< 0.1	0	0.03 ± 0.05	0
Pocillopora									
P. damicornis	5	0	2	0	0.18 ± 0.24	< 0.1	0	0.10 ± 0.20	0
P. verrucosa	2	0	0	0	0.05 ± 0.10	< 0.1	0	0	0
Porites									
P. annae	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
P. cylindrica	0	3	8	9	0.50 ± 0.42	0.5 ± 1.0	0.10 ± 0.20	0.03 ± 0.05	15.3 ± 16.8
P. lobata	15	36	10	10	1.78 ± 1.24	4.1 ± 3.5	0	0.40 ± 0.54	27.9 ± 32.6
P. lutea	0	1	1	0	0.05 ± 0.06	0.2 ± 0.4	0	0	0
P. rus	107	67	43	63	7.00 ± 2.68	26.6 ± 15.7	0.90 ± 0.45	0.93 ± 0.61	11.0 ± 4.1
Sinularia									
S. sp.	1	15	0	0	0.40 ± 0.73	3.2 ± 6.1	0	0	0
Stylocoeniella									
S. armata	1	1	0	0	0.05 ± 0.06	< 0.1	0	0.03 ± 0.05	0
Total	**148**	**132**	**67**	**89**	**10.90 ± 3.75**	**34.9 ± 7.0**	**1.00 ± 0.64**	**1.85 ± 1.22**	**10.82 ± 5.56**

Table 5m. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 13.

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Acanthastrea									
A. echinata	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
Astreopora									
A. gracilis	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
A. myriophthalma	1	5	4	3	0.33 ± 0.17	0.3 ± 0.4	0	0	0
Ctenactis									
C. echinata	0	0	0	1	0.03 ± 0.05	0.1 ± 0.3	0	0	0
Cyphastrea									
C. ocellina	1	0	1	1	0.08 ± 0.05	< 0.1	0	0	0
Favia									
F. helianthoides	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
F. matthaii	1	3	3	1	0.20 ± 0.12	< 0.1	0	0.13 ± 0.10	0
Fungia									
F. paumotensis	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
Galaxea									
F. fascicularis	0	0	0	2	0.05 ± 0.10	< 0.1	0	0	0
Goniastrea									
G. edwardsii	0	0	0	2	0.05 ± 0.10	< 0.1	0	0.03 ± 0.05	0
Lobophyllia									
L. hemprichii	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
Montipora									
M. sp. (enc)	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
Pavona									
P. varians	0	1	1	1	0.08 ± 0.05	< 0.1	0	0	0
Pocillopora									
P. damicornis	1	0	0	5	0.15 ± 0.24	< 0.1	0	0.13 ± 0.19	0
Porites									
P. lobata	4	15	17	15	1.28 ± 0.59	< 0.1	0	0.73 ± 0.41	8.3 ± 16.7
P. rus	0	0	0	3	0.08 ± 0.15	< 0.1	0	0	0
Psammocora									
P. haimeana	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
Stylocoeniella									
S. armata	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
Total	**9**	**26**	**28**	**37**	**2.50 ± 1.17**	**0.6 ± 0.6**	**0**	**1.00 ± 0.45**	**3.6 ± 7.1**

Table 5n. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 14.

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Coscinaraea									
C. exesa	0	1	0	0	0.03 ± 0.05	0.4 ± 0.9	0	0	0
Favia									
F. matthaii	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
Galaxea									
G. fascicularis	0	0	0	2	0.05 ± 0.10	< 0.1	0	0	0
Goniastrea									
G. edwardsii	0	0	0	3	0.08 ± 0.15	< 0.1	0	0	0
Pocillopora									
P. damicornis	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
P. danae	0	1	0	0	0.03 ± 0.05	< 0.1	0	0	0
Porites									
P. lobata	0	1	0	7	0.20 ± 0.34	< 0.1	0	0.03 ± 0.05	1.7
P. lutea	0	0	1	0	0.03 ± 0.05	1.0 ± 2.1	0	0	
P. rus	36	49	38	53	4.40 ± 0.83	46.5 ± 8.6	0.40 ± 0.34	0.50 ± 0.34	1.1 ± 0.2
Sinularia									
S. sp.	3	1	0	1	0.13 ± 0.13	0.2 ± 0.3	0	0	0
Sylocoeniella									
S. armata	0	0	0	1	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Total	**39**	**55**	**39**	**67**	**5.00 ± 1.36**	**48.1 ± 10.1**	**0.40 ± 0.34**	**0.55 ± 0.42**	**1.0 ± 0.1**

Table 5o. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in three 10 m^2 transects at Station 15.

Species	Total no. colonies T1	T2	T3	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Acanthastrea								
A. echinata	1	3	3	0.23 ± 0.12	< 0.1	0	0	27.8 ± 25.5
Acropora								
A. abrotanoides	1	1	1	0.10 ± 0.00	0.1 ± 0.2	0	0	0
A. digitifera	0	1	0	0.03 ± 0.06	0.2 ± 0.4	0	0	0
A. nana	1	0	0	0.03 ± 0.06	< 0.1	0	0	0
A. surculosa	0	0	1	0.03 ± 0.06	< 0.1	0	0	0
Astreopora								
A. myriophthalma	0	3	8	0.37 ± 0.40	0.4 ± 0.3	0	0.13 ± 0.15	16.7 ± 23.6
Cyphastrea								
C. microphthalma	0	2	0	0.07 ± 0.12	< 0.1	0	0	100
C. ocellina	8	0	0	0.27 ± 0.46	< 0.1	0	0.10 ± 0.17	0
C. sp. (enc)	0	0	1	0.03 ± 0.06	< 0.1	0	0	0
Favia								
F. matthaii	4	12	6	0.73 ± 0.42	0.3 ± 0.3	0	0.17 ± 0.06	0
F. pallida	1	0	0	0.03 ± 0.06	< 0.1	0	0.03 ± 0.06	0
F. stellata	0	1	1	0.07 ± 0.06	< 0.1	0	0	0
Favites								
F. pentagona	0	0	1	0.03 ± 0.06	< 0.1	0	0	0
Galaxea								
G. fascicularis	9	0	2	0.37 ± 0.47	0.2 ± 0.2	0	0.13 ± 0.23	0
Goniastrea								
G. edwardsii	5	0	8	0.43 ± 0.40	0.1 ± 0.1	0	0.03 ± 0.06	0
G. pectinata	0	1	0	0.03 ± 0.06	< 0.1	0	0	0
G. retiformis	8	29	11	1.60 ± 1.14	4.8 ± 4.7	0	0.07 ± 0.06	1.3 ± 2.3

Table 5o. Continued

Species	Total no. colonies T1	T2	T3	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Hydnophora								
H. microconis	1	3	1	0.17 ± 0.12	< 0.1	0	0	0
Leptastrea								
L. purpurea	5	12	0	0.57 ± 0.60	0.2 ± 0.4	0	0.43 ± 0.45	0
Leptoria								
L. phrygia	2	4	4	0.33 ± 0.12	2.3 ± 1.8	0	0	0
Montastrea								
M. valenciennesi	0	1	0	0.03 ± 0.06	< 0.1	0	0	100
Montipora								
M. grisea	0	0	1	0.03 ± 0.06	< 0.1	0	0	0
M. sp. 1 (enc)	1	1	0	0.07 ± 0.06	< 0.1	0	0.03 ± 0.06	100
M. sp. 2 (enc)	3	0	0	0.10 ± 0.17	0.3 ± 0.4	0	0	0
M. verrucosa	0	0	1	0.03 ± 0.06	< 0.1	0	0	100
Oulophyllia								
O. crispa	0	1	0	0.03 ± 0.06	< 0.1	0	0	0
Pavona								
P. varians	0	0	1	0.03 ± 0.06	< 0.1	0	0	0
Platygyra								
P. pini	2	1	1	0.13 ± 0.06	0.2 ± 0.2	0	0	50.0 ± 50.0
Pocillopora								
P. damicornis	23	19	18	2.00 ± 0.26	1.2 ± 1.0	0.03 ± 0.06	0.47 ± 0.12	6.1 ± 10.5
P. danae	2	1	2	0.17 ± 0.06	< 0.1	0	0	0
P. eydouxi	0	0	2	0.07 ± 0.12	1.4 ± 2.0	0	0	0
P. meandrina	0	2	0	0.07 ± 0.12	1.3 ± 1.1	0	0	0
P. setchelli	0	1	0	0.03 ± 0.06	< 0.1	0	0	0
P. verrucosa	8	1	1	0.33 ± 0.40	< 0.1	0	0.03 ± 0.06	0
Porites								
P. lobata	15	29	25	2.30 ± 0.72	5.1 ± 5.6	0	0.57 ± 0.21	8.3 ± 7.2
P. rus	15	2	16	1.10 ± 0.78	0.6 ± 1.2	0.33 ± 0.58	0.13 ± 0.15	0
Psammocora								
P. obtusangula	0	1	0	0.03 ± 0.06	0.2 ± 0.3	0	0	0
Sinularia								
S. sp.	1	5	5	0.37 ± 0.23	0.3 ± 0.6	0	0	0
Stylocoeniella								
S. armata	2	2	0	0.13 ± 0.12	< 0.1	0	0.07 ± 0.06	0
Total	**118**	**139**	**121**	**12.60 ± 1.14**	**19.3 ± 7.4**	**0.37 ± 0.55**	**2.40 ± 0.89**	**6.7 ± 5.2**

Table 5p. Coral Species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 – 23, 2006. Coral species parameters (mean ± S.D.) measured in four 10 m^2 transects at Station 16.

Species	Total no. colonies T1	T2	T3	T4	No. colonies m^{-2}	% cover m^{-2}	No. fragments m^{-2}	No. "recent" (1 to < 5 cm) visible sexual recruits m^{-2}	% Colonies > 10 cm parted by fission
Cyphastrea									
C. ocellina	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	0
Favia									
F. matthaii	0	0	1	1	0.05 ± 0.06	< 0.1	0	0.03 ± 0.05	0
Galaxea									
G. fascicularis	0	0	1	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Goniastrea									
G. edwardsii	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
G. pectinata	0	0	1	0	0.03 ± 0.05	< 0.1	0	0	100
Leptastrea									
L. purpurea	19	4	34	22	1.98 ± 1.23	< 0.1	0	1.93 ± 1.16	0
L. transversa	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
Pavona									
P. cactus	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
P. decussata	0	0	1	0	0.03 ± 0.05	< 0.1	0.03 ± 0.05	0	0
P. varians	0	0	13	10	0.58 ± 0.68	< 0.1	0	0.30 ± 0.42	33.3 ± 47.1
P. sp (br)	4	0	0	0	0.10 ± 0.20	< 0.1	0.03 ± 0.05	0.03 ± 0.05	100
Platygyra									
P. pini	1	0	0	0	0.03 ± 0.05	< 0.1	0	0	0
Pocillopora									
P. damicornis	1	0	0	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
P. verrucosa	9	1	0	1	0.28 ± 0.42	< 0.1	0	0.13 ± 0.25	0
P. sp. (br)	1	0	0	0	0.03 ± 0.05	< 0.1	0	0.03 ± 0.05	0
Porites									
P. australiensis	4	2	0	7	0.33 ± 0.30	< 0.1	0	0	0
P. cylindrica	10	3	5	11	0.73 ± 0.39	< 0.1	0.25 ± 0.13	0.15 ± 0.19	0
P. lobata	32	14	25	11	2.05 ± 0.97	10.3 ± 4.8	0	0.53 ± 0.47	20.3 ± 10.2
P. lutea	0	0	0	1	0.03 ± 0.05	< 0.1	0	0	0
P. rus	3	16	13	18	1.25 ± 0.67	2.3 ± 3.7	0.25 ± 0.13	0.25 ± 0.19	2.8 ± 5.6
Psammocora									
P. obtusangula	1	0	0	2	0.08 ± 0.10	<0.1	0.03 ± 0.05	0	0
Sinularia									
S. sp.	22	47	0	15	2.10 ± 1.96	10.4 ± 8.6	0	0.03 ± 0.05	0
Stylocoeniella									
S. armata	7	0	11	9	0.68 ± 0.48	< 0.1	0	0.55 ± 0.39	0
Total	**115**	**87**	**106**	**110**	**10.45 ± 1.22**	**23.0 ± 1.9**	**0.58 ± 0.10**	**3.98 ± 2.15**	**8.2 ± 4.3**

Table 6a. Macroinvertebrate species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 - 23, 2006.

FAMILY	SURVEY STATION (S)															
Genus/species	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
ANCORINIDAE																
Melophlus isis				x	x		x	x				x	x			
Rhabdastrella sp			x	x	x		x	x				x	x	x	x	
Penares nux							x									
DARWINELLIDAE																
Chelonaplysilla sp (purple)			x		x					x						
Chelonaplysilla sp (orange/red)							x			x						
DRUINELLIDAE																
Aplysinella strongylata												x				
SPIRASTRELLIDAE																
Spirastrella sp			x		x										x	
CHALINIDAE																
Adocia sp					x											
Haliclona osiris								x								
AXINELLIDAE																
Acanthella cavernosa			x	x		x								x	x	
Acanthella sp	x					x										
Stylissa sp	x	x						x		x		x				
DICTYONELLIDAE																
Liosina granulosa		x		x	x			x					x			
CLATHRINIDAE																
Clathria sp										x						

Table 6a. Macroinvertebrate species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 - 23, 2006.

FAMILY	SURVEY STATION (S)															
Genus/species	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
HALICHONDRIIDAE																
Axinyssa sp						x	x		x	x	x		x		x	
Haliclona sp		x													x	x
Stylotella aurantium		x	x	x	x	x	x	x		x	x	x	x	x	x	
Stylinos sp							x	x		x						
PLAKINIDAE																
Plakina sp			x	x						x			x			
MICROCIONIDAE																
Xestospongia exigua						x		x						x	x	
PHLOEODICTYIDAE																
Aka sp								x							x	
MICROCIONIDAE																
Clathria eurypa			x	x			x	x					x		x	
MYXILLIDAE																
Iotrochota baculilfera												x				
I. ditrochota			x					x								
RASPAILIIDAE																
Ceratopsion sp				x				x					x			
SPONGIIDAE																
Hyrtios sp	x											x				
Pellina sp							x					x				
NIPHATIDAE																
Cribrochalina sp				x			x	x								

Table 6a. Macroinvertebrate species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 - 23, 2006.

FAMILY	SURVEY STATION (S)															
Genus/species	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
DYSIDEIDAE																
Dysidea granulosa							x	x							x	
D. herbacea			x													
Dysidea sp			x		x	x	x	x						x	x	x
APLYSINELLIDAE																
Aplysinella rhax										x						
Unidentified 'Ascidian' sponge (GP)			x	x			x	x					x			
Unidentified brown sponge			x													
Unidentified yellow sponge				x				x								
Unidentified cream sponge								x								
Unidentified crimson sponge										x						
Unidentified red sponge														x		
ZOANTHIDAE																
Palythoa caesia	x															
ACTINIIDAE																
Entacmea quadricolor					x				x					x		
STICHODACTYLIDAE																
Heteractis sp		x							x							
Stichodactyla haddoni																x
SERPULIDAE																
Spirobranchus giganteus		x			x	x	x	x				x		x	x	
Unidentified tubeworm				x			x									
SABELLIDAE																
Sabellid sp								x								

Table 6a. Macroinvertebrate species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 - 23, 2006.

FAMILY *Genus/species*	SURVEY STATION (S) S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
TROCHIDAE																
Trochus niloticus		x		x		x	x	x	x		x	x			x	x
T. ochroleucus						x		x	x						x	
TURBINIDAE																
Astrea (Astralium) rhodostoma						x	x					x		x	x	x
Turbo argyrostoma				x				x								
CERITHIIDAE																
Cerithium sp							x	x								
Rhinoclavis sinensis							x									
Rhinoclavis sp									x							
VERMITIDAE																
Serpulorbis sp		x	x			x	x	x	x		x	x		x	x	x
STROMBIDAE																
Lambis chiragra															x	
L. lambis						x			x	x	x					x
L. truncata									x							x
Strombus luhuanus	x										x					
S. mutabilis							x	x								
CYPRAEIDAE																
Cypraea arabica													x			
C. annulus						x		x								
C. goodallii						x										
C. moneta								x	x						x	
C. tigris				x	x							x		x	x	

Table 6a. Macroinvertebrate species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 - 23, 2006.

FAMILY *Genus/species*	SURVEY STATION (S) S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
TONOIDEA																
Cymatium hepaticum															x	
MURICIDAE																
Drupa ricinus															x	
COSTELLARIIDAE																
Vexillum sp															x	
THAIDIDAE																
Morula uva	x															
CORALLIOPHILIDAE																
Coralliophila violacea						x	x	x	x			x		x		
TURBINELLIDAE																
Vasum ceramicum		x			x										x	x
V. turbinellus						x	x	x	x		x				x	
MITRIDAE																
Mitra ustulata							x	x								
COSTELLARIIDAE																
Vexillum sp												x				
FASCIOLARIIDAE																
Latirus sp						x		x							x	

Table 6a. Macroinvertebrate species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 - 23, 2006.

FAMILY	SURVEY STATION (S)															
Genus/species	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
CONIDAE																
Conus ebraeus		x				x		x	x						x	
C. eburneus										x						
C. flavidus		x				x		x	x		x				x	
C. imperialis															x	
C. lividus	x	x				x									x	
C. marmoreus						x										
C. miles	x				x			x								
C. pulcarius						x										
CHROMODORIDIDAE																
Chromodoris elizabethina							x									
Glossodoris symmetricus			x							x						
PHYLLIDIIDAE																
Phyllidiella granulosa						x								x		
P. pustulosa	x							x						x		
GLAUCIDAE																
Phidiana indica		x														
PINNIDAE																
Pinna muricata	x						x	x								
MYTILIDAE																
Lithophaga sp	x	x				x	x	x				x				
ISOGNOMONIDAE																
Isognomon perna						x		x								
Isognomon sp								x			x					

Table 6a. Macroinvertebrate species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 - 23, 2006.

FAMILY *Genus/species*	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
SPONDYLIDAE																
Spondylus sp													x			
TRIDACNIDAE																
Tridacna maxima	x	x				x		x	x		x	x		x	x	x
OCTOPODIDAE																
Octopus cyanea					x											
Octopus sp								x	x			x			x	
ARTHROPODA																
Barnacle (1) Unidentified		x														
GONODACTYLOIDEA																
Gonodactylus sp													x			x
XANTHIDAE																
Cymo sp															x	
Trapezia ferruginea						x									x	
T. rufopunctata	x					x									x	
Xanthia sp						x										
Unidentified Bryozoan				x											x	
Unidentified Bryozoan (Red)							x									
OREASTERIDAE																
Culcita novaeguineae										x						
OPHIDIASTERIDAE																
Fromia milleporella			x				x									
Linckia laevigata	x	x	x		x	x	x		x						x	x
L. multifora	x	x			x	x	x	x	x			x			x	

Table 6a. Macroinvertebrate species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 - 23, 2006.

FAMILY	SURVEY STATION (S)															
Genus/species	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
ACANTHASTERIDAE																
Acanthaster planci						x			x					x	x	
ECHINASTERIDAE																
Echinaster luzonicus	x	x	x	x	x	x	x	x						x	x	
Unidentified Brittle Star											x				x	
CIDARIDAE																
Eucidaris metularia																x
DIADEMATIDAE																
Didema setosum	x	x			x			x	x		x	x		x	x	x
Echinothrix calamaris									x		x					x
E. diadema					x											
ECHINOMETRIDAE																
Echinometra mathaei	x	x				x		x	x		x	x			x	
Echinostrephus acciculatus	x	x	x			x		x	x		x				x	x
Heterocentrotus mammillatus											x					
HOTHURIIDAE																
Actinopyga mauritiana						x					x				x	
Bohadschia argus	x	x	x	x	x										x	x
B. vitiensis	x	x				x	x		x				x			
Holothuria atra		x				x	x		x		x		x		x	
H. edulis													x			
H. leucospilota																x
H. pervicax									x							
H. whitmaei	x	x	x											x		
Pearsonothuria graeffei			x					x								

Table 6a. Macroinvertebrate species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 - 23, 2006.

FAMILY *Genus/species*	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
STICHOPODIDAE																
Stichopus chloronotus	x	x				x									x	x
Thelenota ananas									x	x						
SYNAPTIDAE																
Euapta godeffroyi																x
DIDEMNIDAE																
Didemnum molle				x		x	x							x	x	
D. moseleyi																x
CIONIDAE																
Rhopalaea circula	x	x	x	x				x		x	x		x			
R. crassa			x				x	x								
Rhopalaea sp 2 gold spot	x		x				x	x		x	x		x			
ASCIDIIDAE																
Ascidium sp												x				
Phallusia julinea			x	x						x					x	
STYELIDAE																
Polycarpa sp	x			x			x	x	x			x			x	
P. argentata					x							x				
P. cryptocarpa		x	x										x		x	
Total Families per Survey Transect:	19	21	20	21	18	26	27	41	20	14	13	21	13	19	35	18
Total Species per Survey Transect:	26	29	26	22	21	40	38	52	28	18	20	24	18	20	51	21

Note: * = juvenile

Table 6b. Macroinvertebrate species abundance data at sixteen survey stations at Apra Harbor, Guam, January 19 - 23, 2006. Note: The data table represents the average number of observations per square meter.

Genus/species	S1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11	S 12	S 13	S 14	S 15	S 16
Mollusca																
Tridacna maxima	0.15	0.125	0	0	0	0.225	0	0.1	0.025	0	0.125	0.225	0	0.35	0.125	0.075
Trochus niloticus	0	0	0	0.025	0	0.175	0.025	0.05	0.1	0	0.1	0.05	0	0	0.05	0.025
Coralliophila violacea	0	0	0	0	0	0.075	1.925	1.425	0.125	0	0	0	0	1.275	0	0
Cypraea tigris	0	0	0	0.025	0.025	0	0	0	0	0	0	0.025	0	0.05	0	0
Lambis truncata	0	0	0	0	0	0	0	0	0.025	0	0	0	0	0	0	0.025
L. lambis	0	0	0	0	0	0.025	0	0	0.025	0.05	0.025	0	0	0	0	0.025
L. chiragra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.025	0
Echinodermata-Asteroids																
Acanthaster planci	0	0	0	0	0	0.05	0	0	0.025	0	0	0	0	0	0.025	0
Echinaster luzonicus	0.025	0.075	0.025	0.025	0.25	0.2	0.05	0.1	0	0	0	0	0	0.45	0.075	0
Linckia multifora	0.1	0.175	0	0	0.3	0.075	0.075	0.075	0.15	0	0	0.125	0	0	0.1	0
Linckia laevigata	0.025	0.075	0.025	0	0.05	0.15	0	0	0.1	0	0	0	0	0	0.05	0.025
Culcita novaeguineae	0	0	0	0	0	0	0	0	0	0.025	0	0	0	0	0	0
Fromia milleporella	0	0	0.025	0	0	0	0.025	0	0	0	0	0	0	0	0	0
Echinodermata-Echinoids																
Eucidaris metularia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.075
Echinothrix calamaris	0	0	0	0	0	0	0	0	0.3	0	0.225	0	0	0	0	0.525
E. diadema	0	0	0	0	0.025	0	0	0	0	0	0	0	0	0	0	0
Didema setosum	0.375	0.175	0	0	0.05	0	0	0.125	0.05	0	0.2	0.075	0	0.3	0.125	0.7
Echinostrephus acciculatus	0.7	0.55	0.175	0	0	0.425	0	0.025	0.45	0	0.325	0	0	0	0.2	0.025
Echinometra mathaei	0.1	0.075	0	0	0	0.175	0	0.05	0.1	0	0.2	0.2	0	0	0.025	0
Heterocentrotus mammillatus	0	0	0	0	0	0	0	0	0	0	0.025	0	0	0	0	0

***Note: Survey Depth [foot(ft)]**
Survey Station = S#

S1 = 9 ft	S7 = 23 ft	S13 = 47 ft
S2 = 8 ft	S8 = 28 ft	S14 = 21ft
S3 = 30 ft	S9 = 5 ft	S15 = 8 ft
S4 = 50 ft	S10 = 45 ft	S16 = 4 ft
S5 = 20 ft	S11 = 5 ft	
S6 = 5 ft	S12 = 12 ft	

Table 6b. Macroinvertebrate species abundance data at 16 survey stations at Apra Harbor, Guam, January 19 - 23, 2006. Note: The data table represents the average number of observations per square meter.

Genus/species	S1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11	S 12	S 13	S 14	S 15	S 16
Echinodermata-Holothuroids																
Actinopyga mauritiana	0	0	0	0	0	0.175	0	0	0	0	0.025	0	0	0	0.05	0
Holothuria atra	0	0	0	0	0	0.125	0	0	0.125	0	0.05	0	0.025	0	0.05	0.1
H. whitmaei	0.025	0.025	0.025	0	0	0	0	0	0	0	0	0	0	0.05	0	0
H. edulis	0	0	0	0	0	0	0	0	0	0	0	0	0.025	0	0	0
Thelenota ananas	0	0	0	0	0	0	0	0	0.025	0.025	0	0	0	0	0	0
Stichopus chloronotus	0.025	0.05	0	0	0	0.45	0	0	0	0	0	0	0	0	0.225	0.025
Bohadschia argus	0.075	0.025	0.225	0.025	0.025	0	0	0	0	0	0	0	0	0	0.025	0.05
B. vitiensis	0.025	0	0	0	0	0.025	0	0	0.025	0	0	0	0.025	0	0	0
Pearsonothuria graeffei	0	0	0.025	0	0	0	0	0	0	0	0	0	0	0	0	0
Euapta godeffroyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.125
Crustacea																
Trapezia rufopunctata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.15	0
Trapezia ferruginea	0.1	0	0	0	0	0.15	0	0	0	0	0	0	0	0	0.05	0

Table 7. Reef fish species observed at sixteen survey stations at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 - 23, 2006.

FAMILY	SURVEY STATION (S)															
Genus/species	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
CARCHARHINIDAE																
Carcharhinus melanopterus																x
MURAENIDAE																
Gymnothorax javanicus					x							x				
SYNODONTIDAE																
Saurida gracilis															x	
Synodus varieagatus												x				
BELONIDAE																
Platybelone argalus																x
HOLOCENTRIDAE																
Myripristis amaena														x	x	x
M. berndti			x	x	x		x					x		x		x
M. kuntee				x	x		x							x		
M. pralinia					x			x								
Neoniphon sammara				x				x				x		x		x
Sargocentron caudimaculatum														x		
S. diadema					x											
S. microstoma																x
S. punctatissumus																x
S. spiniferum																x
AULOSTOMIDAE																
Aulostomus chinensis					x			x								
FISTULARIIDAE																
Fistularia commersonii	x											x			x	
SCORPAENIDAE																
Pterois antennata			x					x								
Scorpeanodes guamensis					x											
SYNANCEIIDAE																
Synanceia verrucosa					x											
SERRANIDAE																
Cephalopholis argus												x		x		
C. urodeta			x		x							x		x	x	
Epinephelus merra	x	x		x								x		x		x
CIRRHITIDAE																
Paracirrhitus arcuatus		x				x									x	
P. forsteri						x										

Table 7. continued.

FAMILY Genus/species	SURVEY STATION (S) S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
APOGONIDAE																
Cheilidipterus macrodon												x				
C. quinquelineata							x									
CARANGIDAE																
Decapterus macarellus				x												
LUTJANIDAE																
Lutjanus fulvus														x		x
L. monostigma																x
Macolor niger			x											x		
LETHRINIDAE																
Gnathodentax aurolineatus																x
Lethrinus harak										x						x
NEMIPTERIDAE																
Pentapodus caninus				x	x								x			
Scolopsis lineata					x		x	x	x			x		x	x	x
MULLIDAE																
Mulloidichthys flavolineatus																x
M. vanicolensis												x				x
Parupeneus barberinus													x			x
P. cyclostomus				x	x										x	
P. insularis																x
P. multifasciatus	x	x	x	x	x	x		x	x				x		x	x
PEMPHERIDAE																
Pempheris oulaensis												x				
CHAETODONTIDAE																
Chaetodon auriga	x						x		x		x	x	x		x	x
C. bennetti						x	x	x							x	x
C. citrinellus		x		x		x			x		x	x		x	x	x
C. ephippium						x	x	x				x		x	x	
C. lunula					x	x					x	x	x	x		x
C. lunulatus						x	x					x		x	x	x
C. melannotus							x	x							x	
C. mertensii							x									
C. ornatissimus					x									x	x	x
C. punctatofasciatus																x
C. reticulatus					x			x						x	x	
C. trifascialis						x										
C. ulietensis	x	x		x		x	x	x						x	x	x
C. unimaculata												x				x
Forcipiger flavissimus	x		x	x	x		x	x				x		x	x	
Heniochus chrysostomus				x	x			x				x		x		x
H. monoceros							x									x

Table 7. continued.

FAMILY	SURVEY STATION (S)															
Genus/species	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
POMACANTHIDAE																
Centropyge flavissimus						x	x	x				x		x	x	x
C. vrolickii								x								x
Pygoplites diacanthus			x	x	x		x					x	x	x	x	
POMACENTRIDAE																
Abudefduf septemfasciatus																x
A. sordidus																x
A. vaigiensis	x	x												x	x	
Amblylglyphidodon curacao				x	x		x	x				x		x		x
Amphiprion melanopus		x			x				x			x				
Chromis acares								x								
C. atripectoralis												x				x
C. margaritifer								x						x	x	
C.viridis							x							x		x
Chrysiptera brownriggii	x	x				x			x		x					
C. glauca																x
C. traceyi		x	x	x	x		x	x				x		x	x	
Dascyllus aruanus																x
D. reticulatus				x												
D. trimaculatus					x									x		
Plectroglyphidodon dickii								x								
P. lacrymatus	x	x		x	x		x	x			x	x		x	x	x
Pomacentrus vaiuli		x	x	x	x	x	x	x		x	x		x	x	x	x
Stegastes albifasciatus					x											x
S. lividus											x	x		x		
S. nigricans							x					x				x
LABRIDAE																
Anampses meleagrides												x				
A. twisti					x		x							x	x	
Cheilinus chlorurus		x											x			
C. fasciatus	x	x	x	x	x		x	x			x	x	x	x	x	
C. oxycephala												x		x		x
C. trilobatus						x		x			x	x	x	x	x	x
C. unifasciatus				x	x	x	x	x				x				
Cheilio inermis												x				x
Epibulus insidiator	x		x	x		x		x				x				
Gomphosus varius		x			x	x	x	x							x	
Halichoeres biocellatus				x					x						x	
H. hortulanus	x	x			x	x					x	x		x	x	x
H. margaritaceus						x			x						x	
H. marginatus		x										x				
H. trimaculatus																x
Hemigymnus fasciatus								x				x				
H. melapterus							x	x				x			x	x
Labroides dimidiatus				x	x			x			x	x		x		x
Macropharyngodon meleagris		x				x									x	
Novaculichthys taeniorus																x

Table 7. continued.

FAMILY Genus/species	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
LABRIDAE continued																
Oxycheilinus diagrammus														x		
O. unifasciatus												x				
Pseudocheilinus evanidus				x												
P. hexataenia														x		
Stethojulis bandanensis		x				x			x		x				x	x
S. strigiventor																x
Thalassoma amblycephalum		x				x										
T. hardwicki	x	x				x		x	x		x	x			x	x
T. lutescens								x							x	x
T. quinquevittatum	x	x				x			x		x				x	x
SCARIDAE																
Calatomus carolinus							x	x				x			x	
Chlorurus frontalis																x
C. sordidus	x	x		x	x	x	x	x	x		x	x	x	x	x	x
Hipposcarus longiceps							x			x						
Scarus altipinnis							x	x				x				x
S. forsteni							x									
S. globiceps		x		x	x	x						x		x	x	
S. psittacus	x	x											x			x
S. schlegeli	x		x			x	x	x			x		x		x	
PINGUIPEDIDAE																
Parapercis clathrata		x							x	x			x			
P. millipunctata									x							
BLENNIDAE																
Blenniella chrysospilos																x
Cirripectus sp.									x							
Ecsenius bicolor									x							
Meiacanthus atrodorsalis	x	x	x	x		x	x	x			x	x		x	x	x
Plagiotremus tapienosoma						x										
Salarias sp.						x			x							
GOBIIDAE																
Amblyeleotris steinitzi										x						
Cryptocentrus sp.													x			
Eviota saipanensis													x			
Gnatholepis sp.													x			
Oplopomus oplopomus										x						
Valenciennea puellaris										x						
V. strigata		x														
MICRODESMIDAE																
Ptereleotris evides		x														
P. microlepis													x			
SIGANIDAE																
Siganus spinus																x

Table 7. continued.

FAMILY Genus/species	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16
	SURVEY STATION (S)															
ZANCLIDAE																
Zanclus cornutus	x			x		x	x				x			x	x	x
ACANTHURIDAE																
Acanthurus blochii										x			x			
A. lineatus						x	x				x					
A. nigricans				x		x								x	x	x
A. nigricauda																x
A. nigrofuscus	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x
A. nigroris	x	x	x	x											x	x
A. olivaceus													x			
A. pyroferus							x									
A. triostegus						x										
A. xanthopterus										x						
Ctenochaetus striatus	x	x	x	x		x	x	x	x		x	x	x	x	x	x
N. lituratus				x			x	x							x	x
N. unicornis	x														x	x
N. vlamingii				x	x		x	x				x	x	x	x	
Zebrasoma flavescens					x		x					x		x		
Z. scopas								x								
Z. veliferum		x		x	x	x	x				x	x		x	x	x
BALISTIDAE																
Balistapus undulatus			x					x							x	x
Balistoides viridescens																x
Rhinecanthus aculeatus																x
Sufflamen bursa			x				x									
S. chrysoptera		x								x			x			
MONOCANTHIDAE																
Cantherhines dumerilii																x
Pervagor janthinosoma				x			x									
OSTRACIIDAE																
Ostracion meleagris												x				
TETRADONTIDAE																
Arothron meleagris																x
A. nigropunctatus										x						x
Canthigaster amboinensis															x	
C. solandri	x	x	x					x	x	x	x		x	x		
C. valentini			x	x		x		x				x		x	x	
Total number of families	12	15	14	15	13	12	13	15	11	8	9	18	13	14	18	21
Total number of species	24	34	16	37	38	38	37	45	20	12	23	55	25	51	55	78

Note: Bold species = rare

Table 8. Average percent cover of marine algae and seagrass that have been identified as green turtle forage in other world areas, as measured at sixteen survey stations at the Kilo Wharf and Orote Channel, Apra Harbor, Guam, January 19 – 23, 2006. (P = species present outside transects)

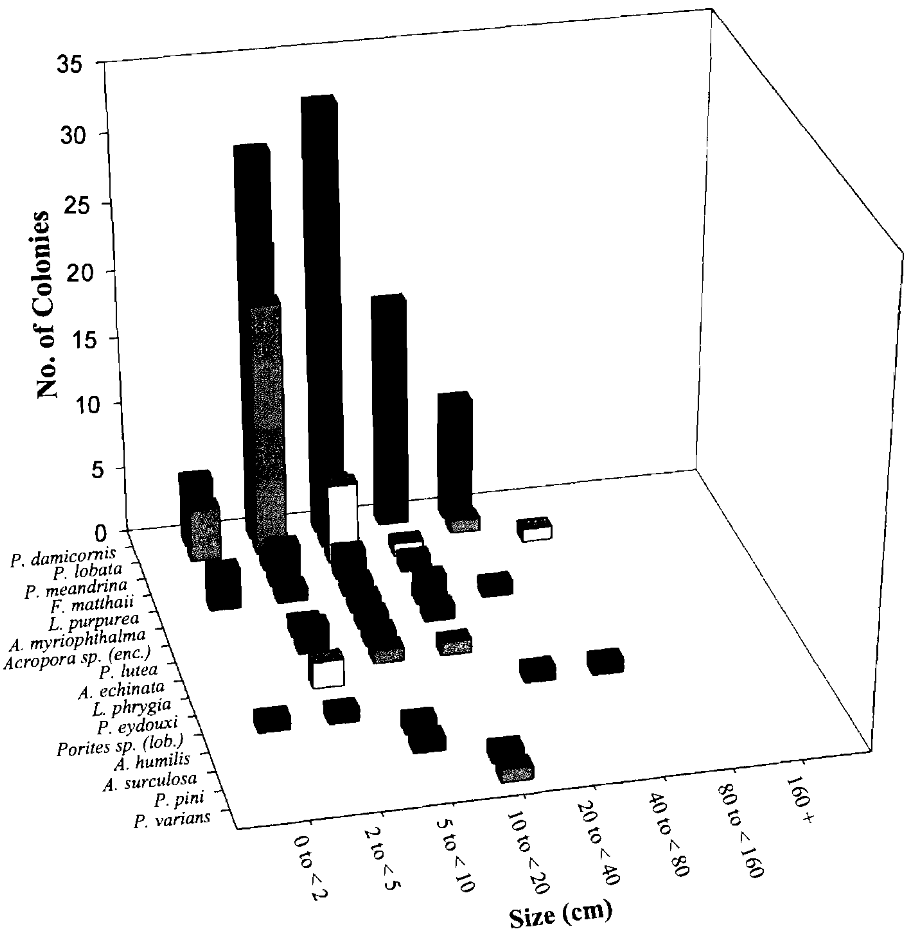
	Site															
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Cyanophyta																
Microcoleus lyngbyaceus	1.0		0.5	7.0	1.0	0.5	2.0	1.5			0.5	2.5		0.5	1.0	
Chlorophyta																
Caulerpa racemosa											0.5					
Caulerpa serrulata								1.0								
Chlorodesmis fastigiata																
Codium edule	30.5	18.5	0.5			2.0			63.5		35.0				1.0	
Dictyosphaeria versluysii						1.0									1.0	
Halimeda opuntia	0.0	1.5	18.5	21.5	2.0	3.0	10.0	7.0	0.5		3.0	14.0	8.5	9.5	4.0	4.5
Phaeophyta																
Dictyota bartayresii	2.0	1.5	0.5		1.0	2.5			0.5		1.0	2.5				
Lobophora variegata	0.5			0.5								0.5			1.0	
Sargassum cristaefolium									0.5							
Turbinaria ornata		0.5				0.5		0.5	0.5		1.5				2.5	
Anthophyta																
Halophila sp.										P						
Total	**34.0**	**22.0**	**20.0**	**29.0**	**4.0**	**9.5**	**12.0**	**10.0**	**65.5**	**P**	**41.5**	**19.5**	**8.5**	**10.0**	**10.5**	**4.5**

Table 9. Global Position System data for sixteen survey stations (thirty-two transects) at Kilo Wharf and Orote Island, Apra Harbor, Guam, January 19 - 23, 2006.

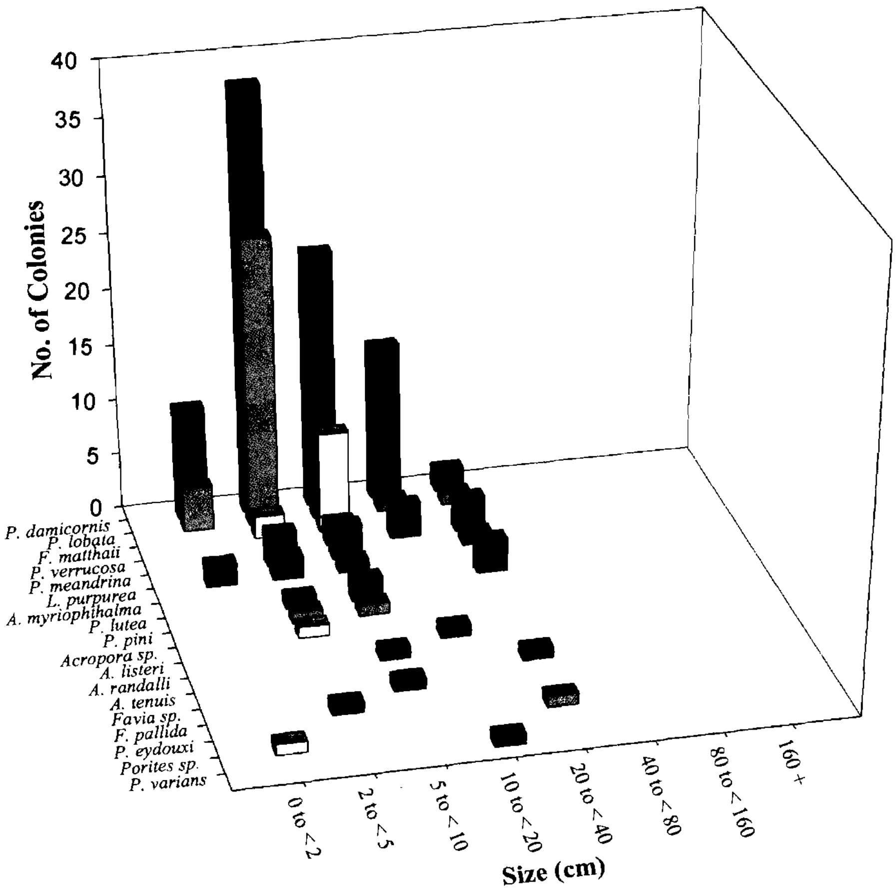
Survey Station(S)/Transect(T)	Date	Latitude	Longitude	Transect Bearing
S1/T1	19-Jan-06	13.44619	144.62996	300
S1/T2	19-Jan-06	13.44616	144.62965	120
S2/T1	19-Jan-06	13.44637	144.62957	300
S2/T2	19-Jan-06	13.44644	144.62934	120
S3/T1	19-Jan-06	13.44652	144.62944	330
S3/T2	19-Jan-06	13.44660	144.62926	150
S4/T1	20-Jan-06	13.44674	144.62904	290
S4/T2	20-Jan-06	13.44709	144.62857	120
S5/T1	20-Jan-06	13.44689	144.62870	310
S5/T2	20-Jan-06	13.44719	144.62831	120
S6/T1	20-Jan-06	13.44656	144.62872	340
S6/T2	20-Jan-06	13.44698	144.62848	130
S7/T1	21-Jan-06	13.44486	144.63204	80
S7/T2	21-Jan-06	13.44483	144.63253	280
S8/T1	21-Jan-06	13.44504	144.63164	130
S8/T2	21-Jan-06	13.44483	144.63179	300
S9/T1	21-Jan-06	13.44491	144.63144	150
S9/T2	21-Jan-06	13.44468	144.63151	320
S10/T1	21-Jan-06	13.44617	144.63040	120
S10/T2	21-Jan-06	13.44595	144.63080	290
S11/T1	22-Jan-06	13.44457	144.63190	120
S11/T2	22-Jan-06	13.44442	144.63237	290
S12/T1	22-Jan-06	13.44472	144.63226	80
S12/T2	22-Jan-06	13.44475	144.63275	250
S13/T1	22-Jan-06	13.44656	144.62967	290
S13/T2	22-Jan-06	13.44674	144.62925	100
S14/T1	22-Jan-06	13.44713	144.62836	300
S14/T2	22-Jan-06	13.44738	144.62795	110
S15/T1	23-Jan-06	13.44692	144.62836	300
S15/T2	23-Jan-06	13.44721	144.62793	110
S16/T1	23-Jan-06	13.44705	144.62008	50
S16/T2	23-Jan-06	13.44706	144.62033	230

Note: Datum = WGS 84

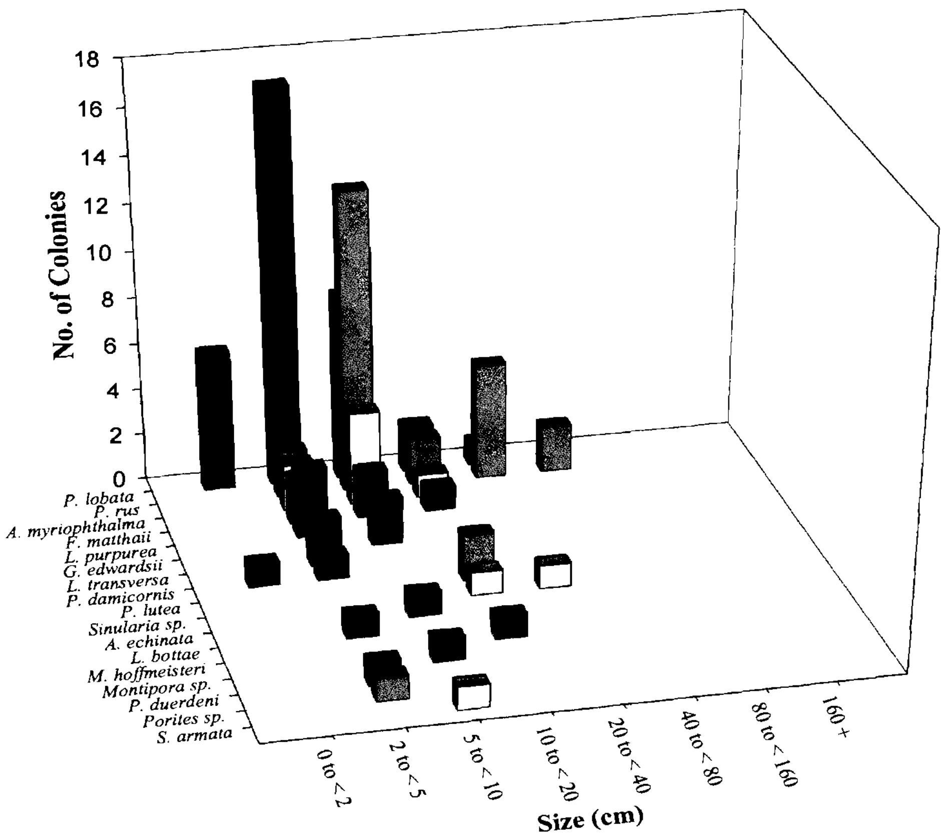
APPENDIX 1



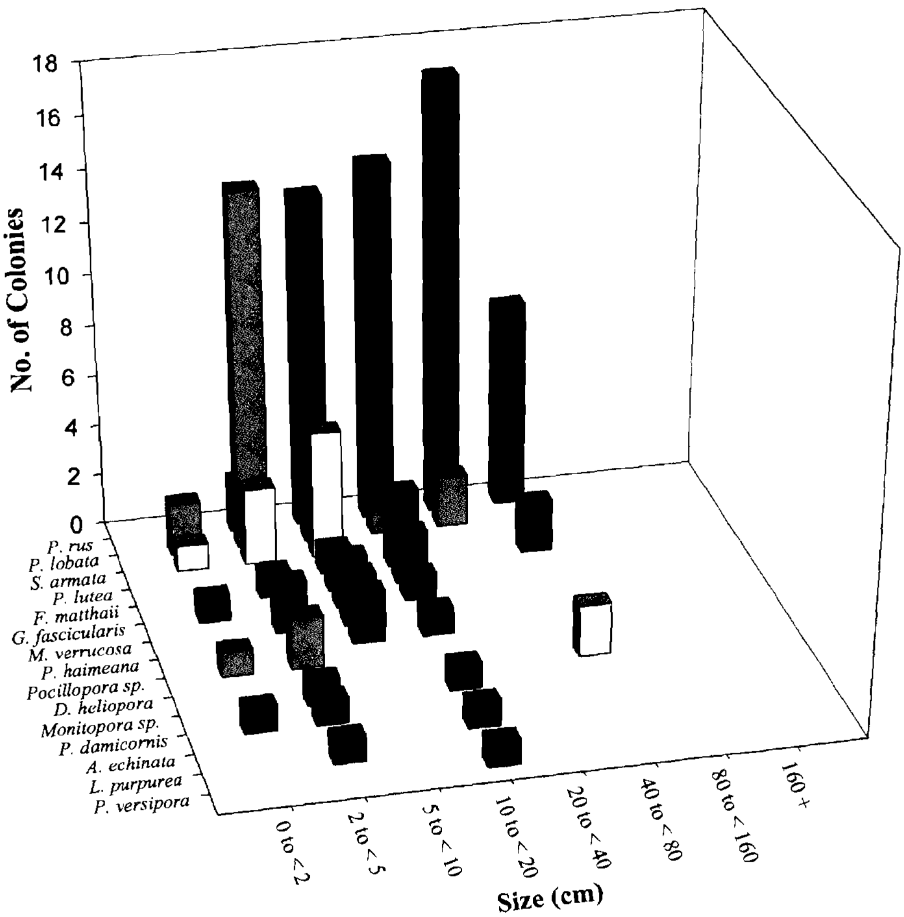
Appendix 1. Figure 1a. Size distributions of coral species observed within four 10 m^2 transects at Station 1.



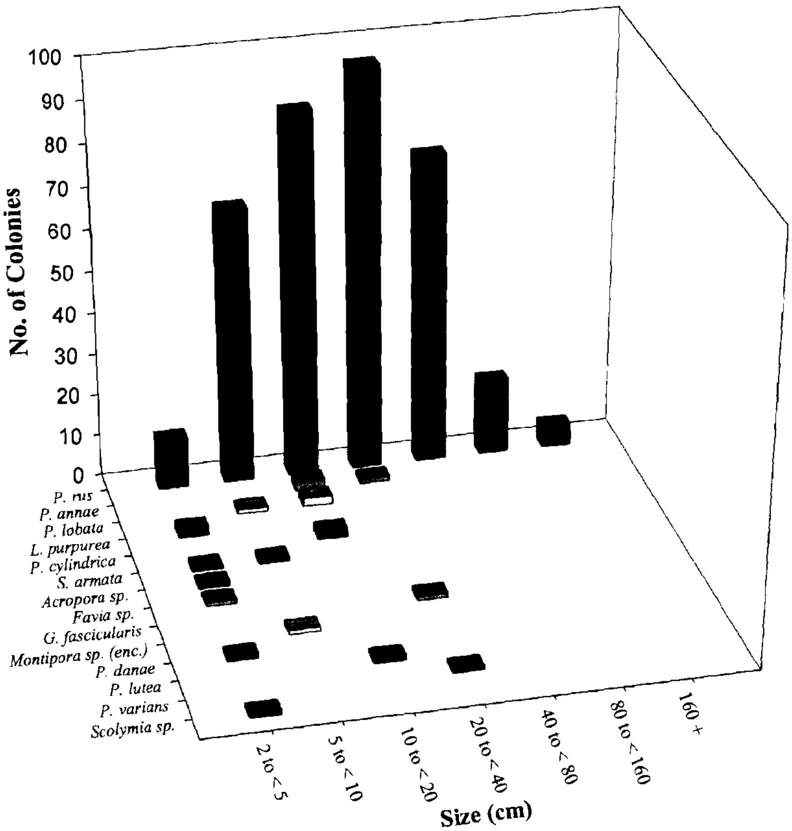
Appendix 1. Figure 1b. Size distributions of coral species observed within four 10 m^2 transects at Station 2.



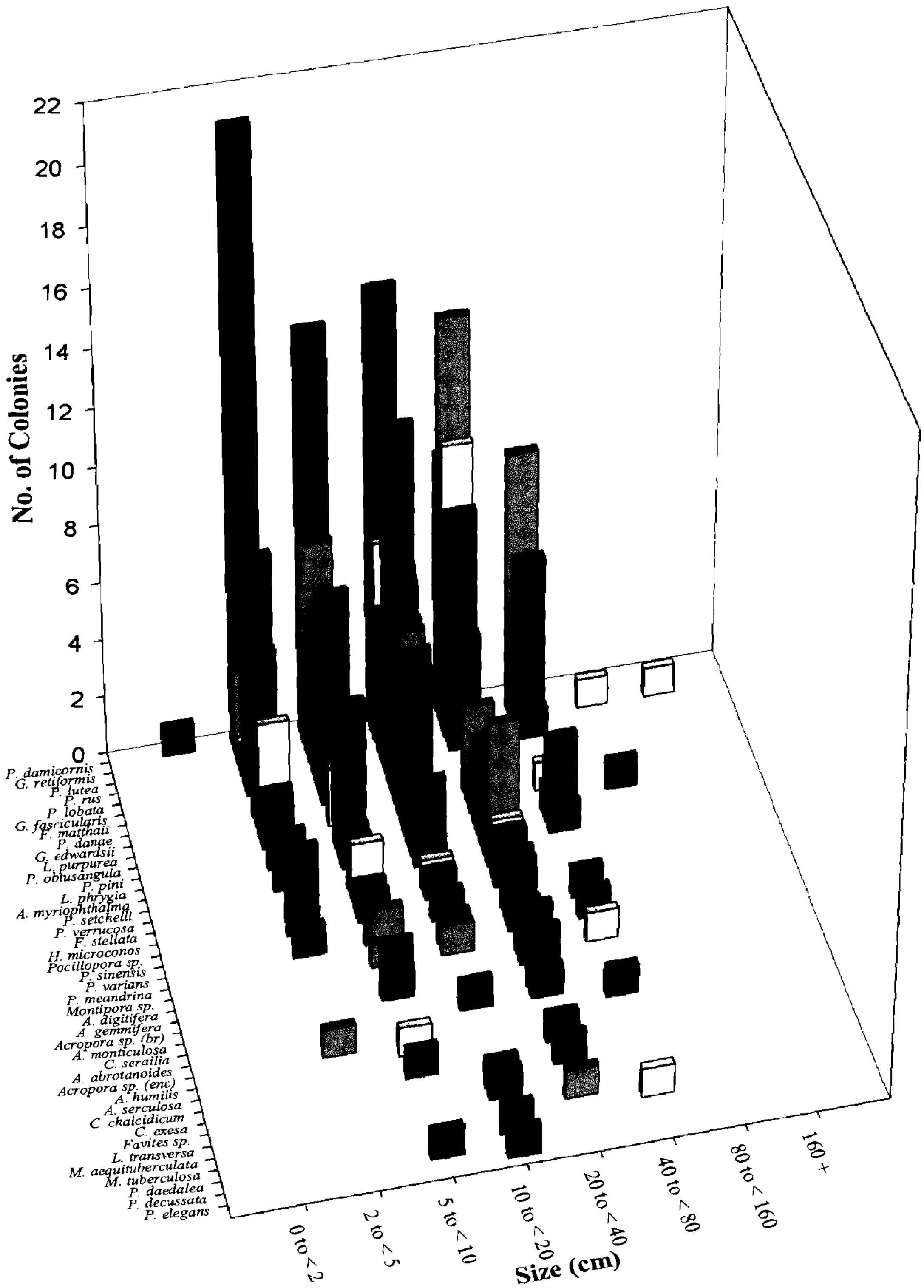
Appendix 1. Figure 1c. Size distributions of coral species observed within four 10 m^2 transects at Station 3.



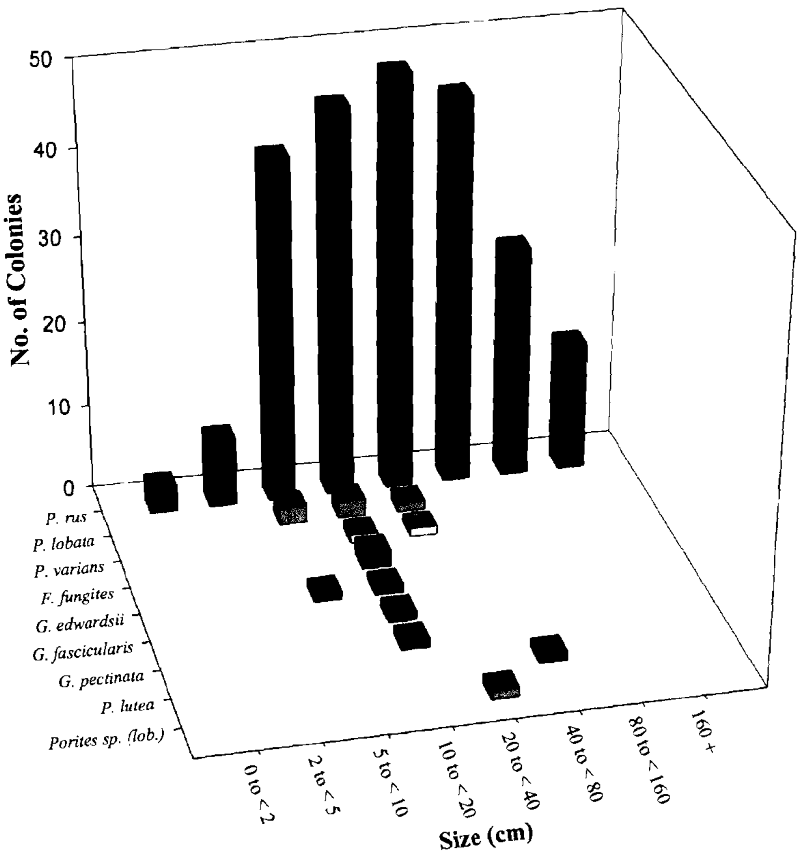
Appendix 1. Figure 1d. Size distributions of coral species observed within four 10 m^2 transects at Station 4.



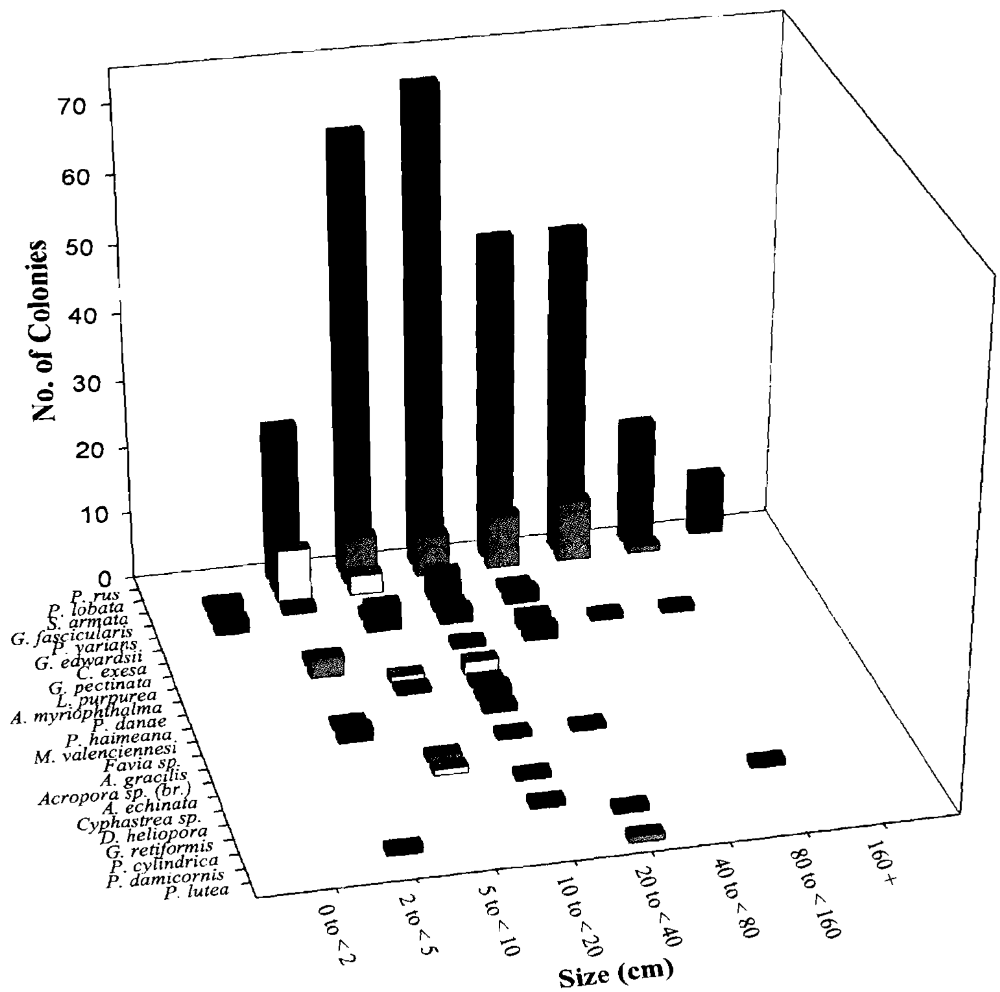
Appendix 1. Figure 1e. Size distributions of coral species observed within four 10 m^2 transects at Station 5.



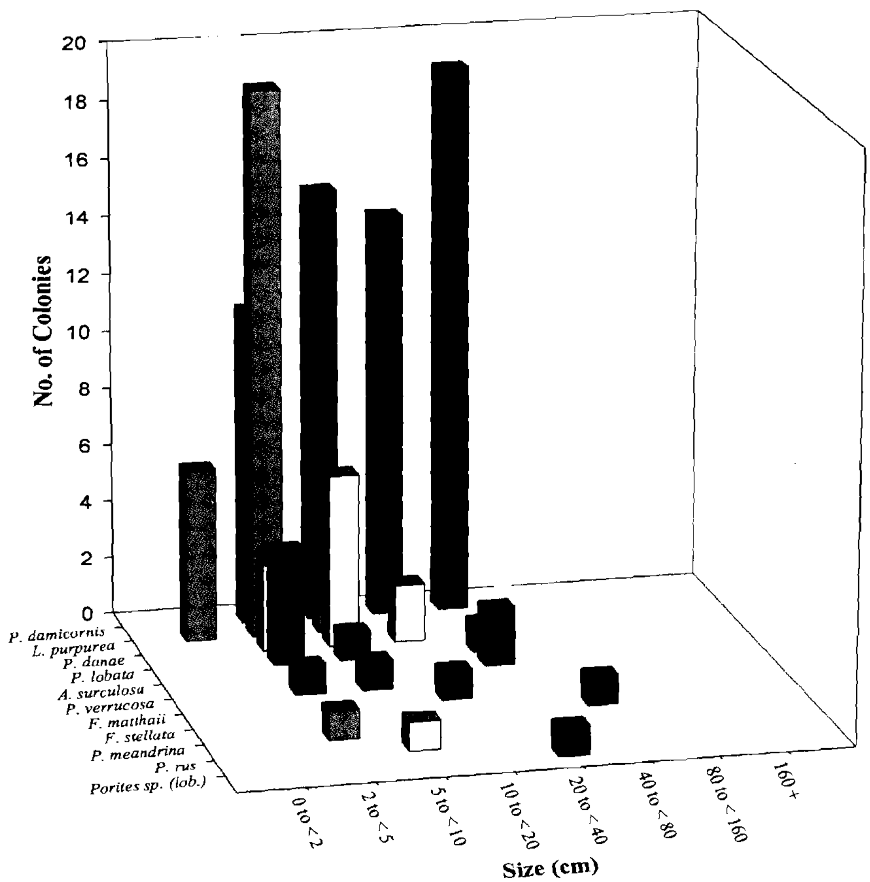
Appendix 1. Figure 1f. Size distributions of coral species observed within four 10 m^2 transects at Station 6.



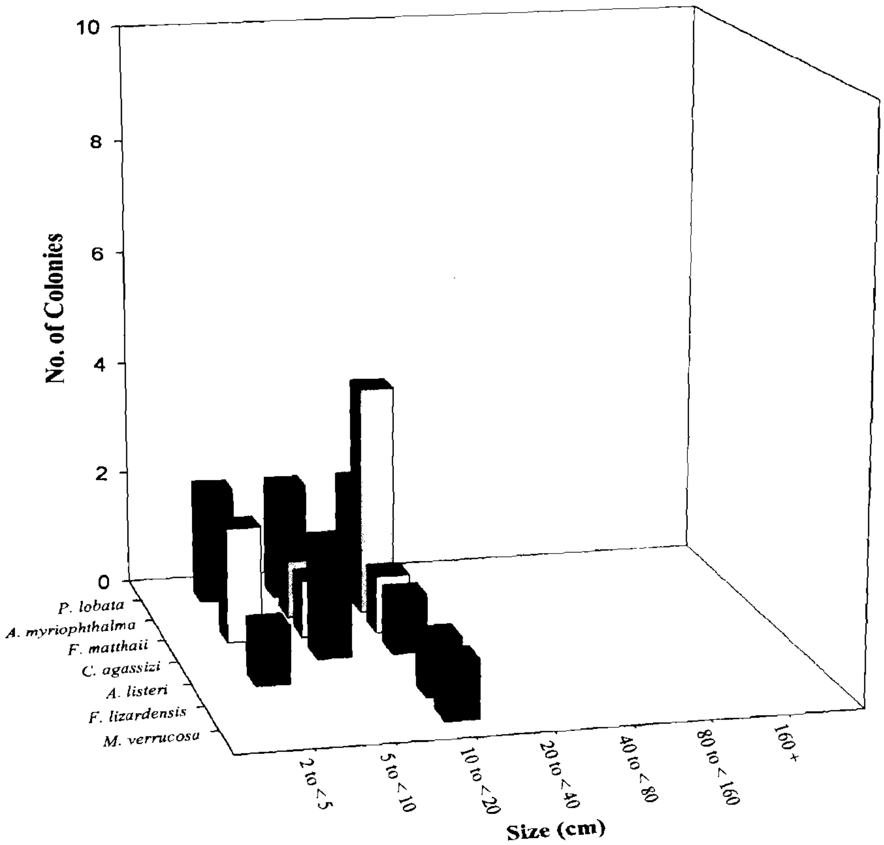
Appendix 1. Figure 1g. Size distributions of coral species observed within four 10 m^2 transects at Station 7.



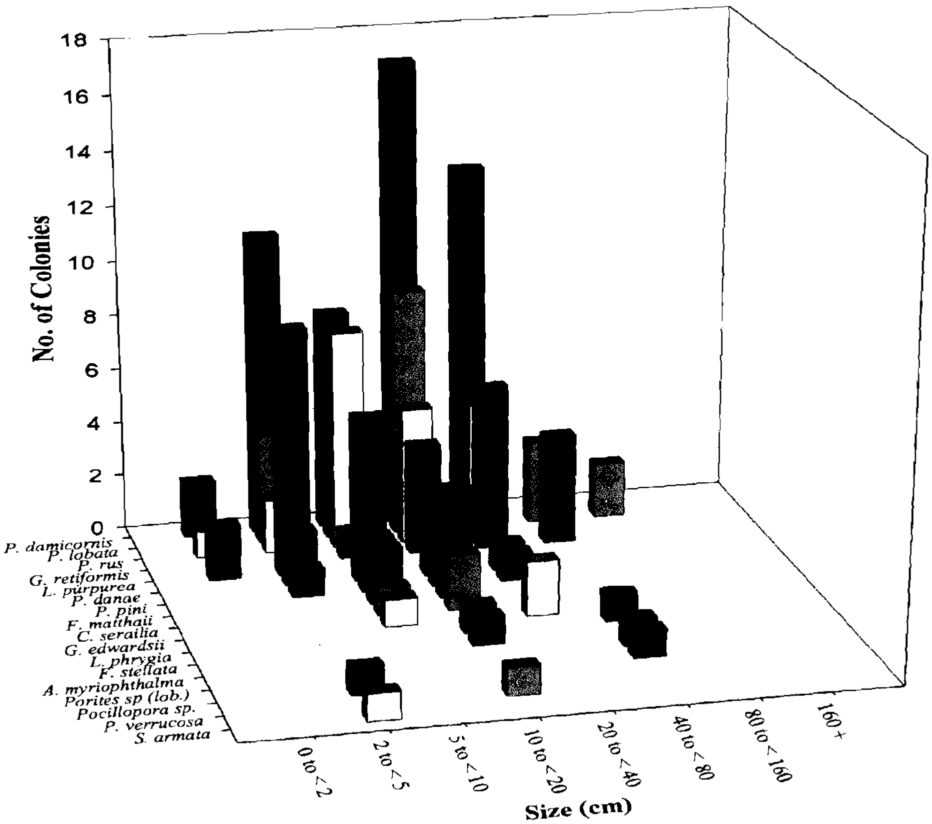
Appendix 1. Figure 1h. Size distributions of coral species observed within four 10 m^2 transects at Station 8.



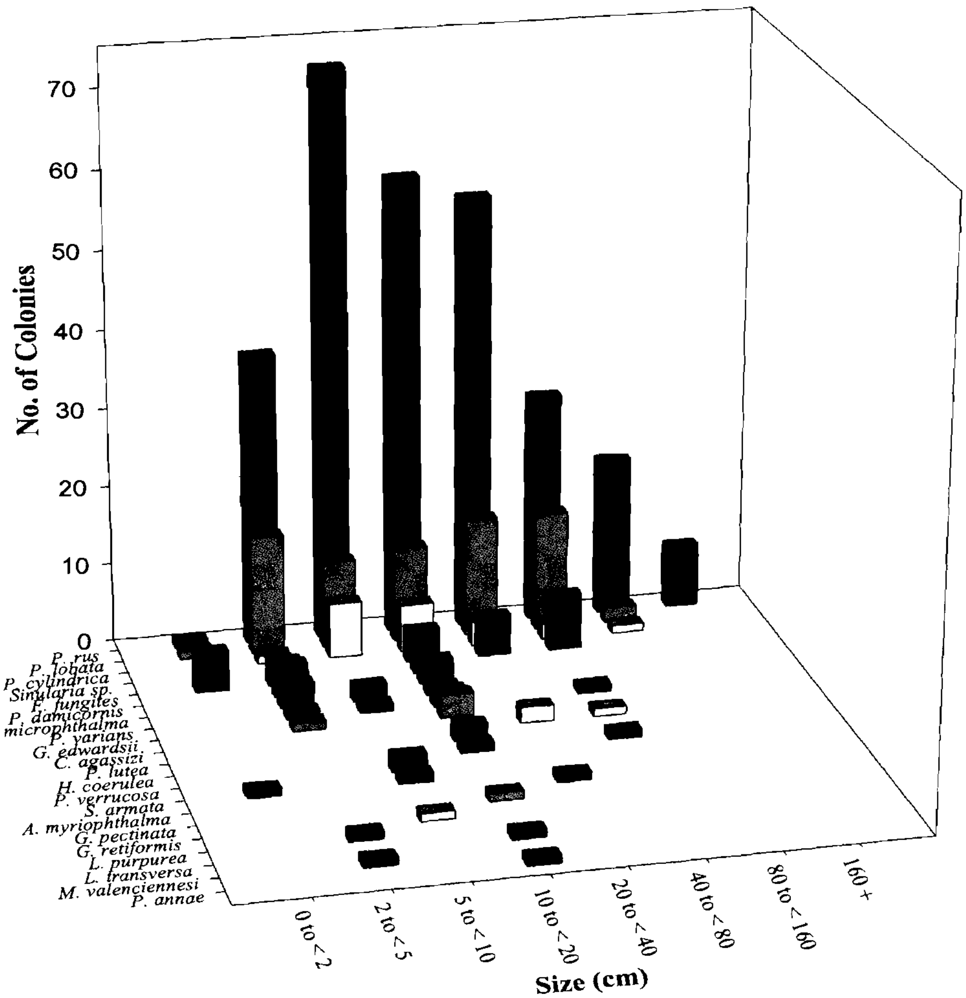
Appendix 1. Figure 1i. Size distributions of coral species observed within four 10 m^2 transects at Station 9.



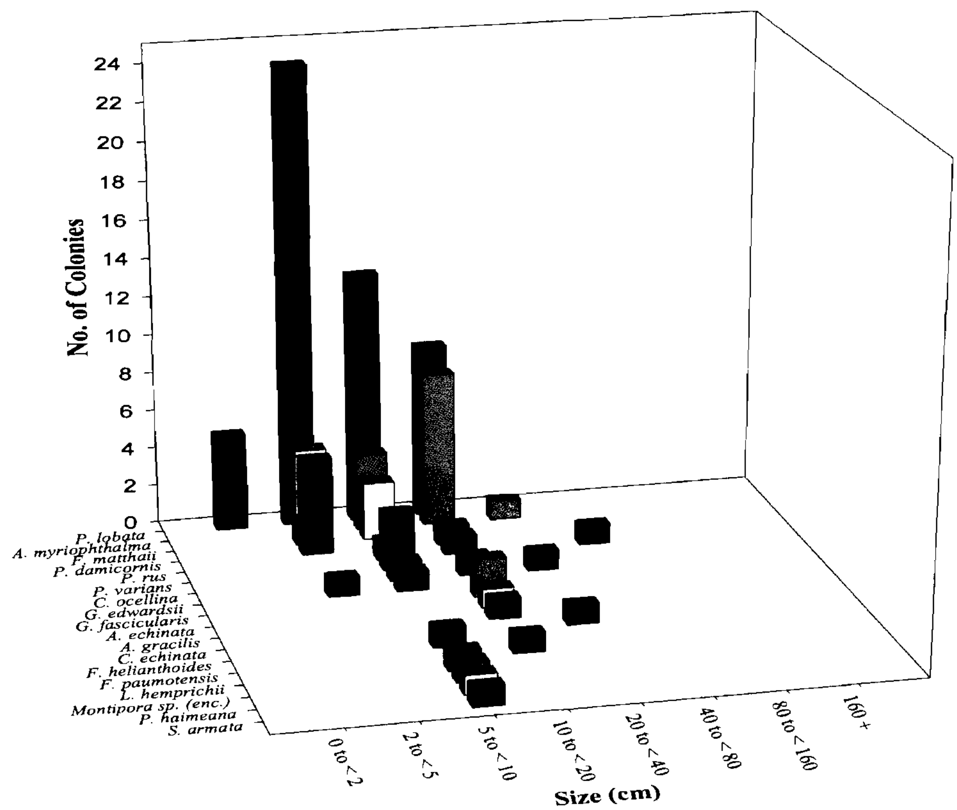
Appendix 1. Figure 1j. Size distributions of coral species observed within four 10 m^2 transects at Station 10.



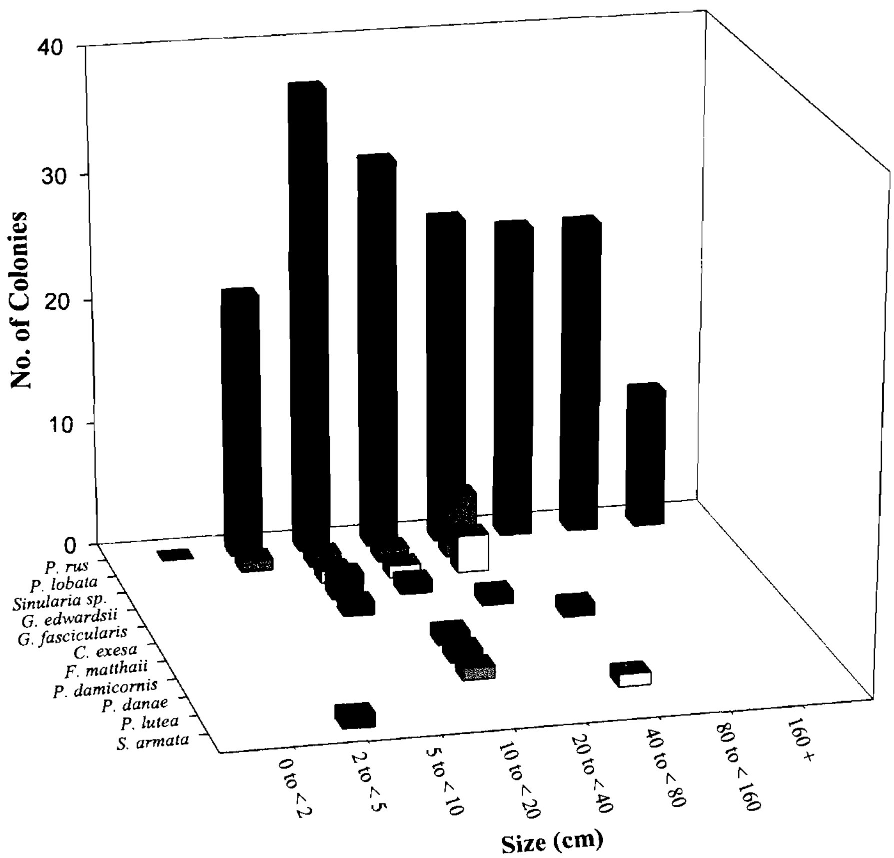
Appendix 1. Figure 1k. Size distributions of coral species observed within four 10 m^2 transects at Station 11.



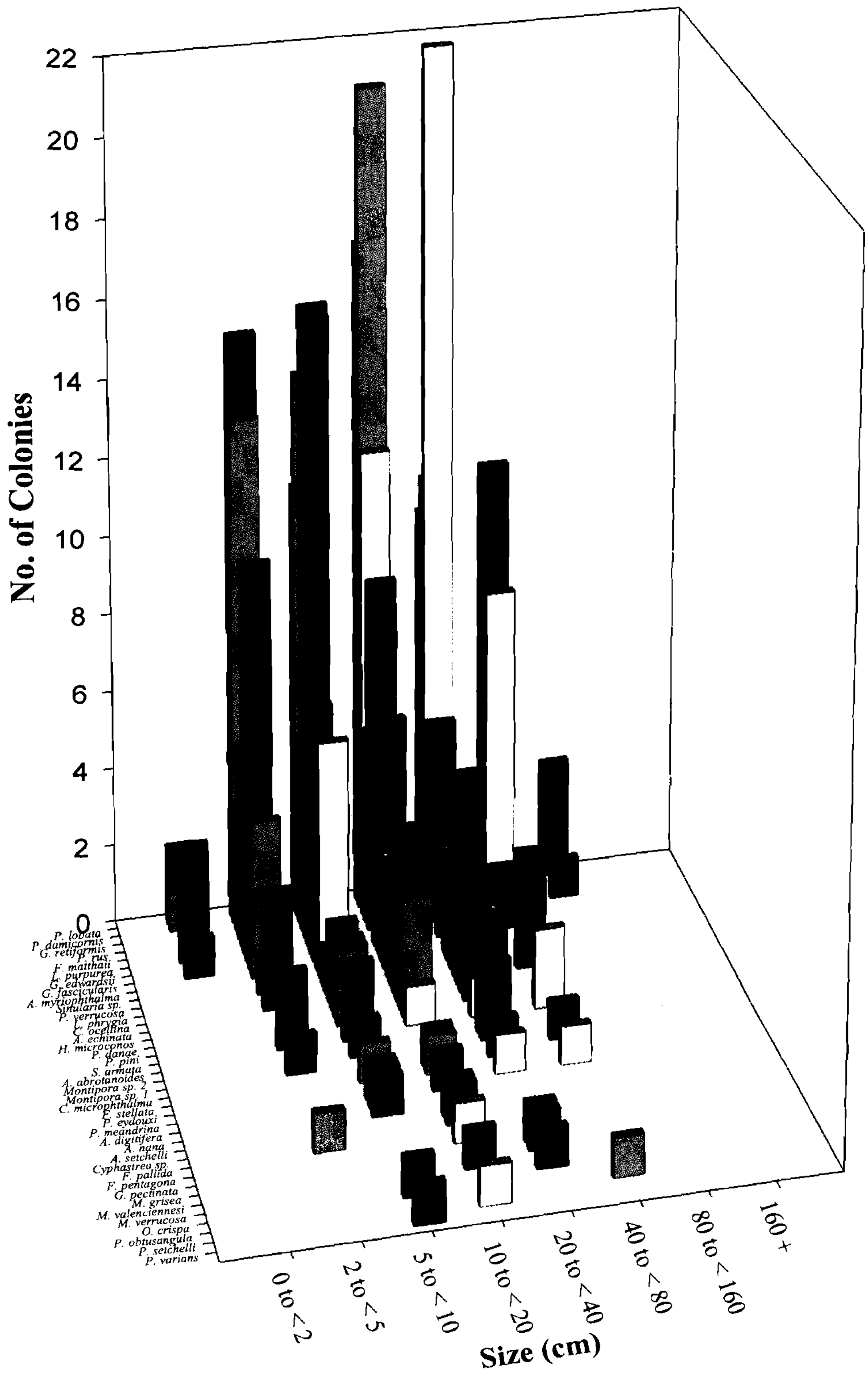
Appendix 1. Figure 11. Size distributions of coral species observed within four 10 m^2 transects at Station 12.



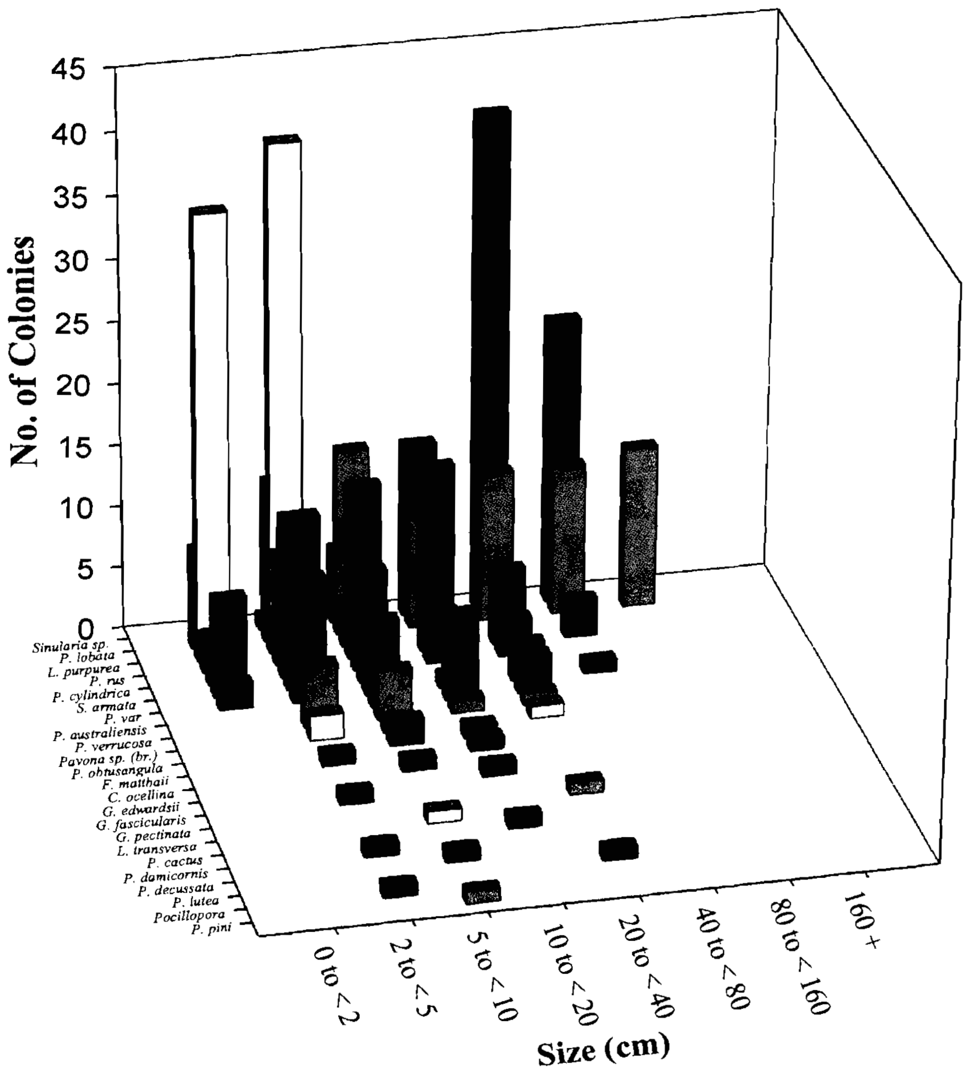
Appendix 1. Figure 1m. Size distributions of coral species observed within four 10 m^2 transects at Station 13.



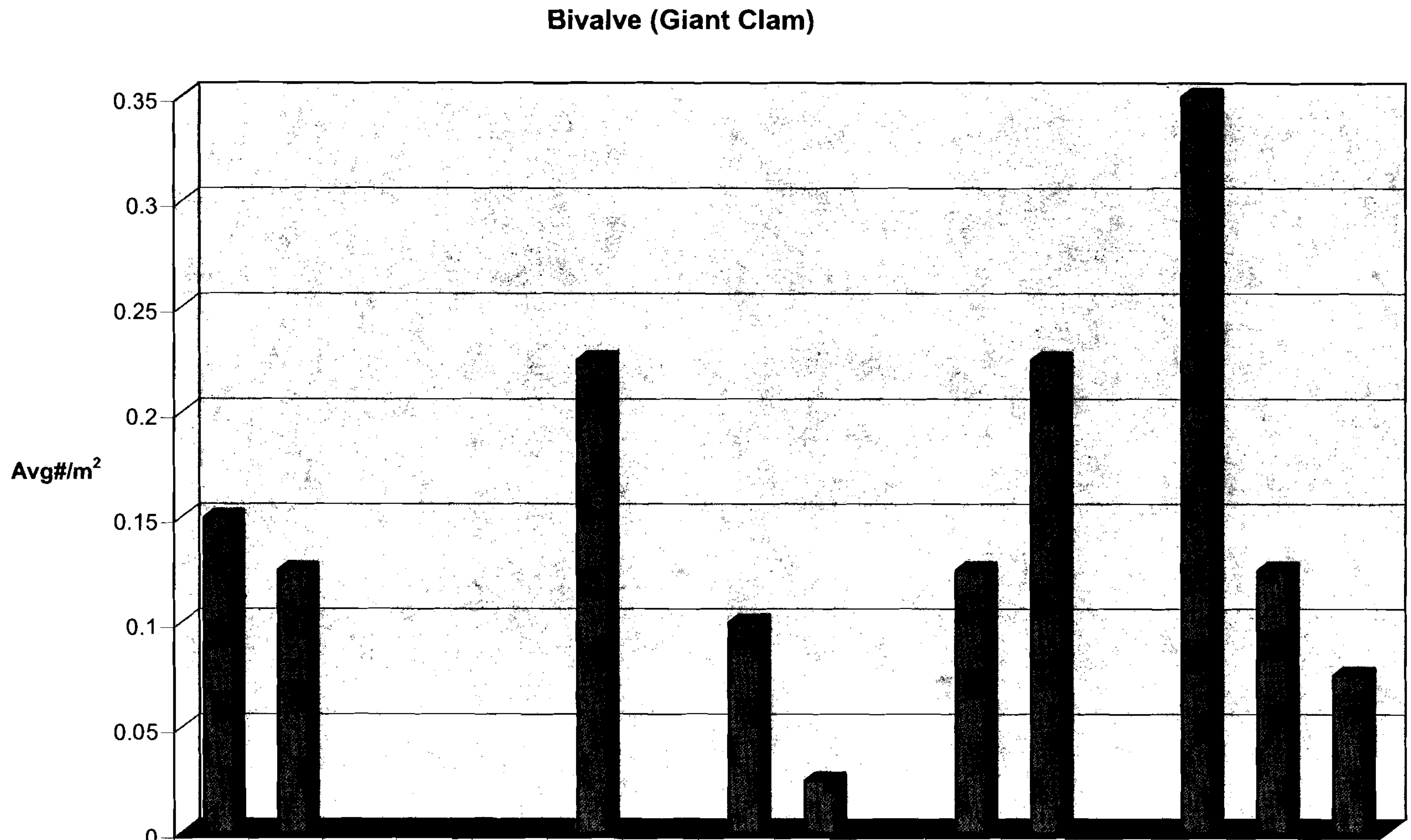
Appendix 1. Figure 1n. Size distributions of coral species observed within four 10 m^2 transects at Station 14.



Appendix 1. Figure 1o. Size distributions of coral species observed within three 10 m^2 transects at Station 15.



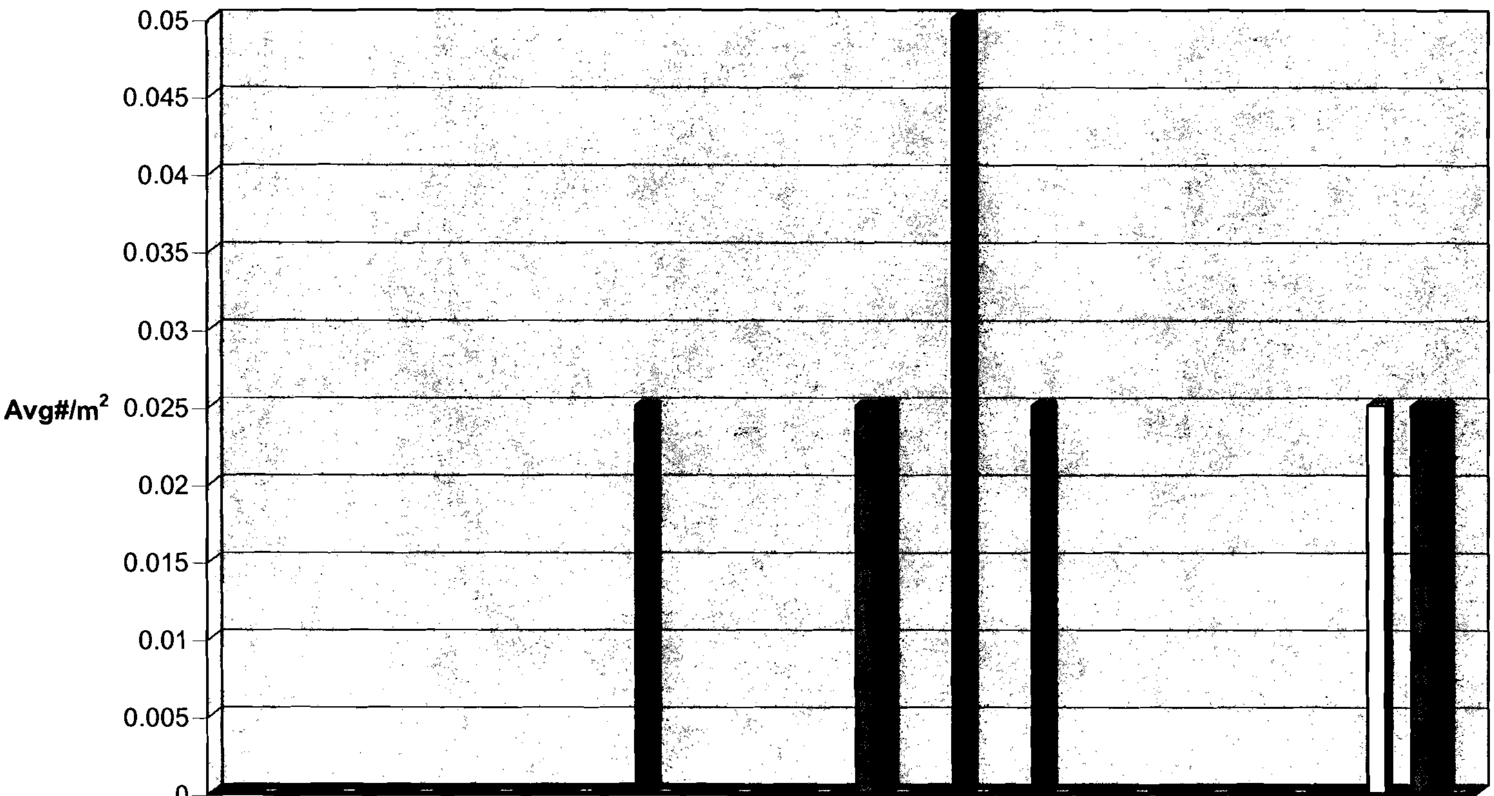
Appendix 1. Figure 1p. Size distributions of coral species observed within four 10 m^2 transects at Station 16.



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Tridacna maxima	0.15	0.125	0	0	0	0.225	0	0.1	0.025	0	0.125	0.225	0	0.35	0.125	0.075

Appendix 1. Figure 2a. Abundance of Tridacna maxima - Average Number of Observations per Square Meter (avg#/m^2)

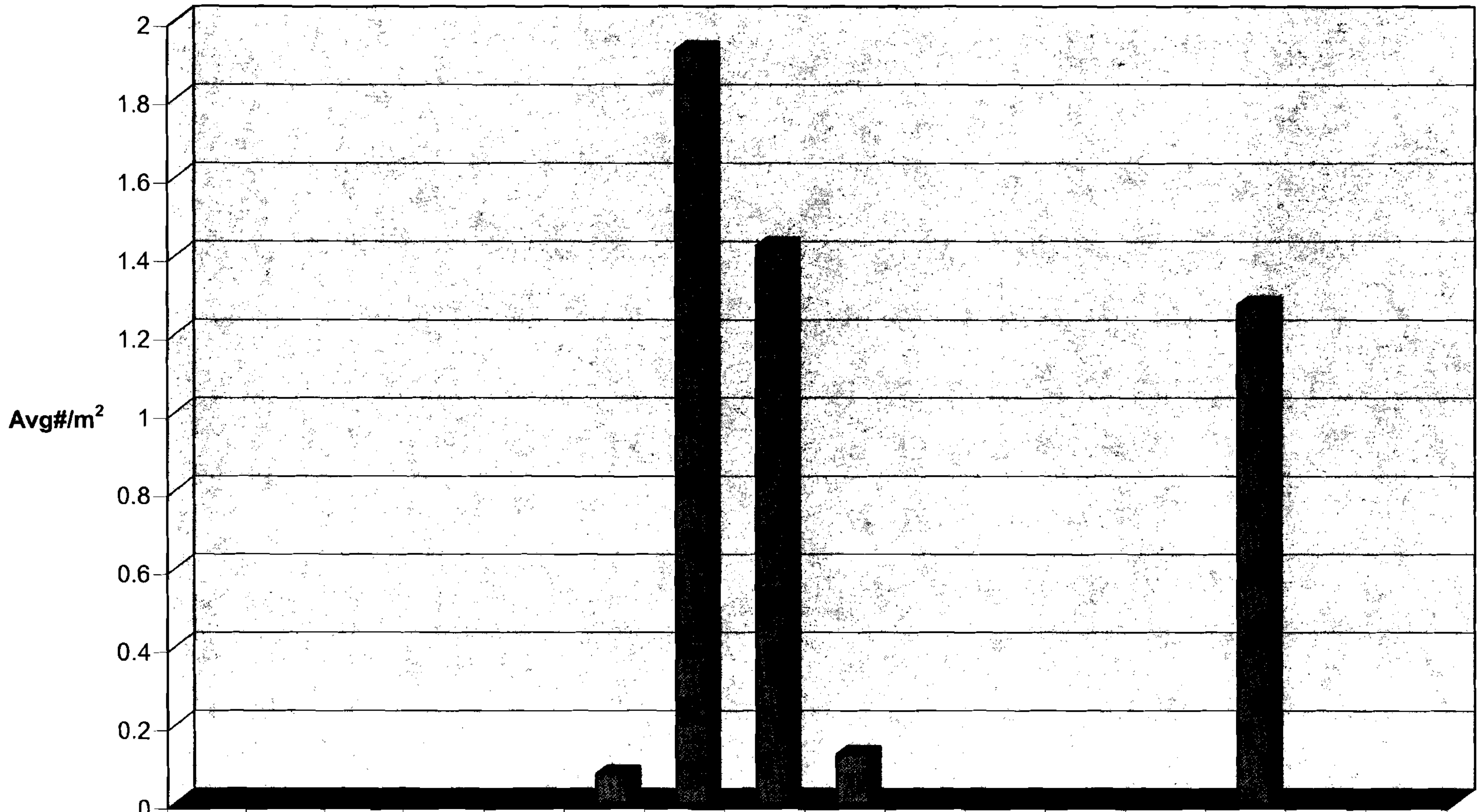
Gastropods (Finger Conchs)



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Lambis truncata	0	0	0	0	0	0	0	0	0.025	0	0	0	0	0	0	0.025
L. lambis	0	0	0	0	0	0.025	0	0	0.025	0.05	0.025	0	0	0	0	0.025
L. chiragra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.025	0

Appendix 1. Figure 2b. Abundance of Lambids - Average Number of Observations per Square Meter ($avg\#/m^2$)

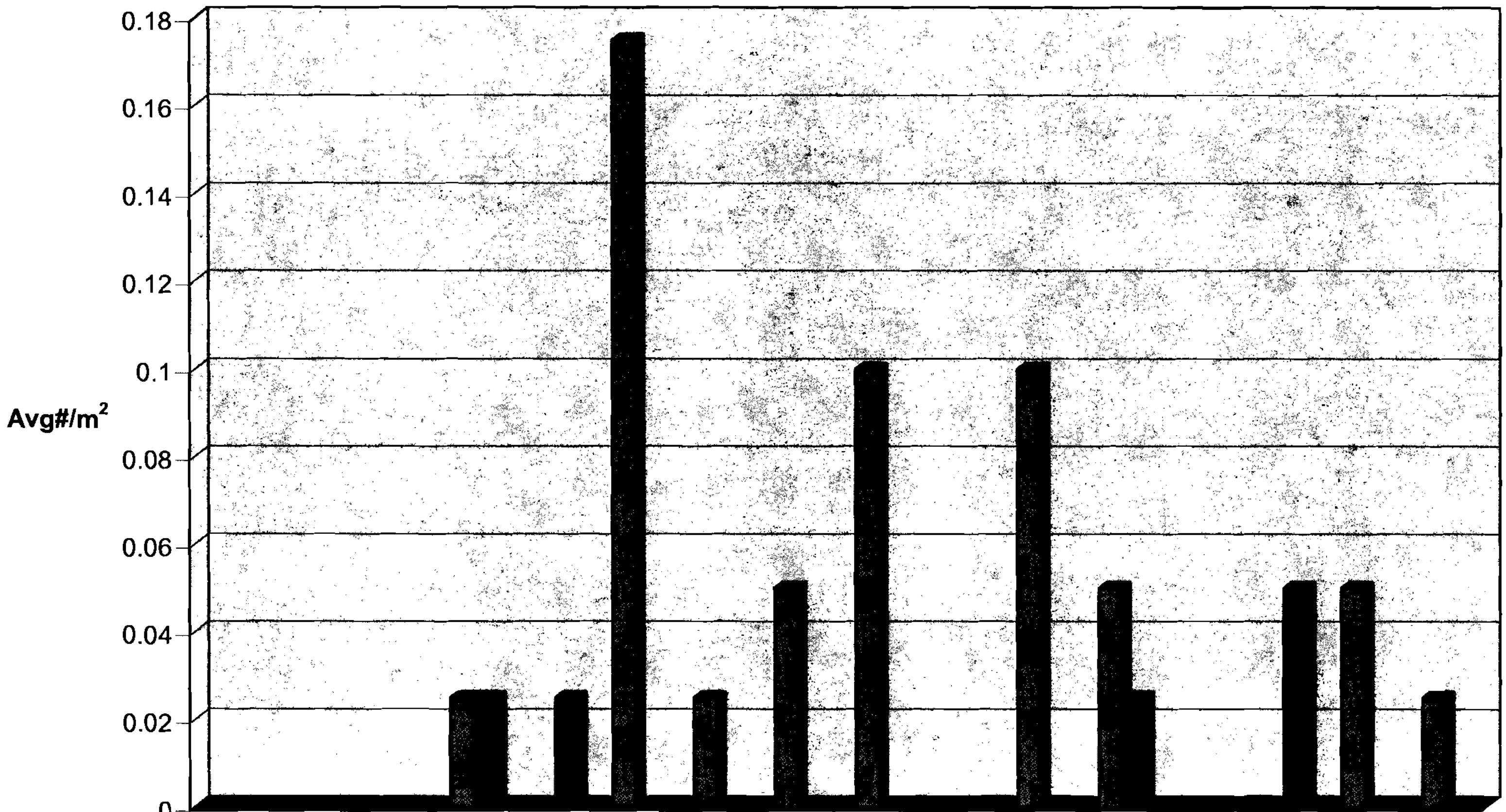
Gastropod (Coralliophid Snail)



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Coralliophila violacea	0	0	0	0	0	0.075	1.925	1.425	0.125	0	0	0	0	1.275	0	0

Appendix 1. Figure 2c. Abundance of Coralliophila - Average Number of Observations per Square Meter ($avg\#/m^2$)

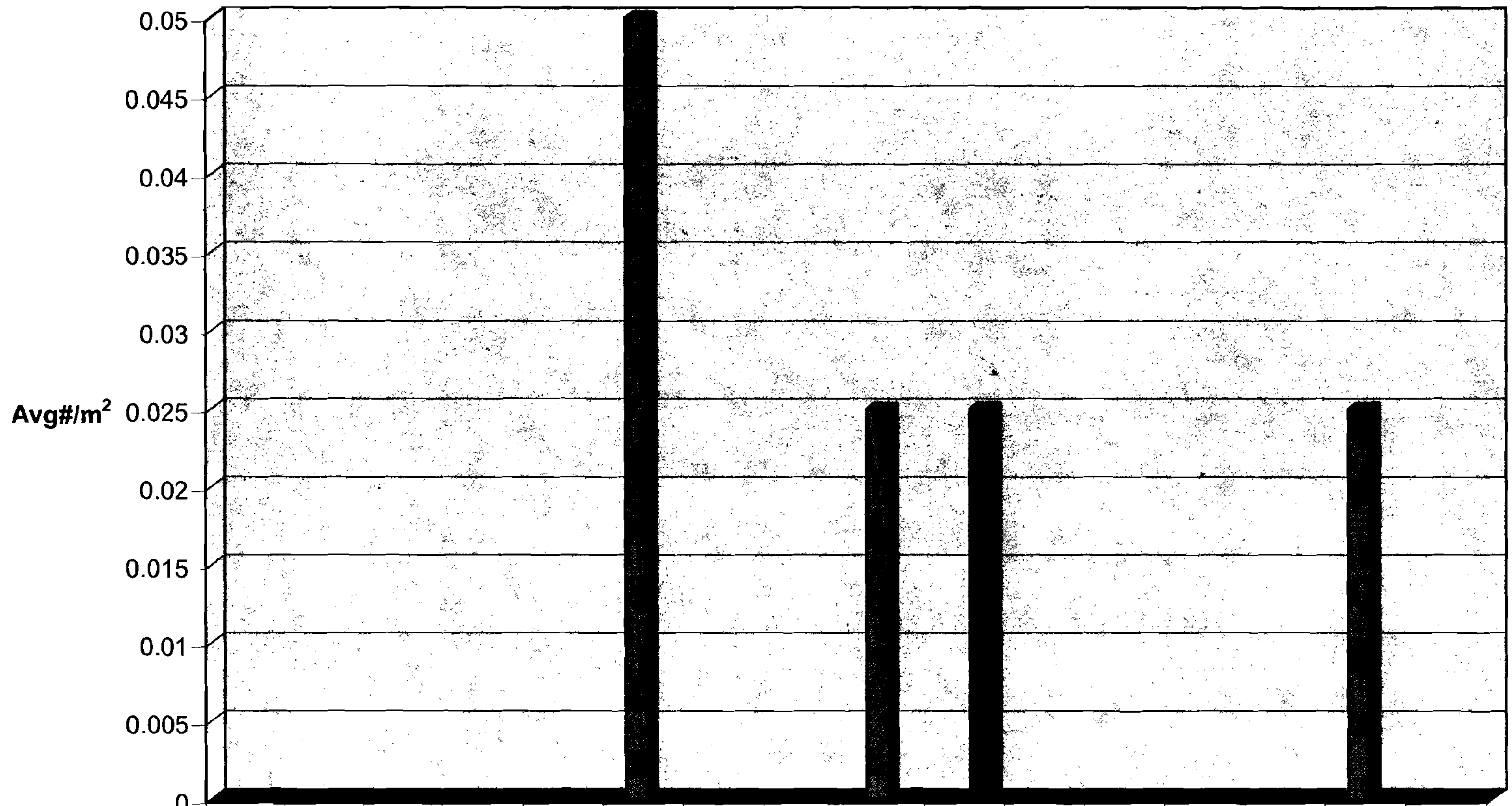
Gastropods [Trochus (Top Shell Snails) and Cypraea (Tiger Cowrie)]



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Trochus niloticus	0	0	0	0.025	0	0.175	0.025	0.05	0.1	0	0.1	0.05	0	0	0.05	0.025
Cypraea tigris	0	0	0	0.025	0.025	0	0	0	0	0	0	0.025	0	0.05	0	0

Appendix 1. Figure 2d. Abundance of Trochus and Cypraea - Average Number of Observations per Square Meter (avg#/m^2)

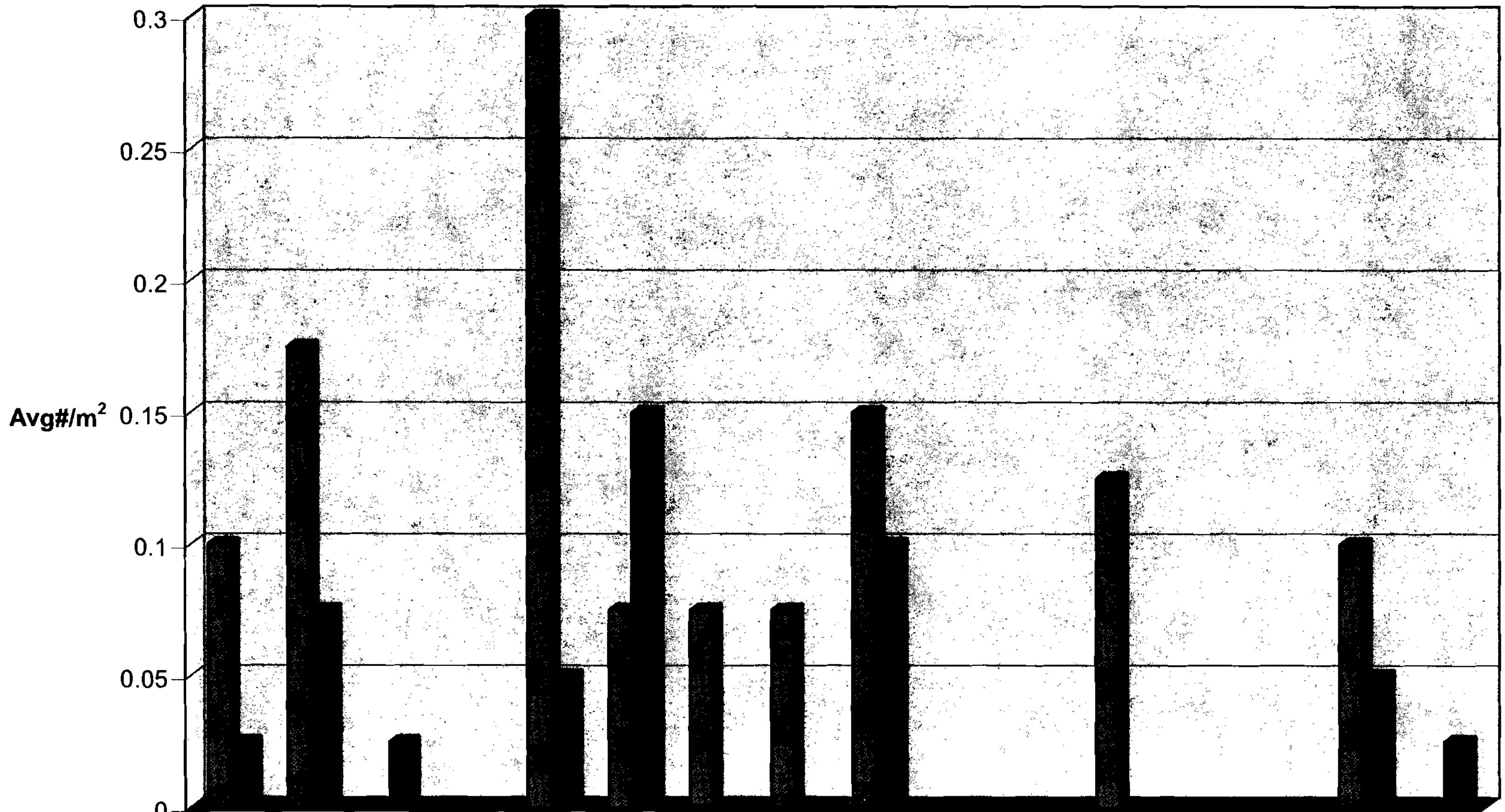
Asteroids (Corallivore Sea Star)



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Acanthaster planci	0	0	0	0	0	0.05	0	0	0.025	0	0	0	0	0	0.025	0
Culcita novaeguineae	0	0	0	0	0	0	0	0	0	0.025	0	0	0	0	0	0

Appendix 1. Figure 2e. Abundance of Acanthaster planci (Crown of Thorns) and Culcita novaeguineae (Pin Cushion) Sea Stars - Average Number of Observations per Square Meter (avg#/m^2)

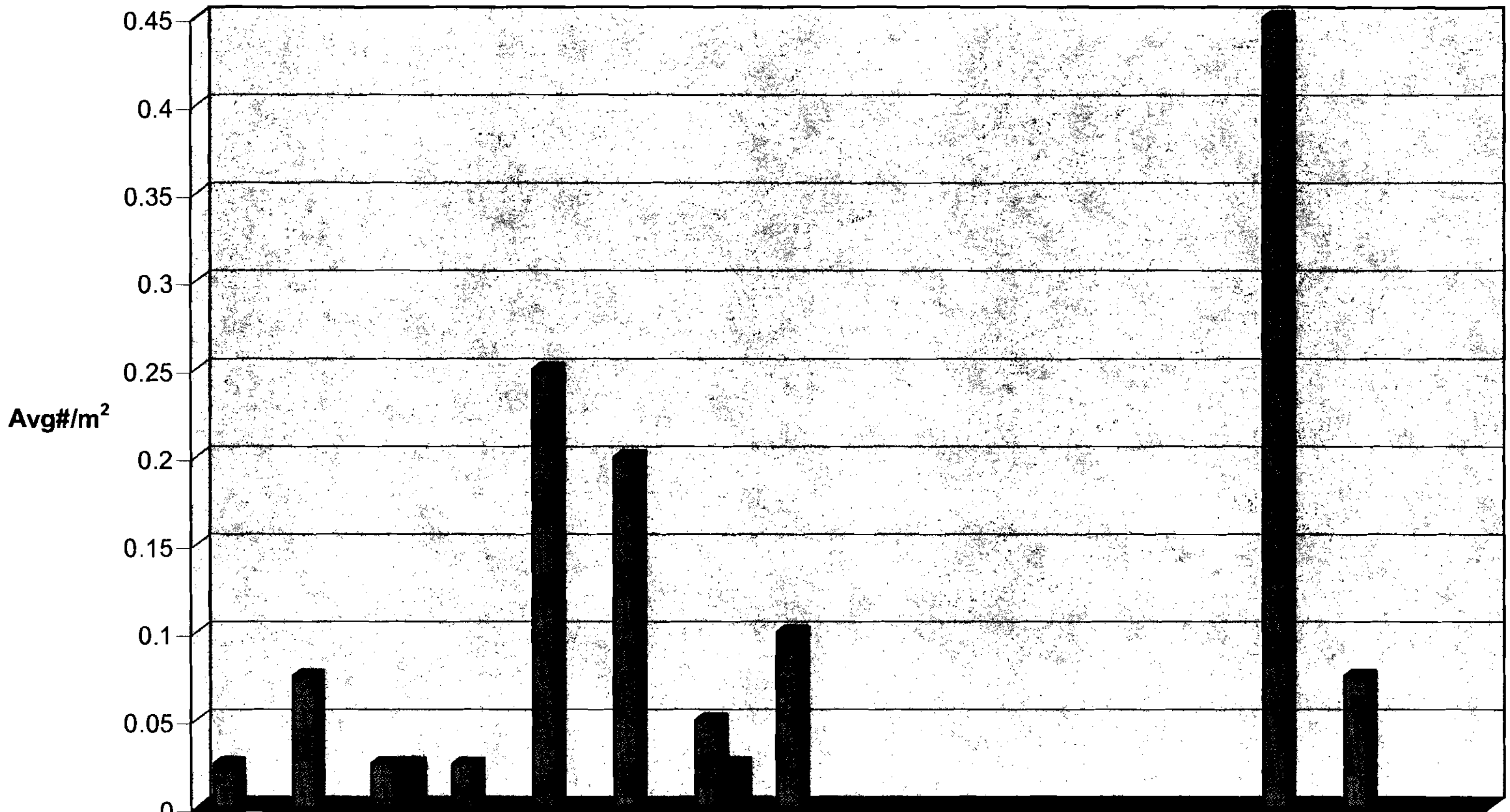
Asteroids (Multi-pore and Blue Sea Stars)



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Linckia multifora	0.1	0.175	0	0	0.3	0.075	0.075	0.075	0.15	0	0	0.125	0	0	0.1	0
L. laevigata	0.025	0.075	0.025	0	0.05	0.15	0	0	0.1	0	0	0	0	0	0.05	0.025

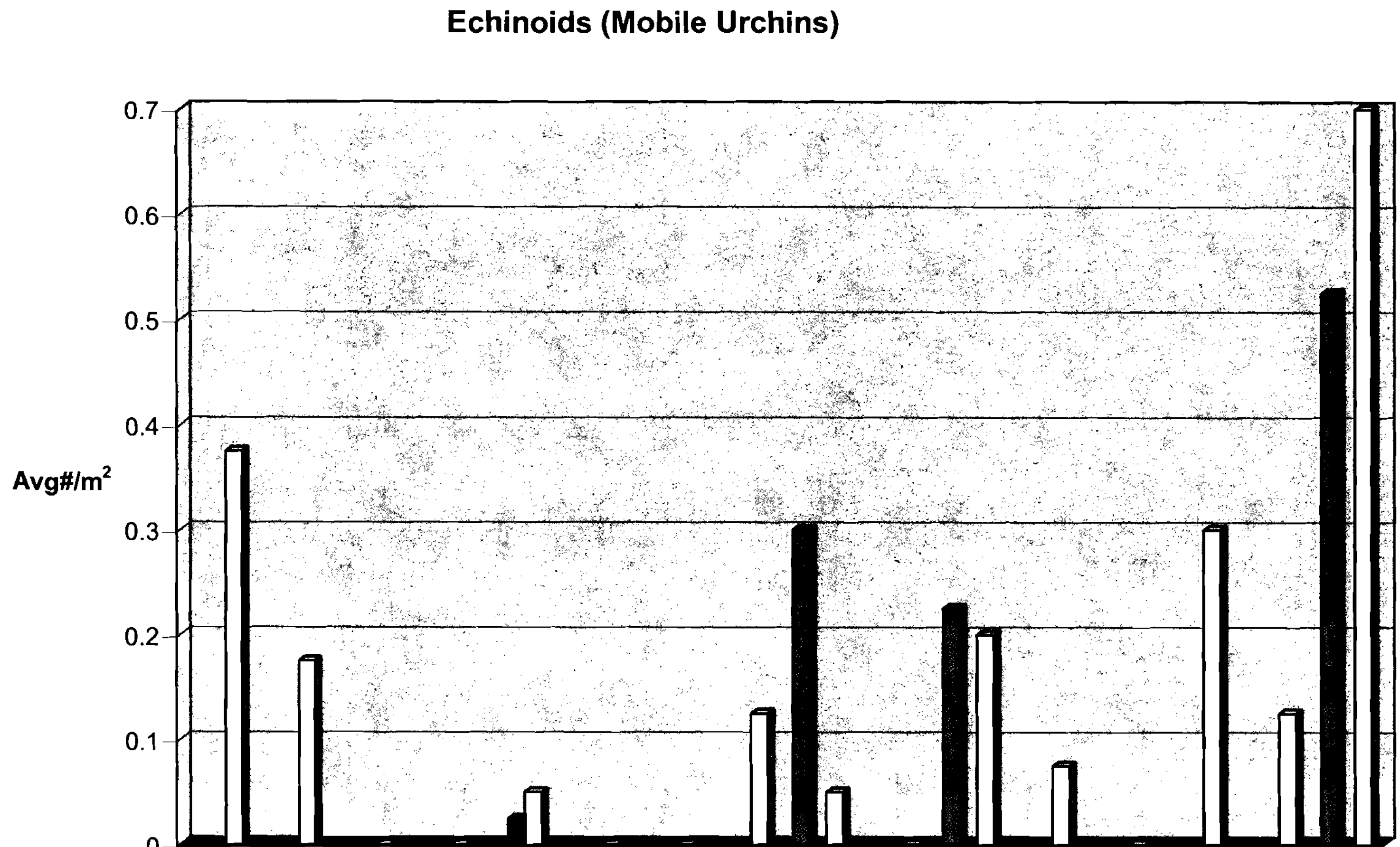
Appendix 1. Figure 2f. Abundance of Linckia - Average Number of Observations per Square Meter (avg#/m^2)

Asteroids (Bali Red and Thousand Pores Sea Star)



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Echinaster luzonicus	0.025	0.075	0.025	0.025	0.25	0.2	0.05	0.1	0	0	0	0	0	0.45	0.075	0
Fromia milleporella	0	0	0.025	0	0	0	0.025	0	0	0	0	0	0	0	0	0

Appendix 1. Figure 2g. Abundance of Echinaster and Fromia (Sea Stars) - Average Number of Observations per Square Meter (avg#/m^2)



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Echinothrix calamaris	0	0	0	0	0	0	0	0	0.3	0	0.225	0	0	0	0	0.525
E. diadema	0	0	0	0	0.025	0	0	0	0	0	0	0	0	0	0	0
Diadema setosum	0.375	0.175	0	0	0.05	0	0	0.125	0.05	0	0.2	0.075	0	0.3	0.125	0.7

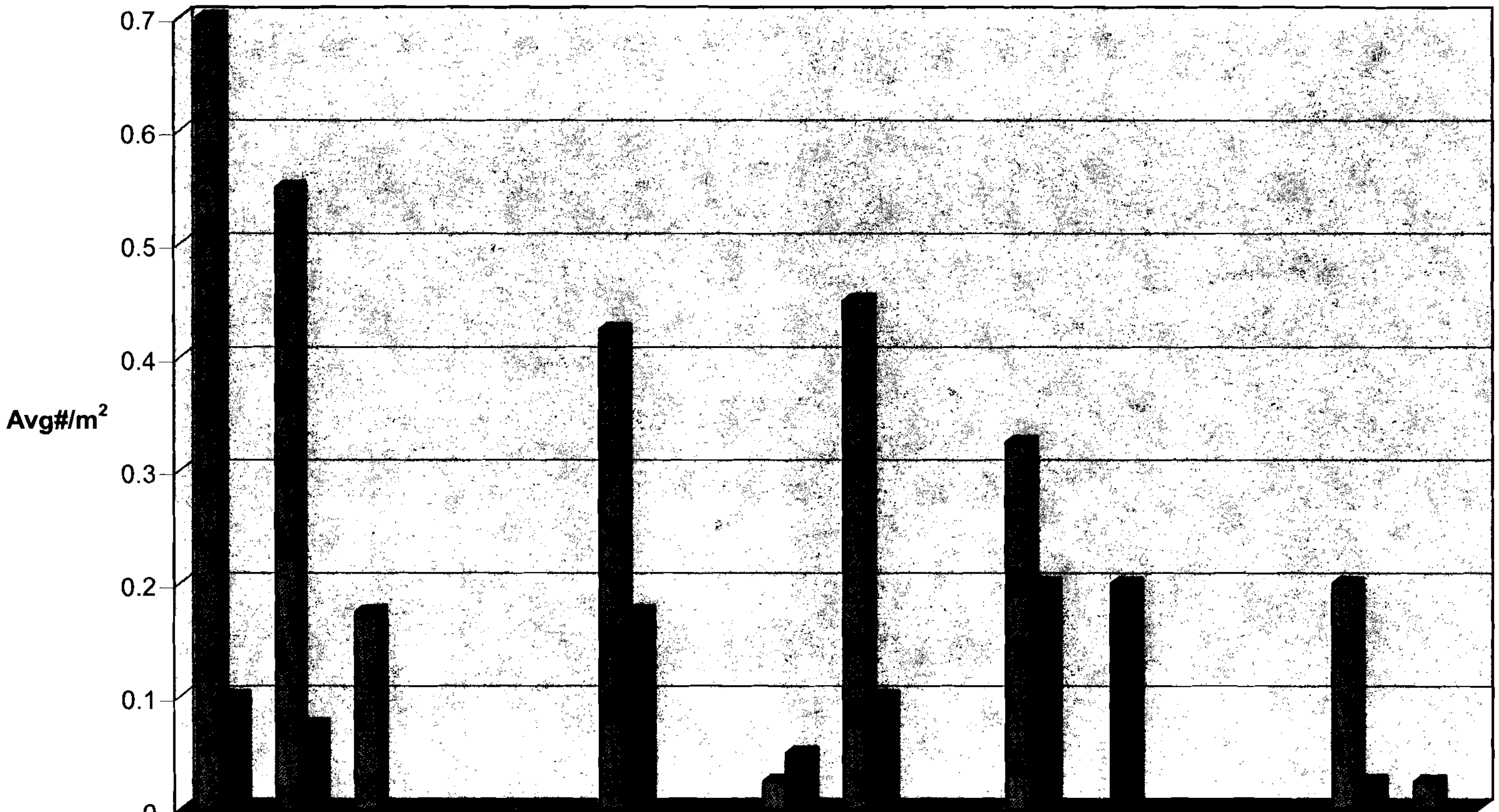
Appendix 1. Figure 2h. Abundance of Echinothrix and Diadema - Average Number of Observations per Square Meter (avg#/m^2)

Echinoids (Secretive Urchins)

	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Eucidaris metularia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.075
Heterocentrotus mammillatus	0	0	0	0	0	0	0	0	0	0	0.025	0	0	0	0	0

Appendix 1. Figure 2i. Abundance of Eucidaris and Heterocentrotus - Average Number of Observations per Square Meter (avg#/m²)

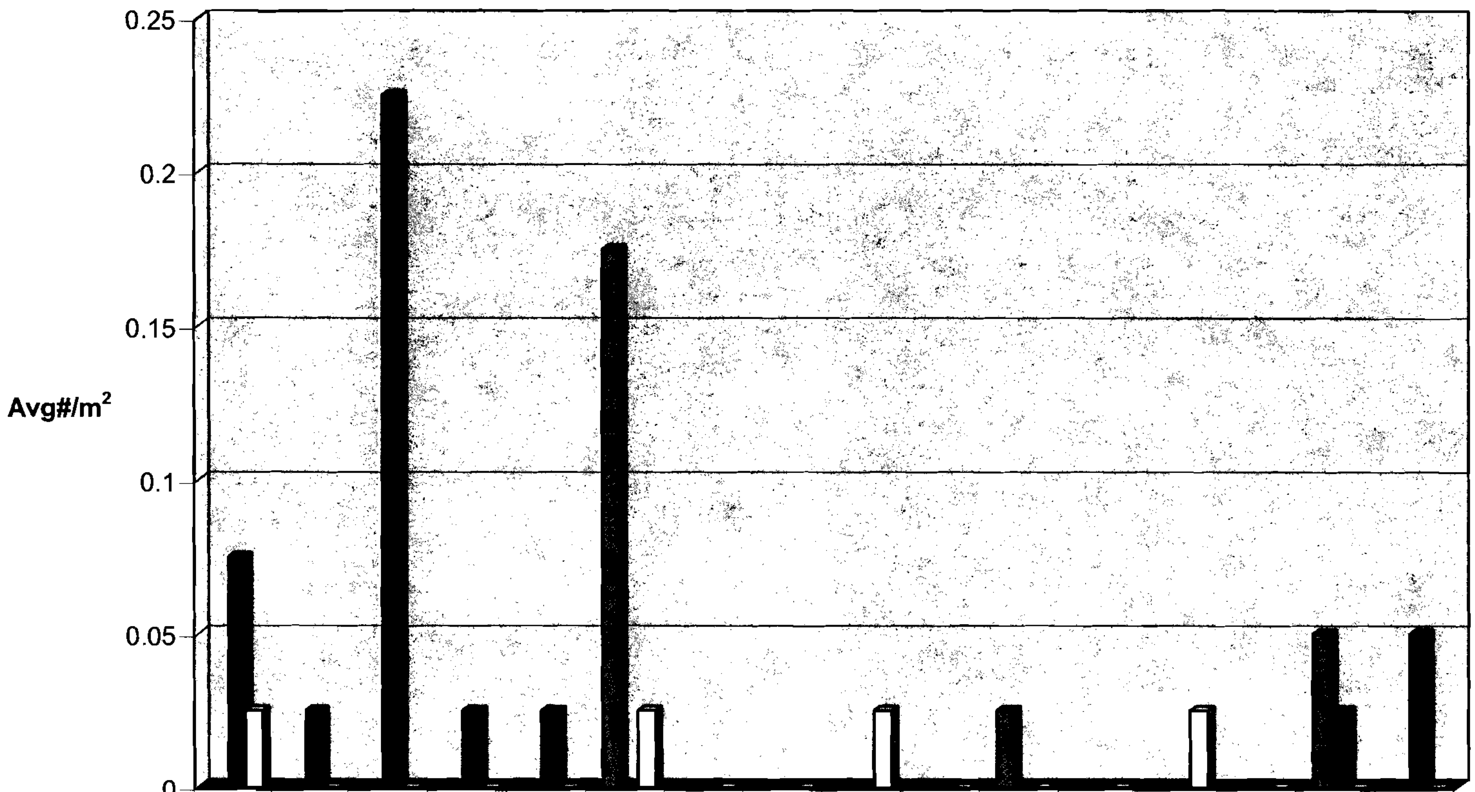
Echinoids (Boring Urchins)



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Echinostrephus acciculatus	0.7	0.55	0.175	0	0	0.425	0	0.025	0.45	0	0.325	0	0	0	0.2	0.025
Echinometra mathaei	0.1	0.075	0	0	0	0.175	0	0.05	0.1	0	0.2	0.2	0	0	0.025	0

Appendix 1. Figure 2j. Abundance of Echinostrephus and Echinometra - Average Number of Observations per Square Meter (avg#/m^2)

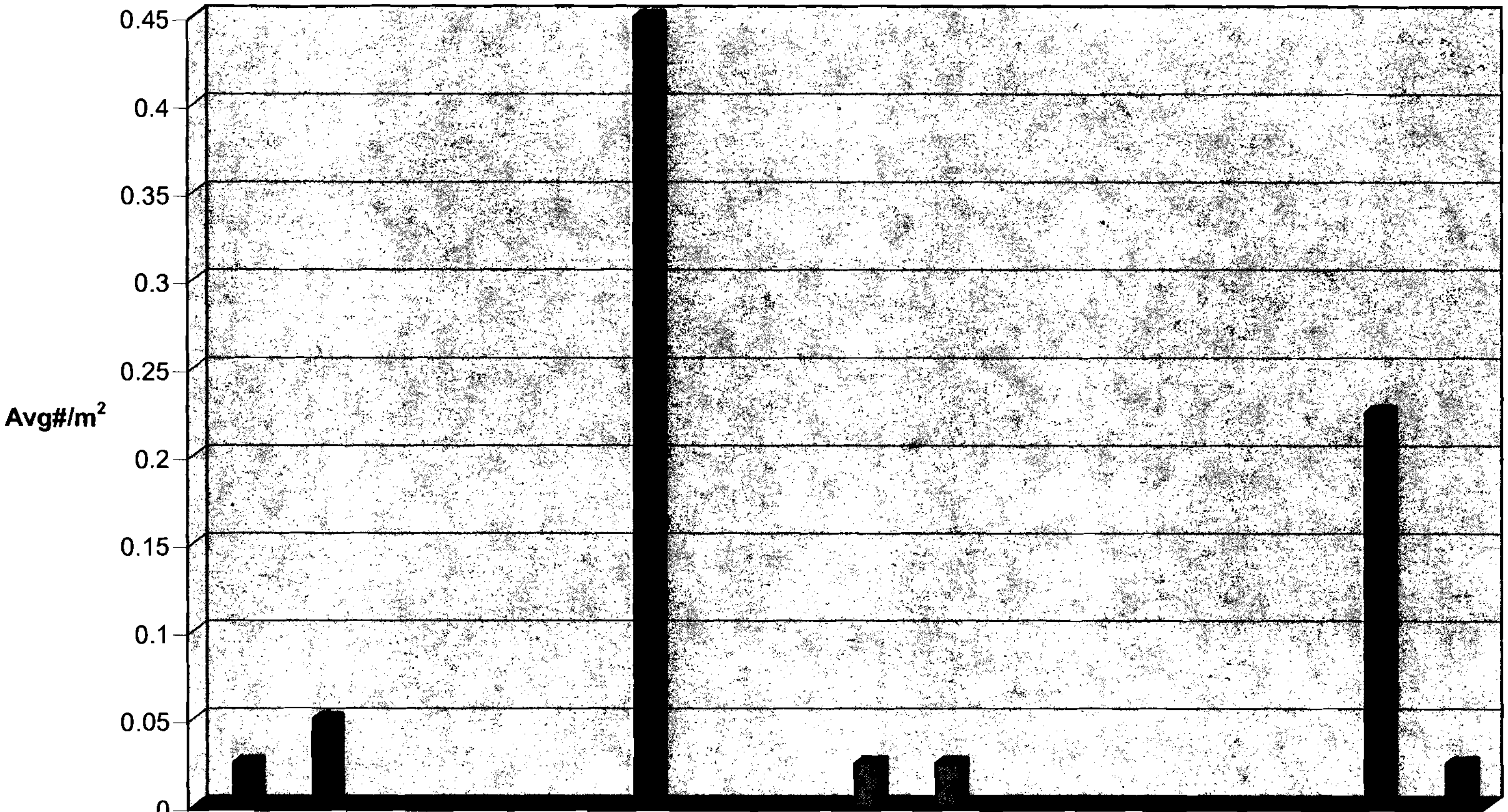
Holothuroids (Mauritian, Eyed, and Brown Sandfish Sea Cucumbers)



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Actinopyga mauritiana	0	0	0	0	0	0.175	0	0	0	0	0.025	0	0	0	0.05	0
Bohadschia argus	0.075	0.025	0.225	0.025	0.025	0	0	0	0	0	0	0	0	0	0.025	0.05
B. vitiensis	0.025	0	0	0	0	0.025	0	0	0.025	0	0	0	0.025	0	0	0

Appendix 1. Figure 2k. Abundance of Actinopyga and Bohadschia - Average Number of Observations per Square Meter (avg#/m^2)

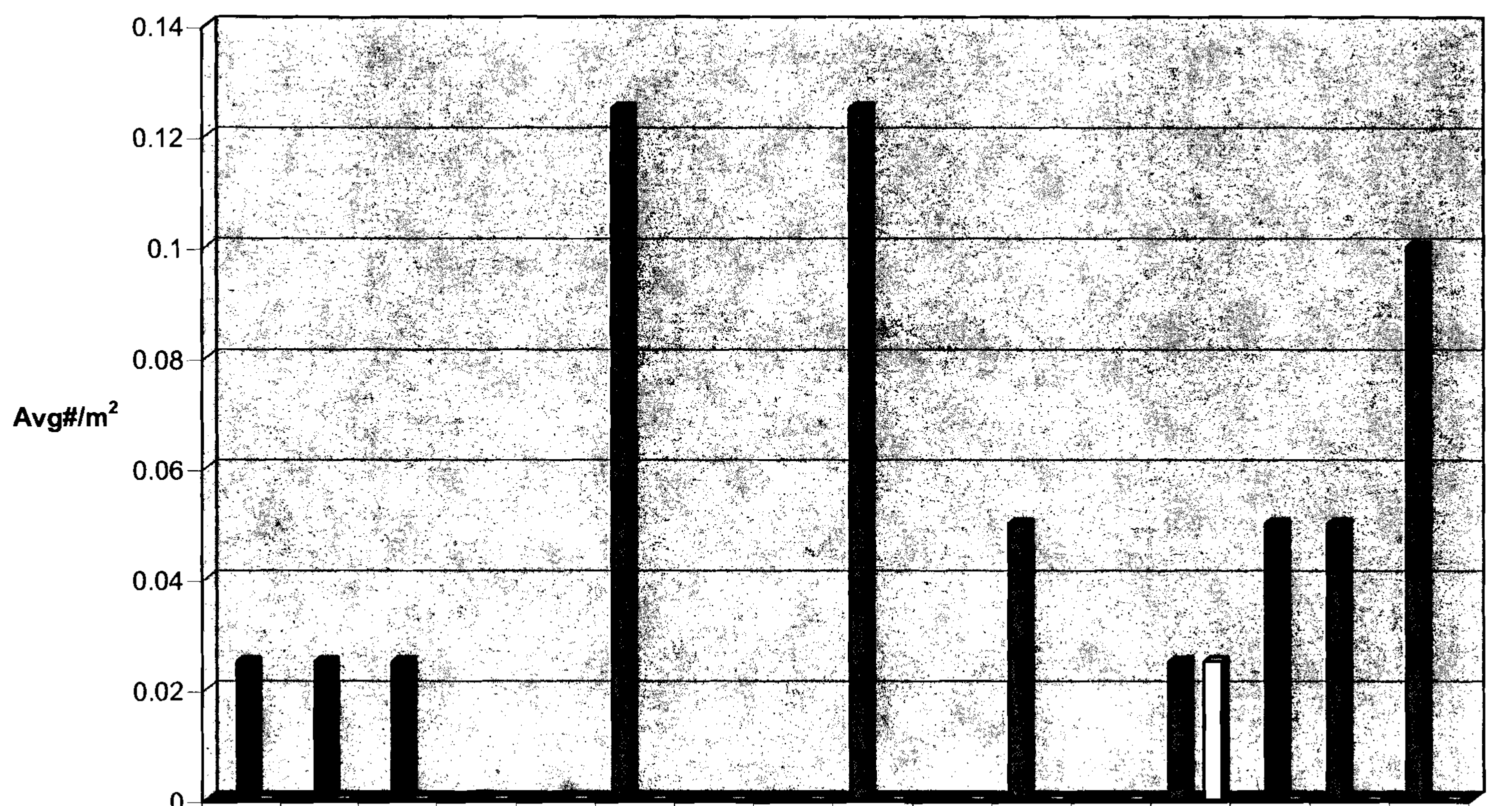
Holothuroids (Pineapple and Dark Green Sea Cucumbers)



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Thelenota ananas	0	0	0	0	0	0	0	0	0.025	0.025	0	0	0	0	0	0
Stichopus chloronotus	0.025	0.05	0	0	0	0.45	0	0	0	0	0	0	0	0	0.225	0.025

Appendix 1. Figure 2I. Abundance of Thelenota and Stichopus - Average Number of Observations per Square Meter (avg#/m^2)

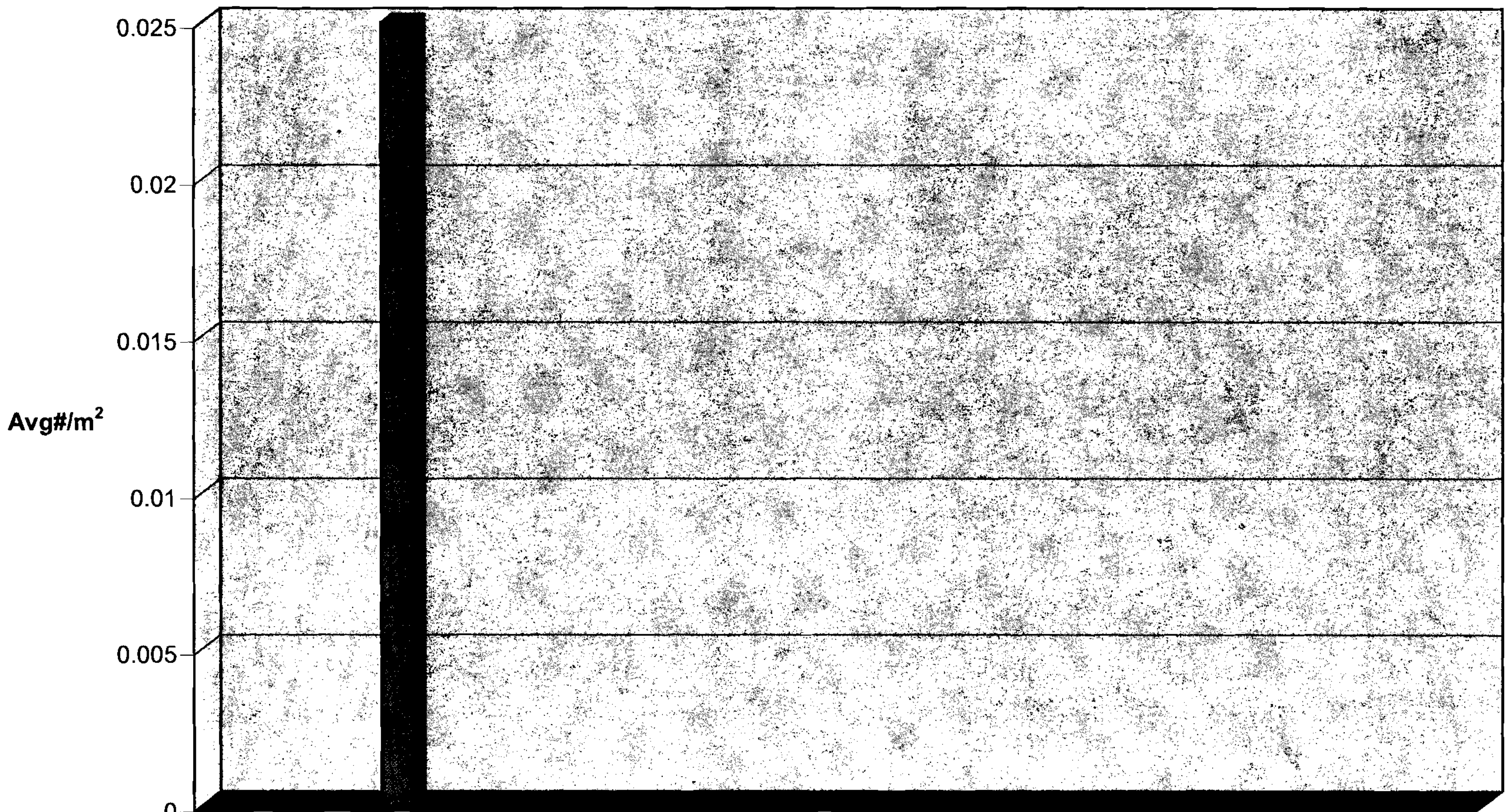
Holothuroids (Black, Black teatfish, and Edible Sea Cucumbers)



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Holothuria atra	0	0	0	0	0	0.125	0	0	0.125	0	0.05	0	0.025	0	0.05	0.1
H. whitmaei	0.025	0.025	0.025	0	0	0	0	0	0	0	0	0	0	0.05	0	0
H. edulis	0	0	0	0	0	0	0	0	0	0	0	0	0.025	0	0	0

Appendix 1. Figure 2m. Abundance of Holothurians - Average Number of Observations per Square Meter (avg#/m^2)

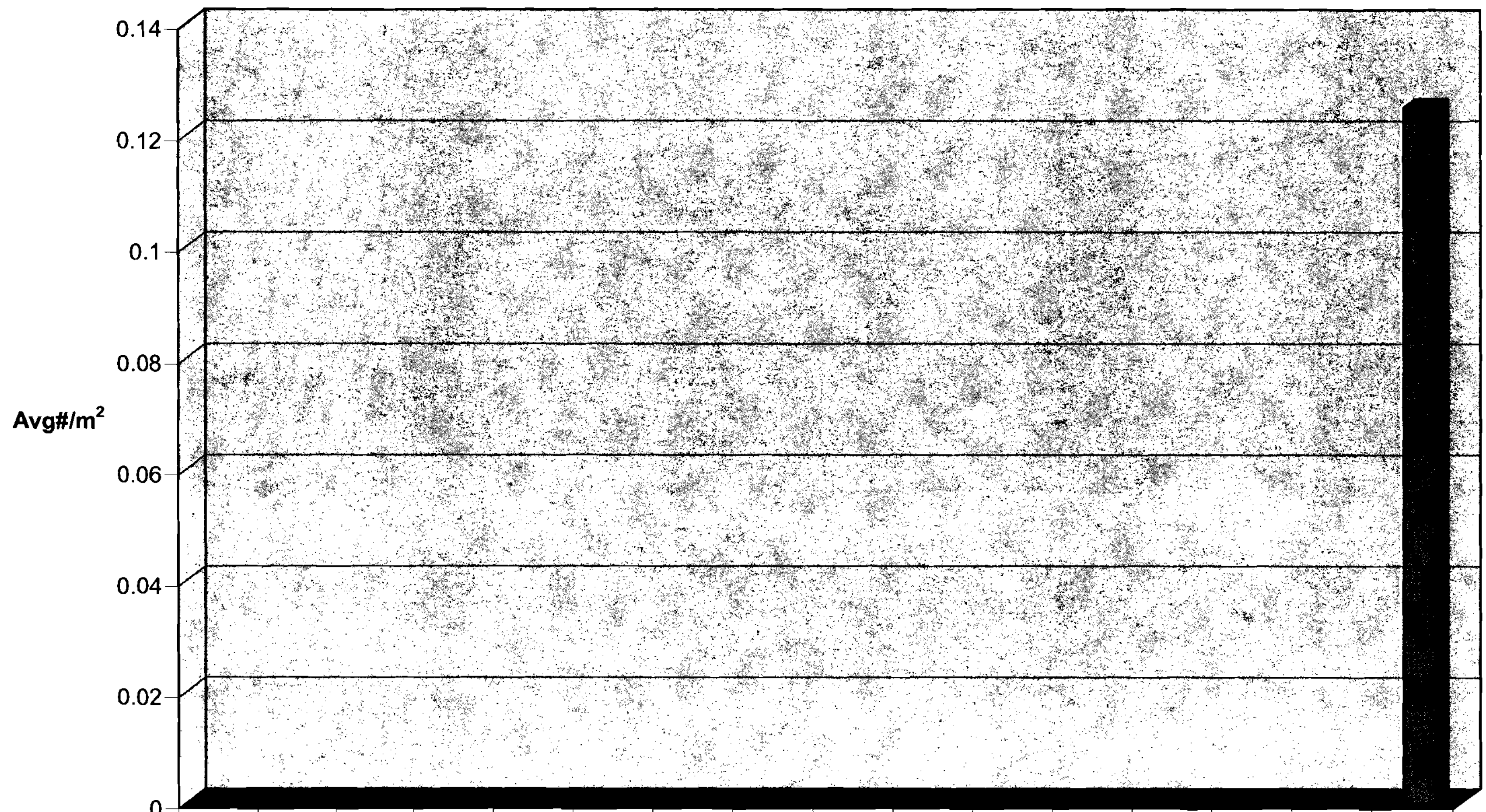
Holothuroid (Graeffe's Sea Cucumber)



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Pearsonothuria graeffei	0	0	0.025	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1. Figure 2n. Abundance of Pearsonothuria - Average Number of Observations per Square Meter ($avg\#/m^2$)

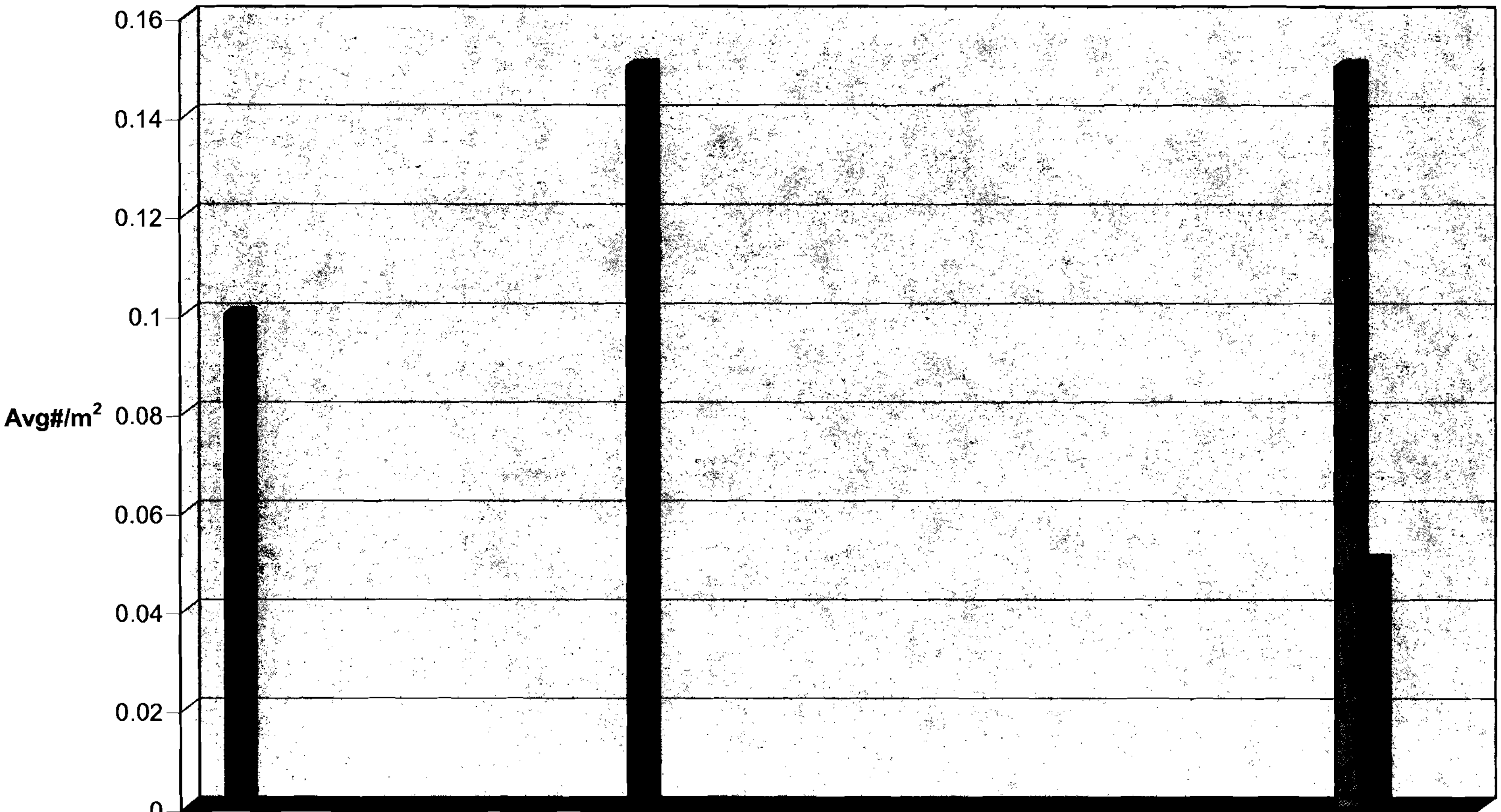
Holothuroid (Lion's Paw Sea Cucumber)



	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Euapta godeffroyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.125

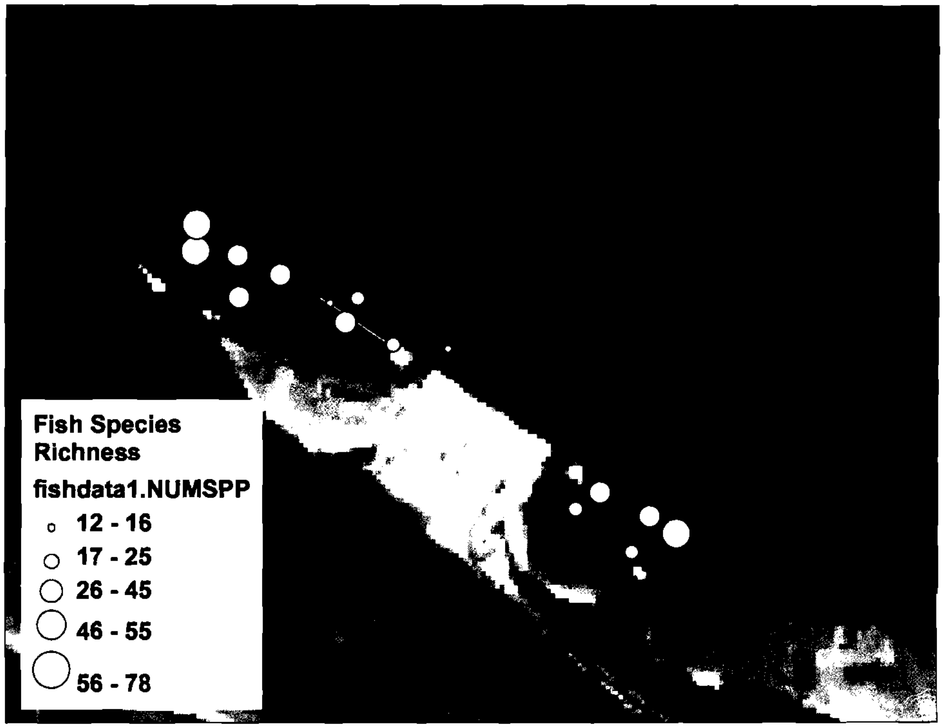
Appendix 1. Figure 2o. Abundance of Euapta - Average Number of Observations per Square Meter (avg#/m^2)

Crustacea (Rusty and Red Spotted Guard Crabs)

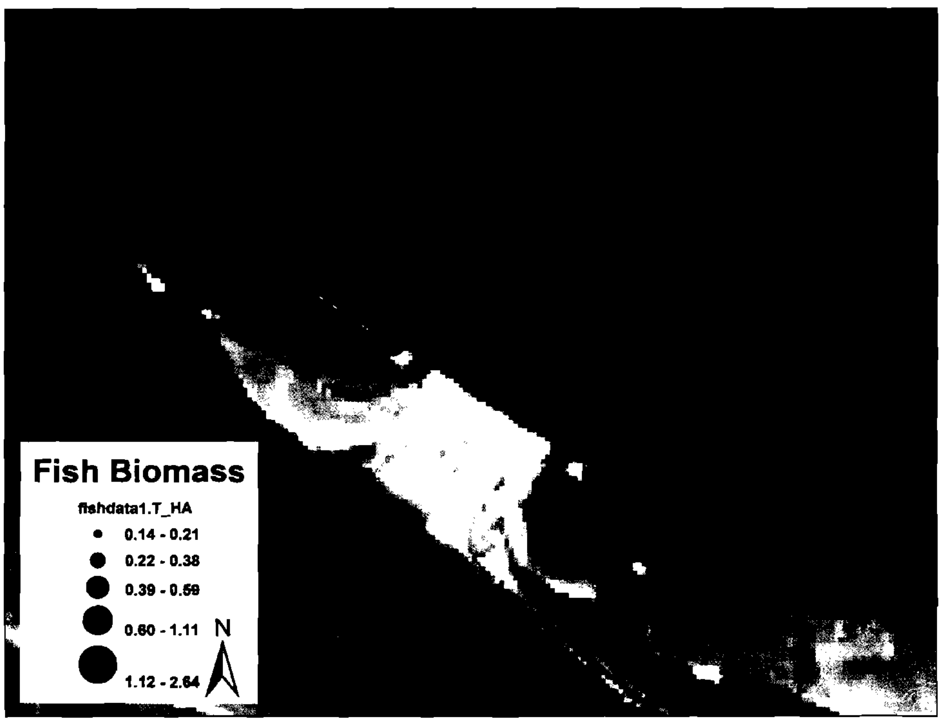


	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14	D 15	D 16
Trapezia rufopunctata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.15	0
Trapezia ferruginea	0.1	0	0	0	0	0.15	0	0	0	0	0	0	0	0	0.05	0

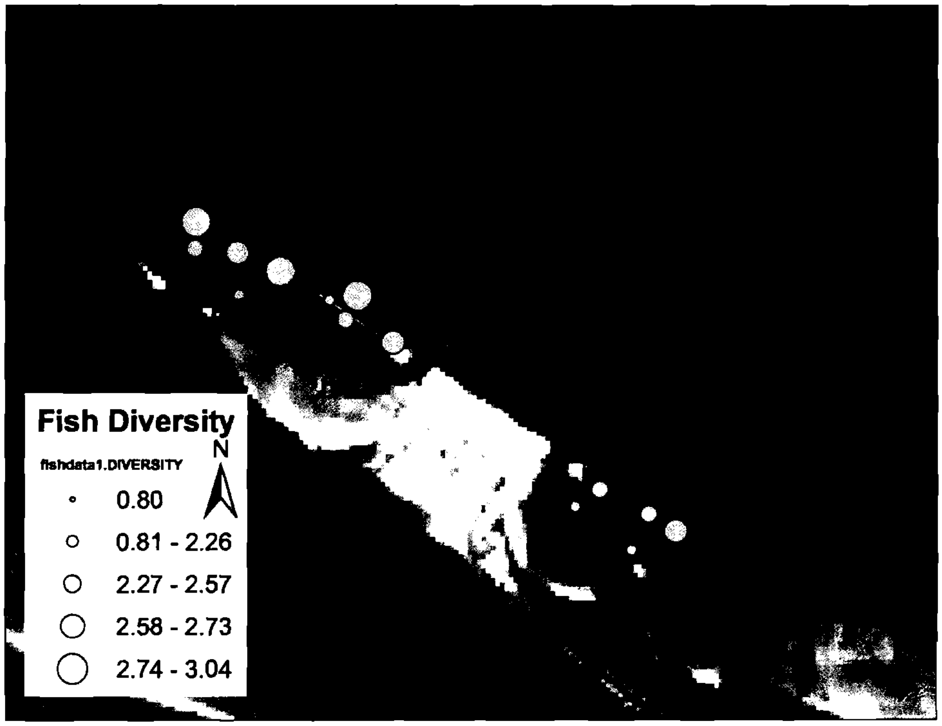
Appendix 1. Figure 2p. Abundance of Trapezia - Average Number of Observations per Square Meter (avg#m^2)



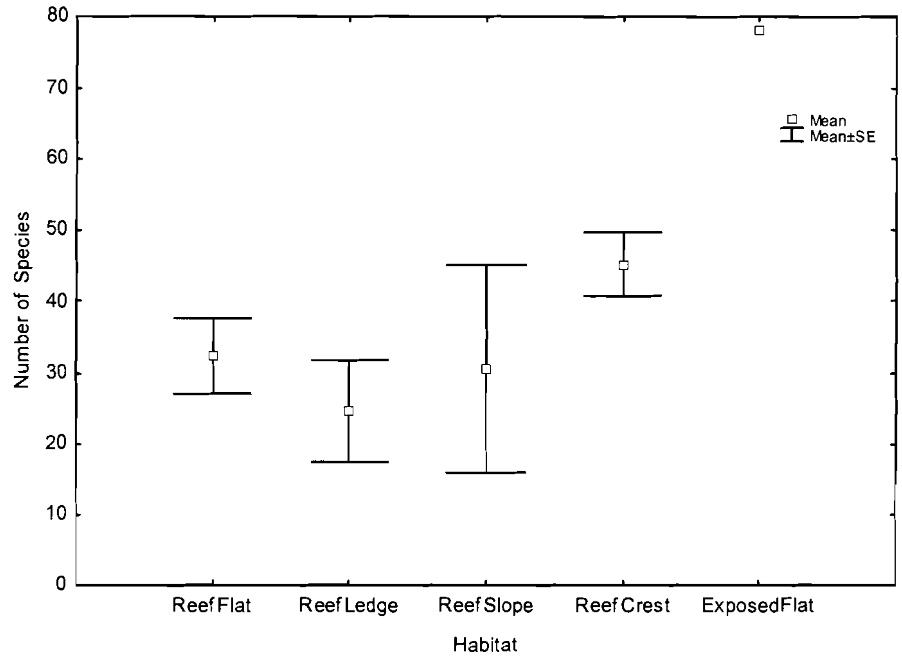
Appendix 1. Figure 3a. Fish species richness observed during roving diver surveys, Kilo Wharf, Guam.



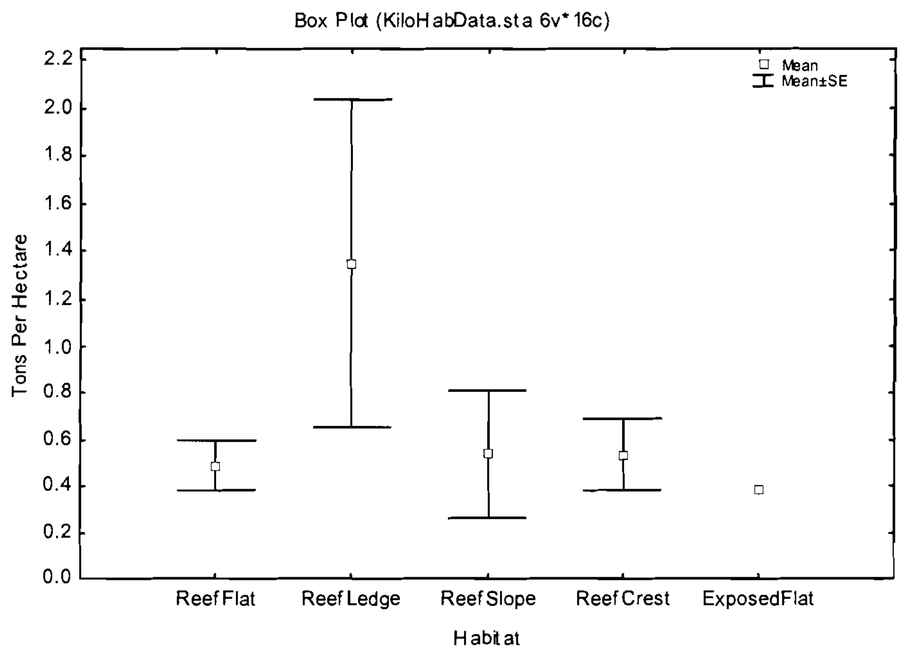
Appendix 1. Figure 3b. Fish biomass observed on belt transect surveys, Kilo Wharf, Guam.



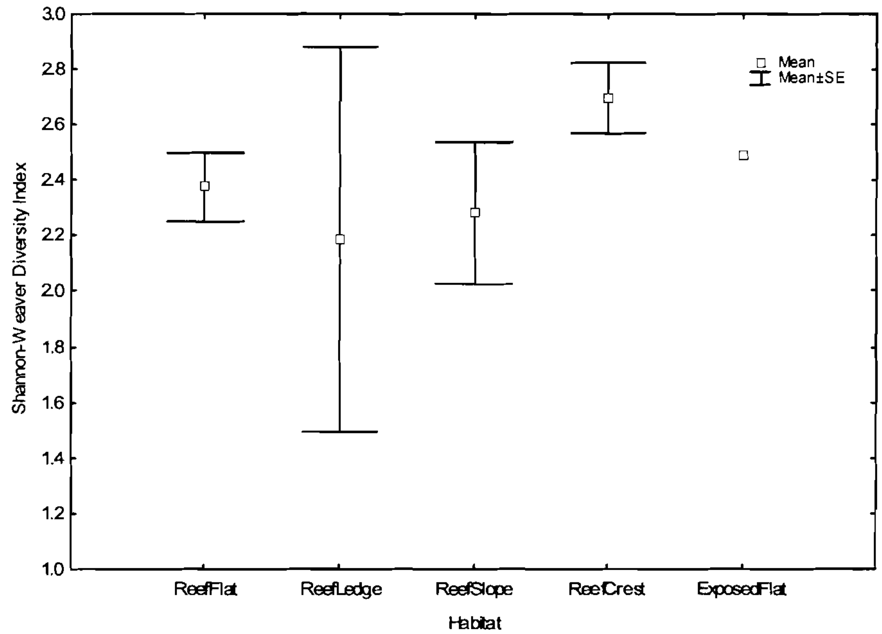
Appendix 1. Figure 3c. Fish diversity (Shannon-Weaver H`) observed on belt transect surveys, Kilo Wharf, Guam.



Appendix 1. Figure 3d. Mean species richness of fish species observed during roving diver surveys. Error bars represent standard error of the mean. (Reef flat n = 6; reef ledge n = 3; reef slope n = 2; reef crest = 4; exposed flat n = 1.)



Appendix 1. Figure 3e. Mean biomass of fish observed during belt transect surveys. Error bars represent standard error of the mean. (Reef flat n = 6; reef ledge n = 3; reef slope n = 2; reef crest = 4; exposed flat n = 1.)



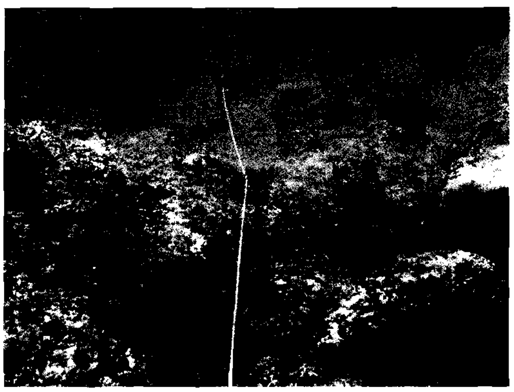
Appendix 1. Figure 3f. Diversity of fish species observed during belt transect surveys. Error bars represent standard error of the mean. (Reef flat n = 6; reef ledge n = 3; reef slope n = 2; reef crest = 4; exposed flat n = 1.)

APPENDIX 2

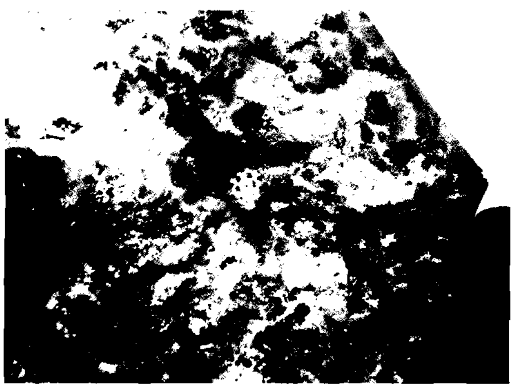
Appendix 2a. Photo sequence for marine survey station 1


Codium sp (Green Algae)


Pocillopora sp (Coral)


Low Relief Habitat


Crevices and Small Boulders


Green Algae and Snail


Sand and Green Algae

Appendix 2a. Continued

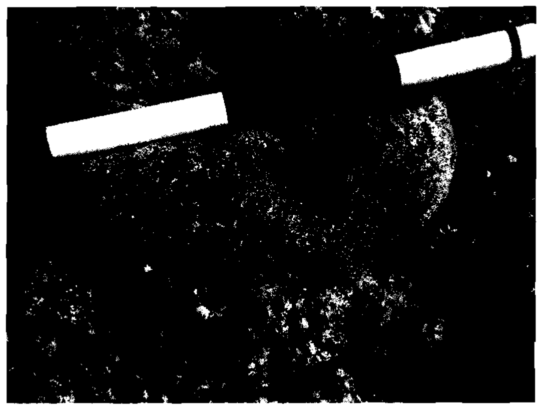
Low Relief Benthic Substrate

Appendix 2b. Photo sequence for marine survey station 2

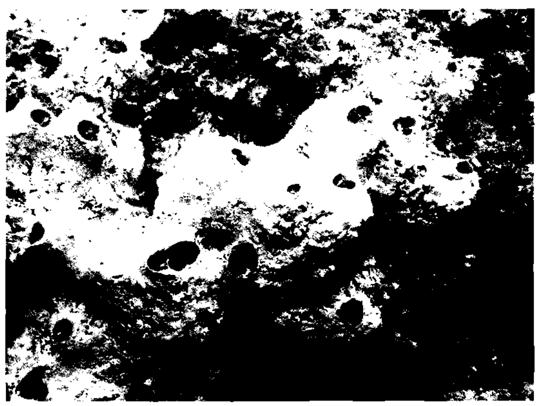

Echinaster luzonicus (Sea Star)


Stylotella aurantium (Sponge)

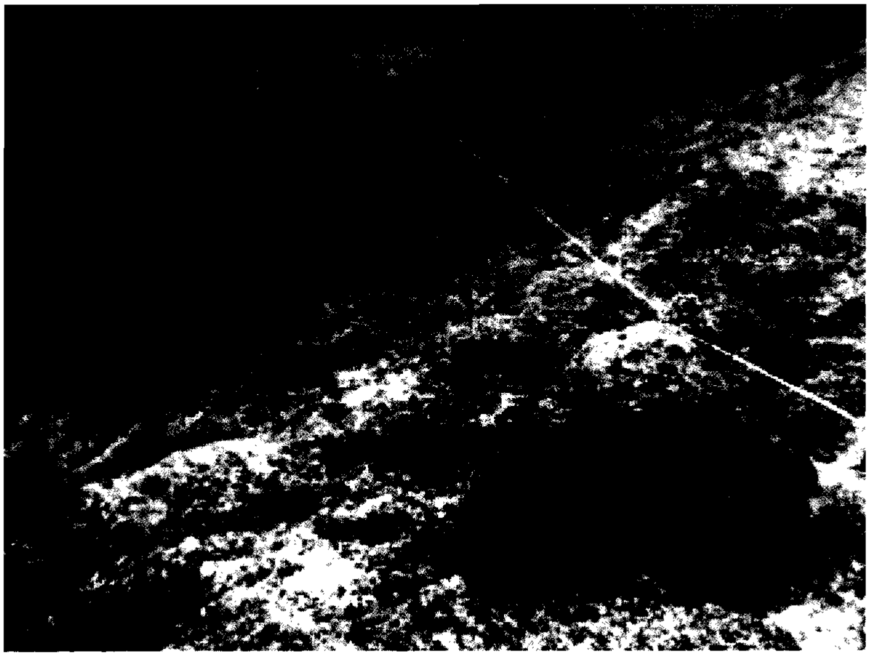

Phidiana indica (Nudibranch)


Holothuria whitmae (Sea Cucumber)


Vasum ceramicum (Snail)

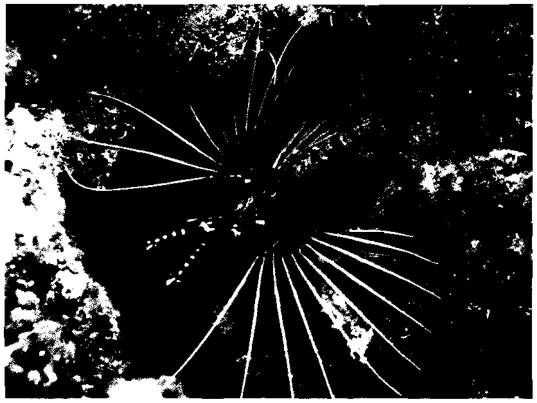

Liosina granulose (Sponge)

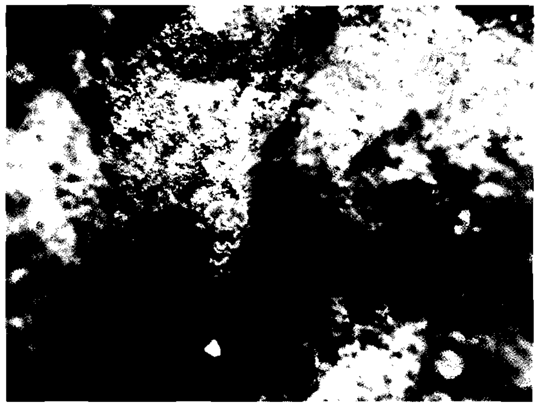
Appendix 2b. Continued



Low Reliefe Benthic Substrate

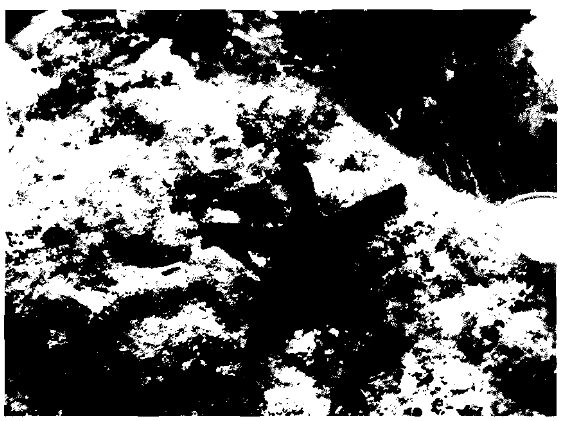
Appendix 2c. Photo sequence for marine survey 3

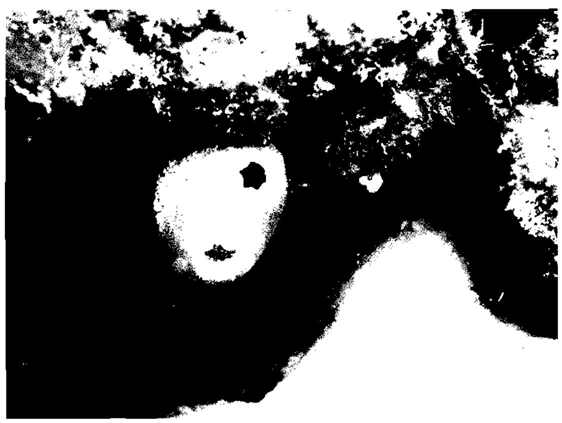

Pterois antennata (Lion Fish)


Glossodoris symmerticus (Nudibranch)

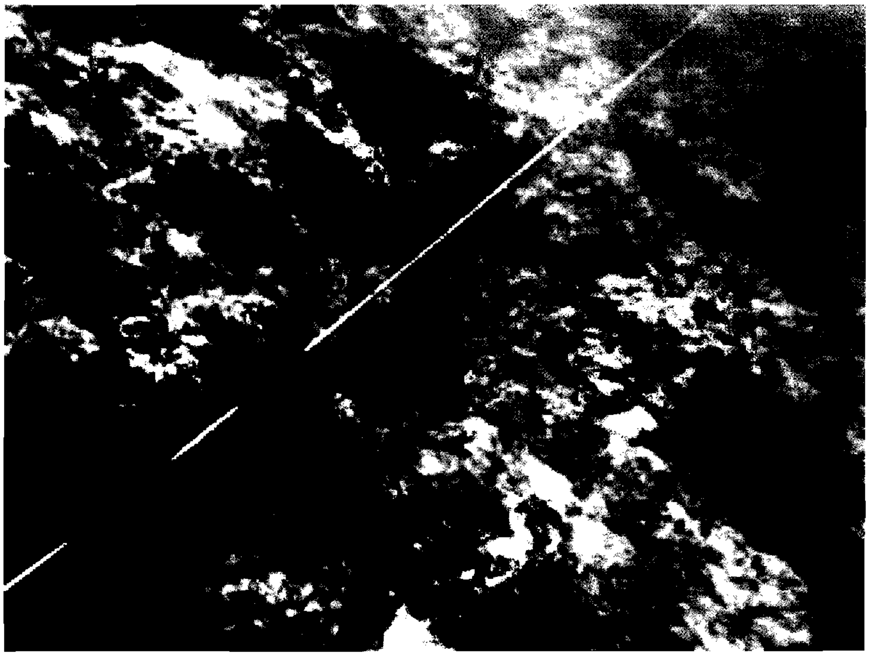

Pearsonothuria graeffei (Sea Cucumber)


Bohadschia argus (Sea Cucumber)


Fromia milleporella (Sea Star)

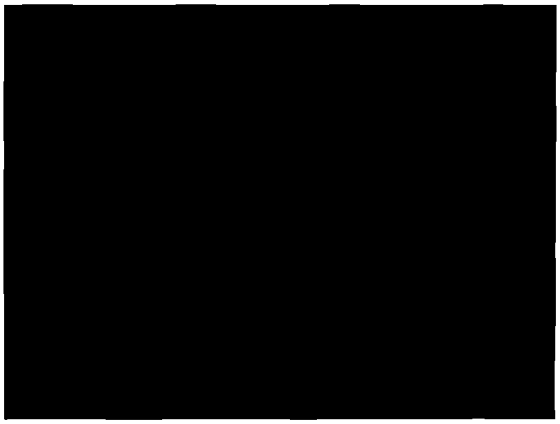

Rhopalaea crassa (Sea Squirt)

Appendix 2c. Continued

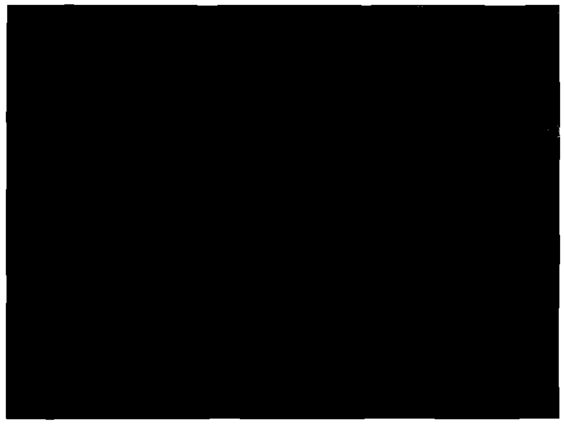


Reef Slope Habitat (Calcareous Green Algae – *Halimeda* sp)

Appendix 2d. Photo sequence for marine survey station 4

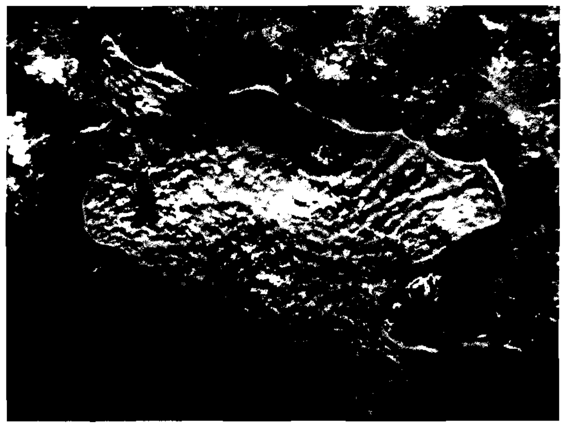


Meloplus isis (Sponge)

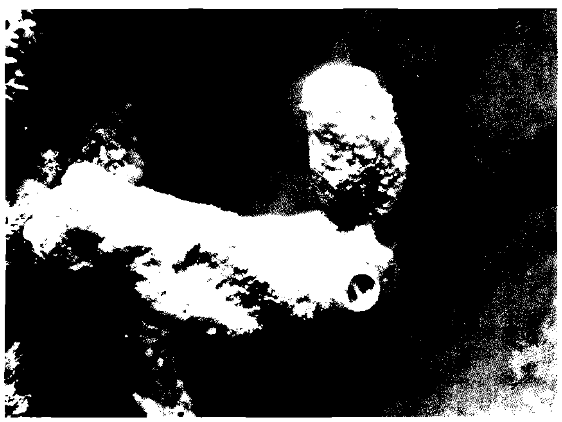


Didemnum molle (Sea Squirt)

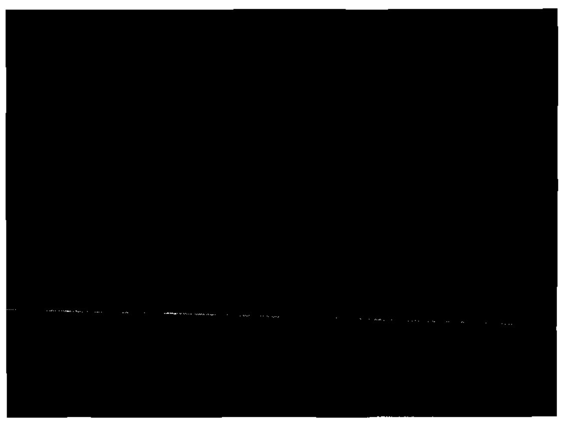
Cypraea tigris (Tiger Cowry)



Plakina sp (Encrusting Sponge)

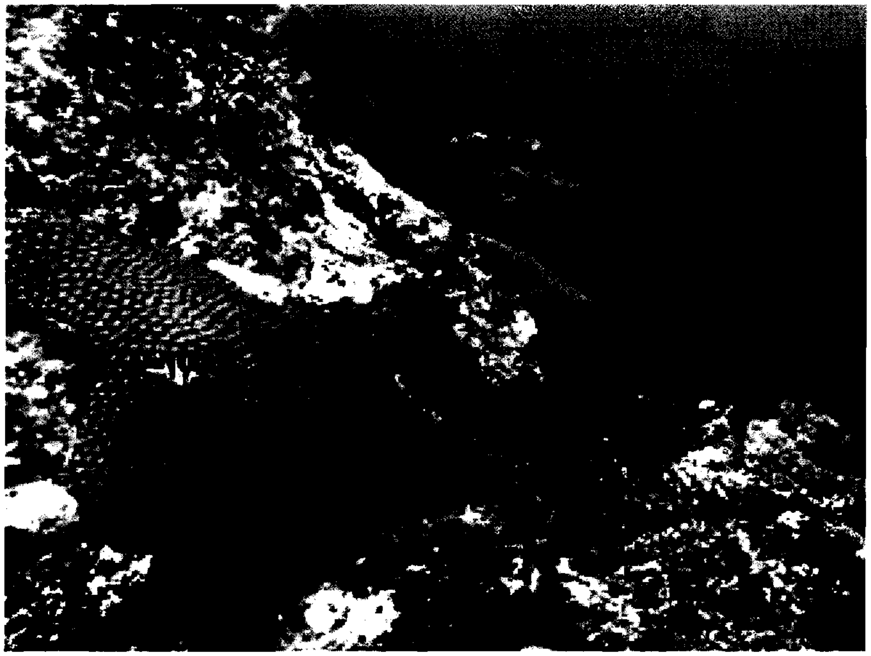


Stylotella aurantium (Sponge)



Halimeda sp meadow (Green Algae)

Appendix 2d. Continued



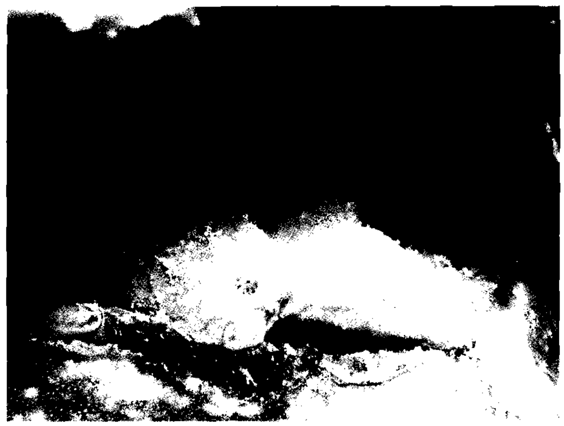
Reef Slope Habitat

Appendix 2e. Photo sequence for marine survey station 5

Porites rus (Coral)

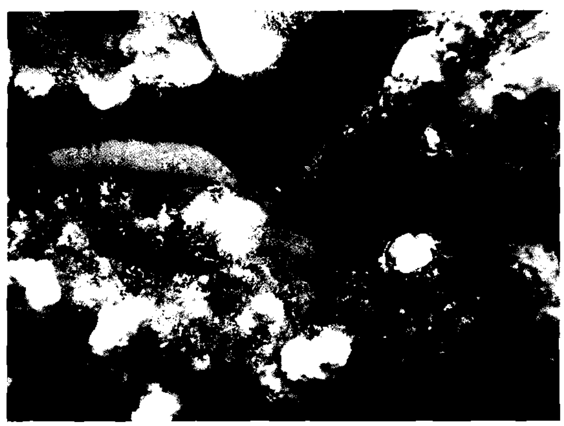
Porites rus (Coral)

Synanceia verrucosa (Stone Fish)



Adocia sp (Sponge)

Porites rus (Coral) and *Halimeda* sp (Algae)



Linckia laevigata (Sea Star)

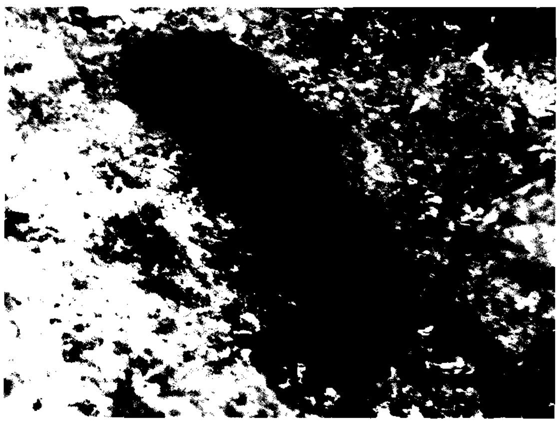
Appendix 2e. Continued

Sunken Reef Crest/Slope Habitat

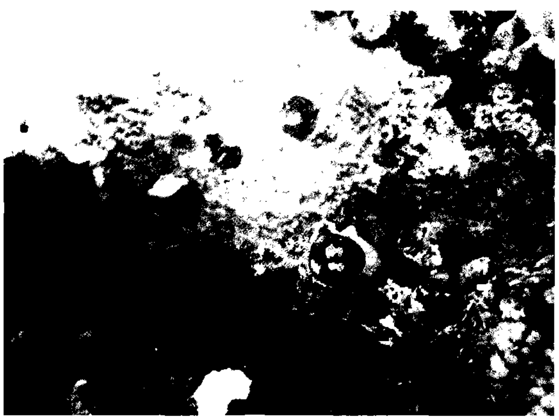
Appendix 2f. Photo sequence for marine survey 6


Tridacna maxima (Giant Clam)


Actinopyga mauritiana (Sea Cucumber)

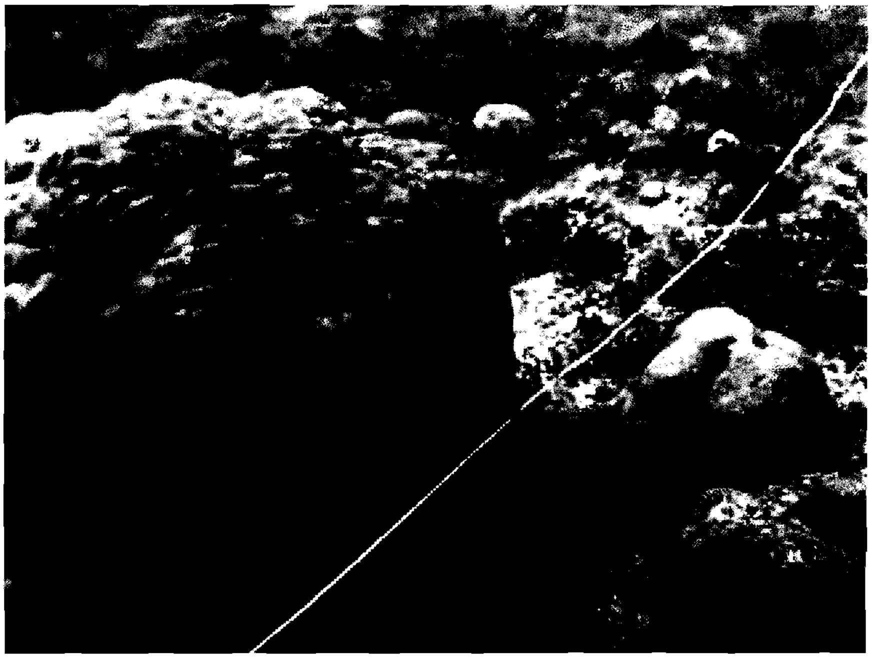

Stichopus chloronotus (Sea Cucumber)


Porites lobata (Coral)

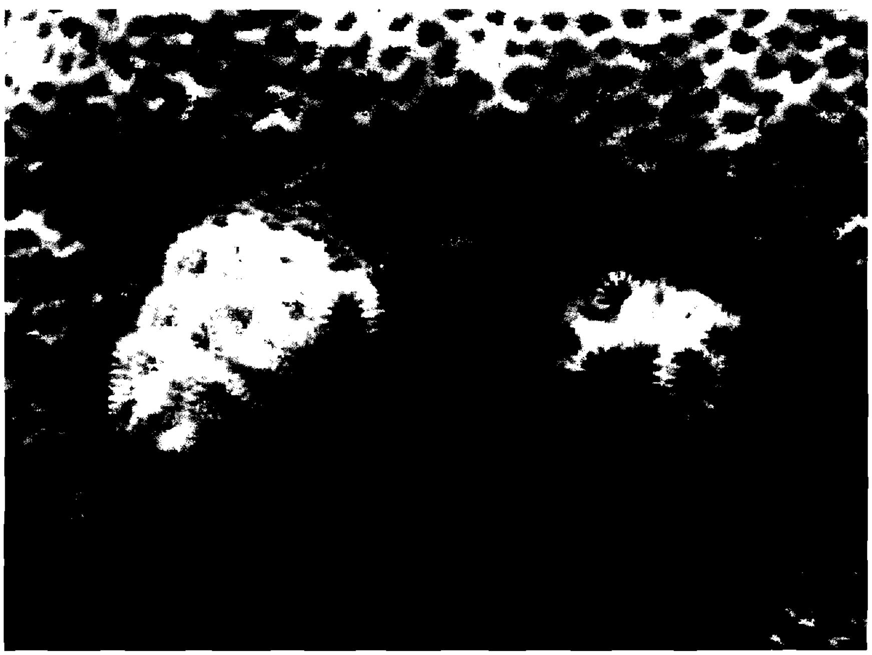

Serpulorbis sp (Vermetid Snails)


Cypraea goodlalii (Cowry Shell)

Appendix 2f. Continued



Reef flat

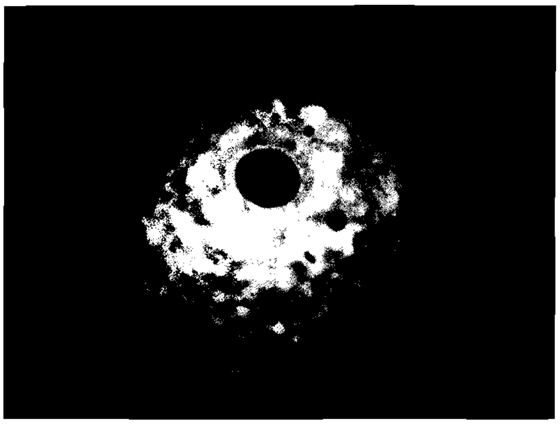


Goniastrea growth anomaly, *G. edwardsii*

Appendix 2g. Photo sequence for marine survey station 7

Pellina sp (Sponge)

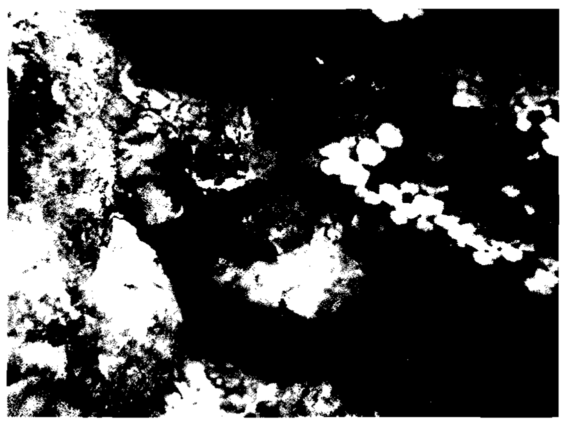
Coralliophila violacea (Snail)



Melophlus isis (Sponge)

Porites rus (Coral)

Porites rus (Coral)

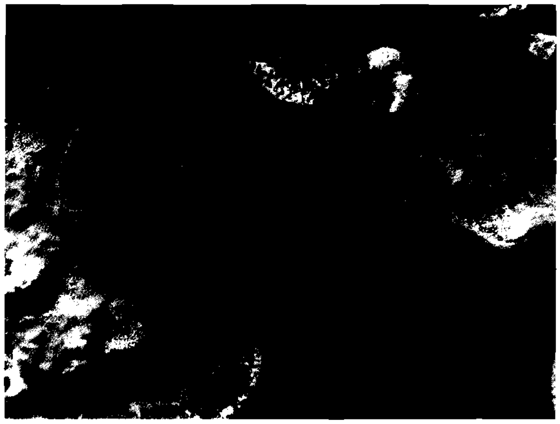


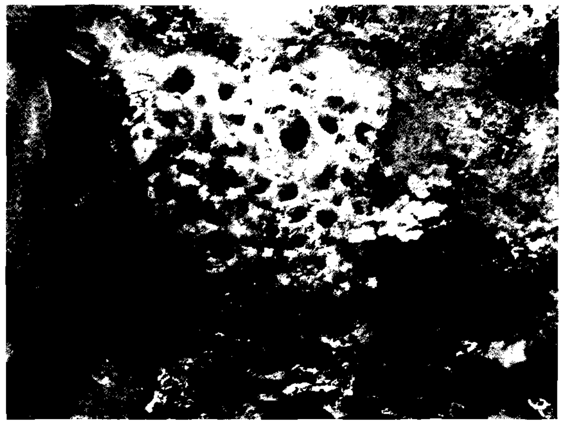
Fromia milleporella (Sea Star)

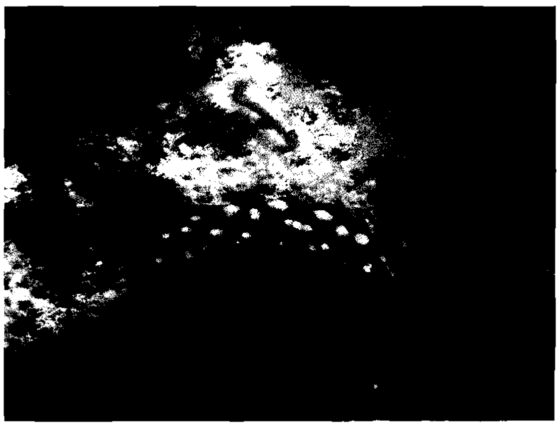
Appendix 2g. Continued

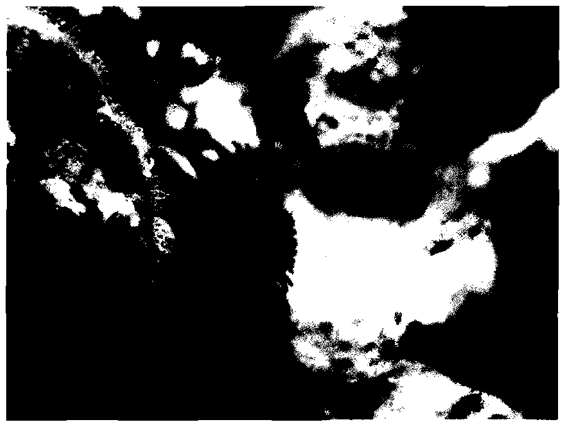
Sunken Reef Crest

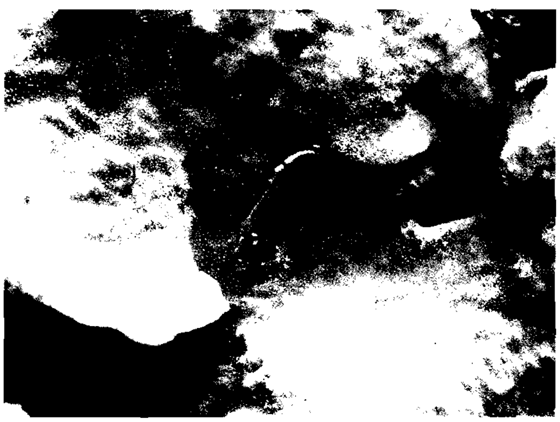
Appendix 2h. Photo sequence for marine survey station 8


Clathrya eurypa (Sponge)


Haliclona osiris (Sponge)


Phyllidiella pustulosa (Nudibranch)


Spirobranchus giganteus (Marine Worm)


Rhopalaea 2 gold spot (Sea Squirt)


Pearsonothuria graeffei (Sea Cucumber)

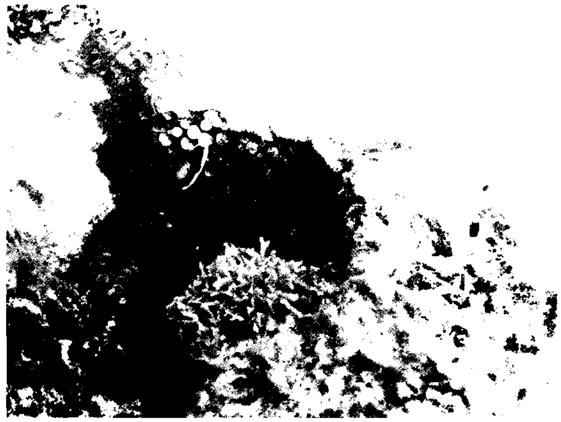
Appendix 2h. Continued

Reef Ledge/Slope

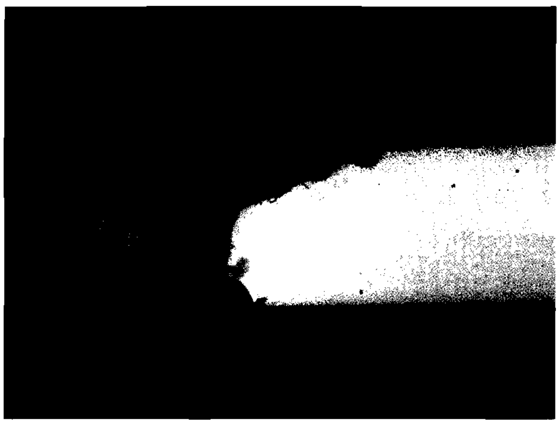
Aggregate distribution of *Coscinarea exesa*

Appendix 2i. Photo sequence for marine survey station 9

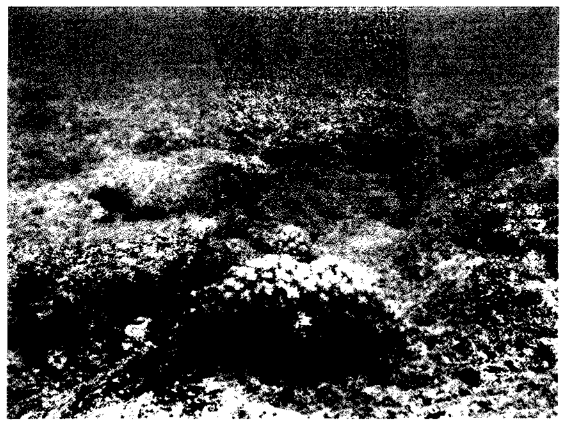
Lambis lambis (Finger Conch Snail)



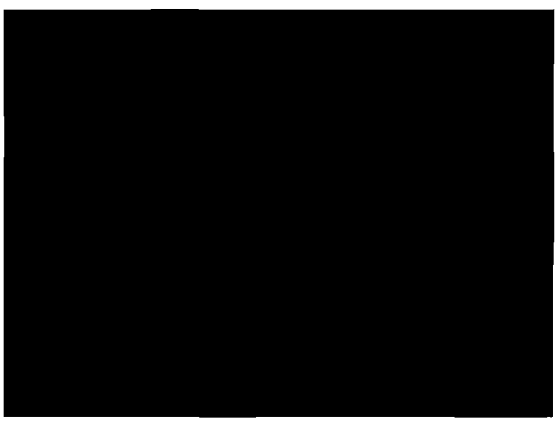
Entacmea quadricolor (Anenome)



Rhinoclavis sp (Snail)



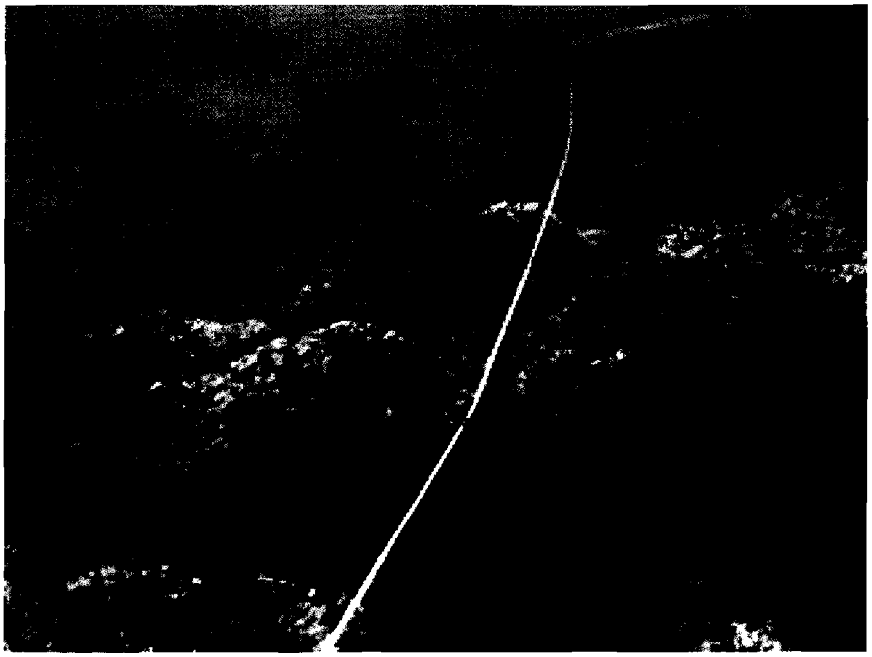
Pocillopora damicornis (Coral)



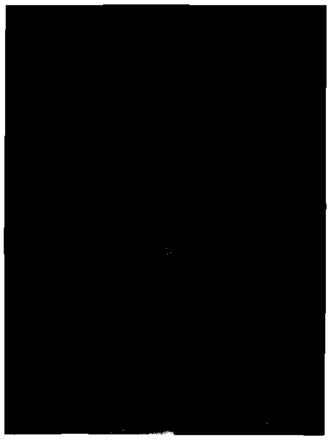
Thelenota ananas (Sea Cucumber)

Bohadscia vitiensis (Sea Cucumber)

Appendix 2i. Continued

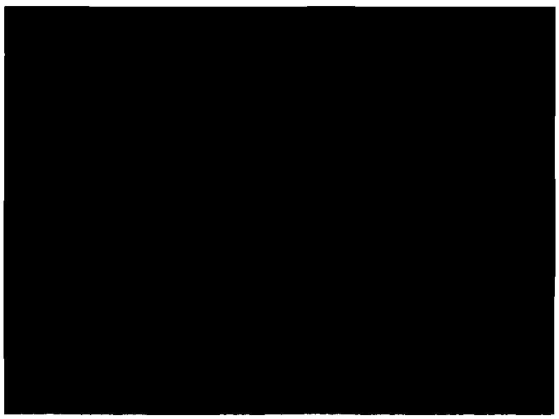

Reef Flat Habitat

Appendix 2j. Photo sequence for marine survey station 10

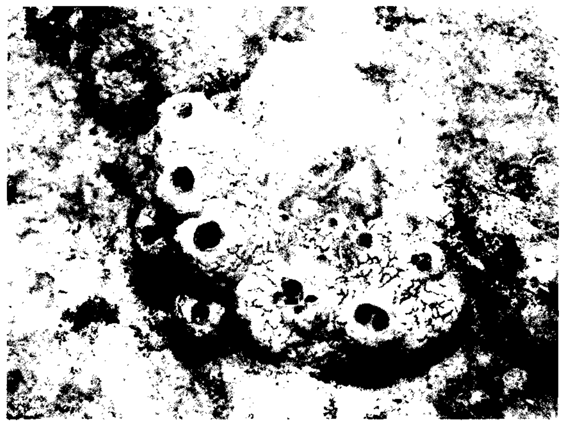


Ledge Habitat

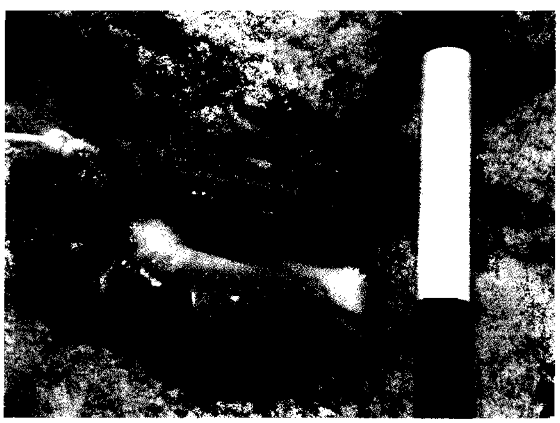
Aplysinella rhax (Sponge)



Culcita novaeguineae (Pin Cushion Sea Star)



Liosina granulosa (Sponge)



Lambis lambis (Finger Conch Snail)

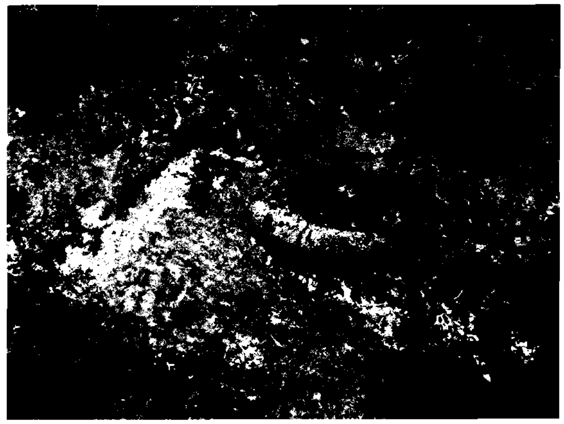
Clathria sp (Sponge)

Appendix 2j. Continued

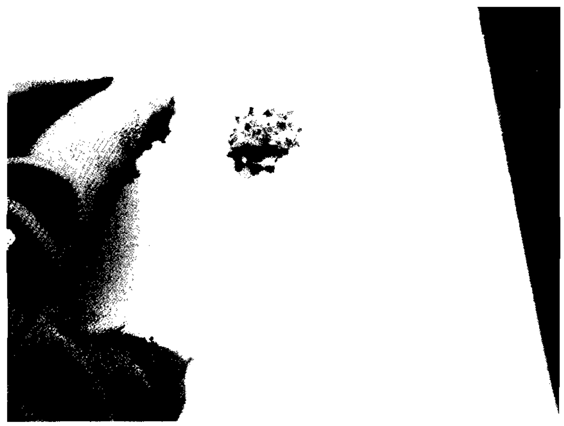
Reef Ledge Habitat

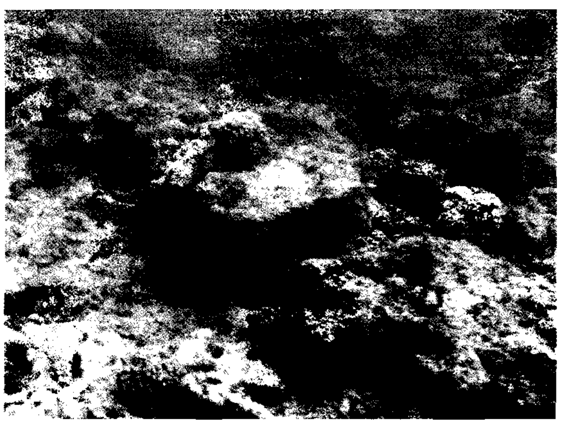
Appendix 2k. Photo sequence for marine survey station 11

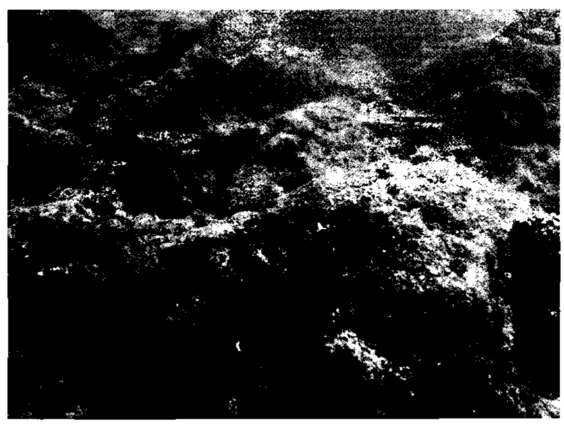

Lambis lambis (Finger Conch Snail)


Holothuria atra (Sea Cucumber)

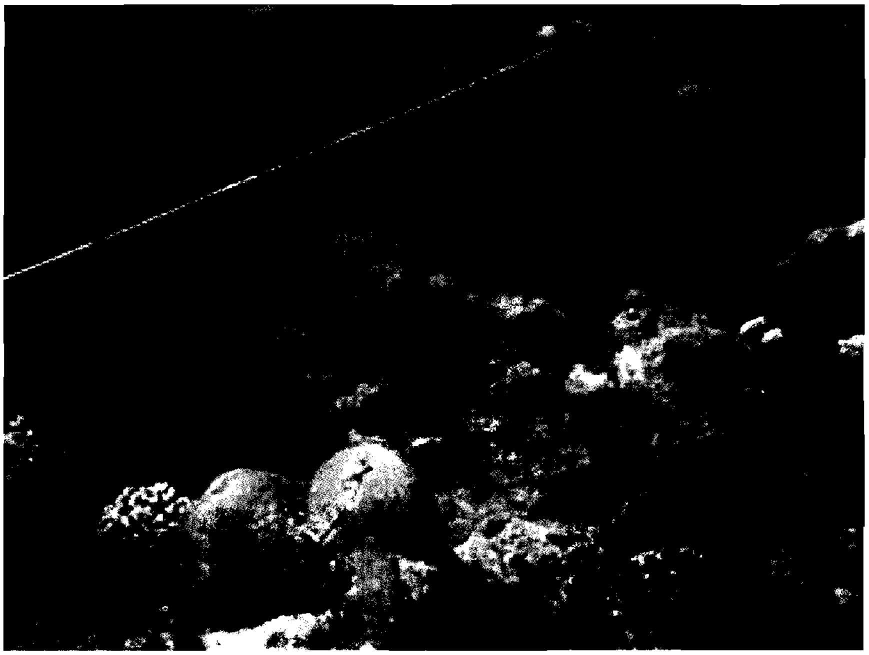

Tridacna maxima (Giant Clam)


Vasum turbinellus (Snail)


Moderate Relief Reef Flat


Halimeda sp (Green Algae)

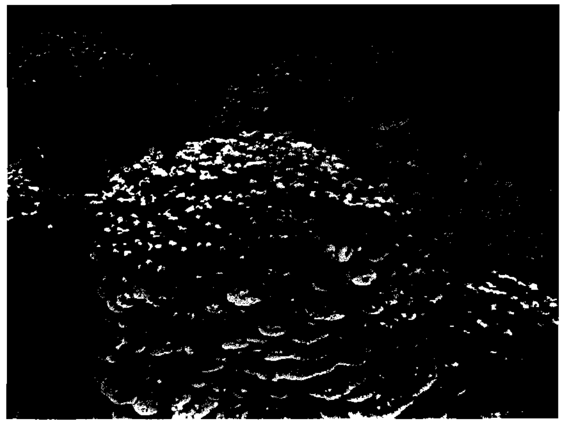
Appendix 2k. Continued

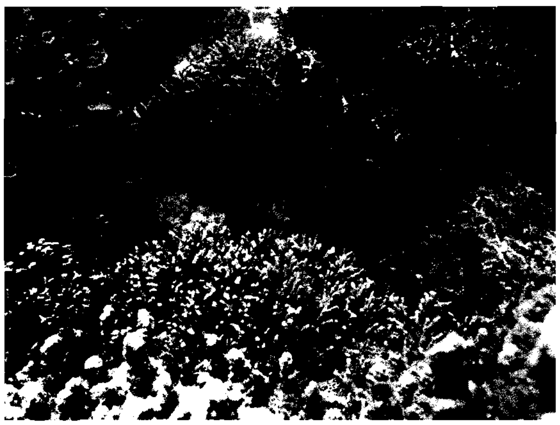


Reef Flat

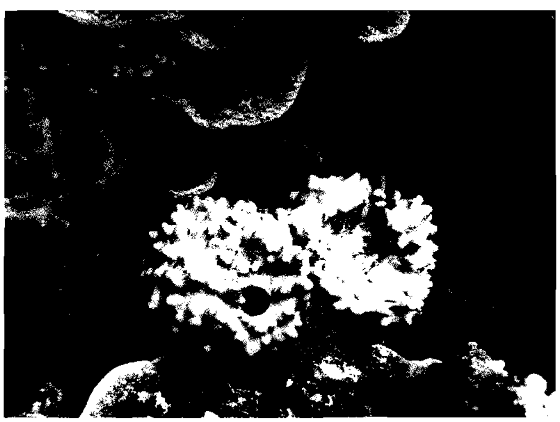
Appendix 21. Photo sequence for marine survey station 12

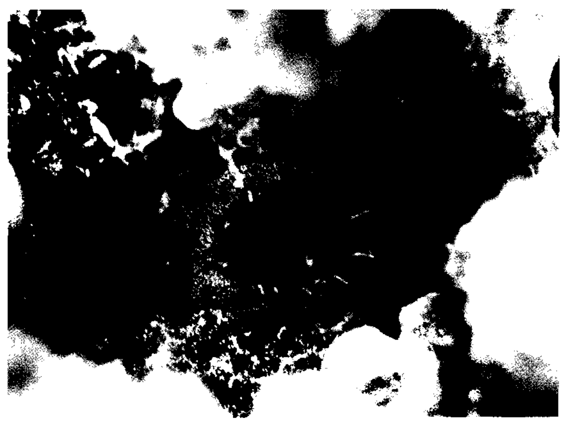

Clathria eurypa (Sponge)


Massive *Porites* coral colonies


Soft and Hard Coral Community


Hyrtios sp (Sponge)


Aplysinnella strongylata (Sponge)

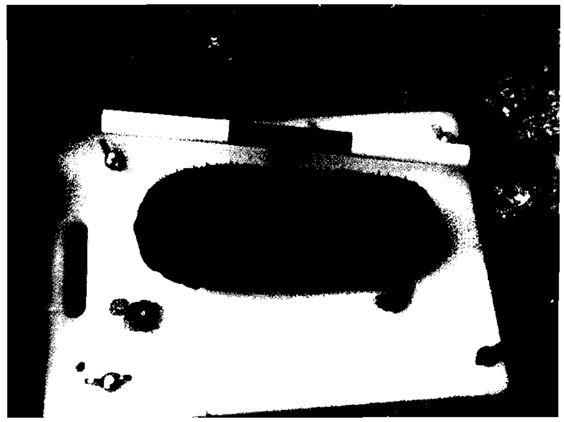

Ascidia sp (Sea Squirt)

Appendix 21. Continued

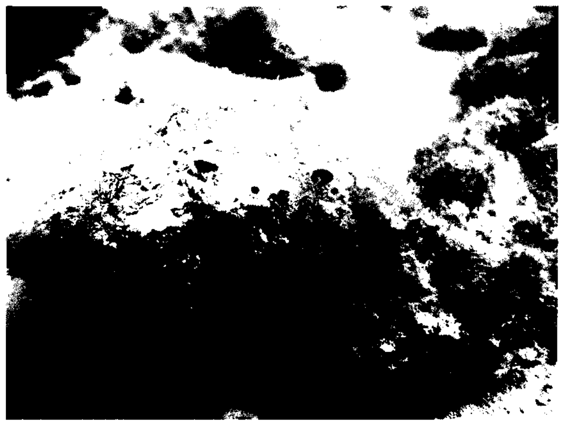
Reef Crest Habitat

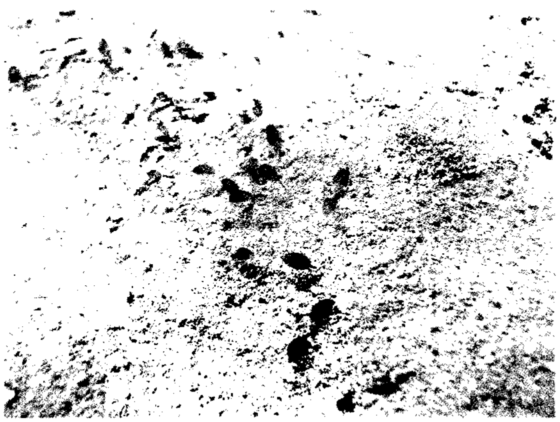
Appendix 2m. Photo sequence for marine survey station 13


Encrusting Coral


Bohadschia vitiensis (Sea Cucumber)

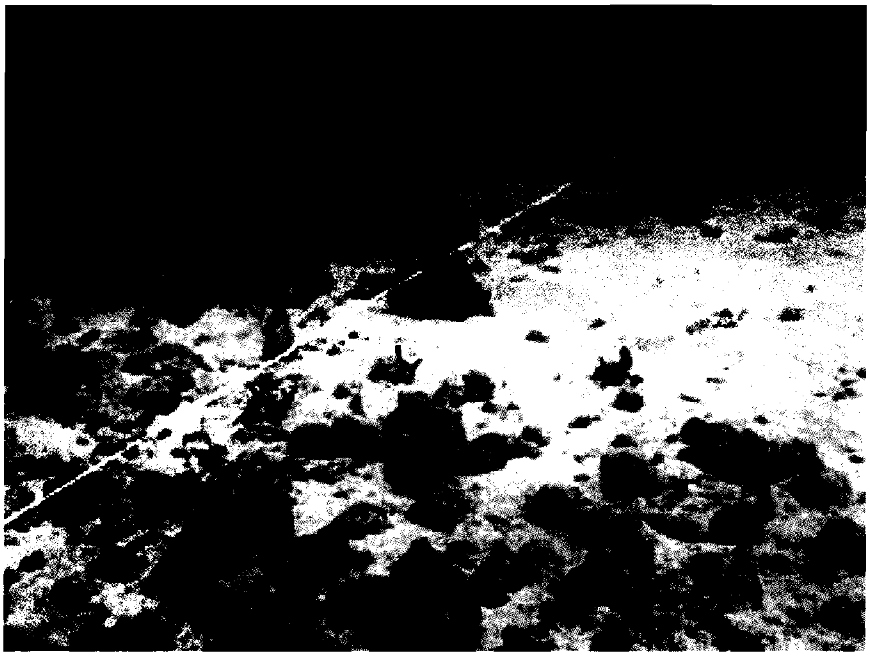

Rhopalaea circula (Sea Squirt)


Liosina granulosa (Sponge)


Halophila ovalis (Sea Grass)


Holothuria atra (Sea Cucumber)

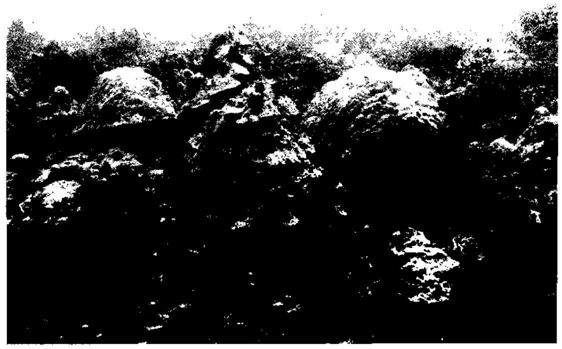
Appendix 2m. Continued



Reef Ledge Habitat

Appendix 2n. Photo sequence for marine survey station 14

Heteractis sp (Anenome)

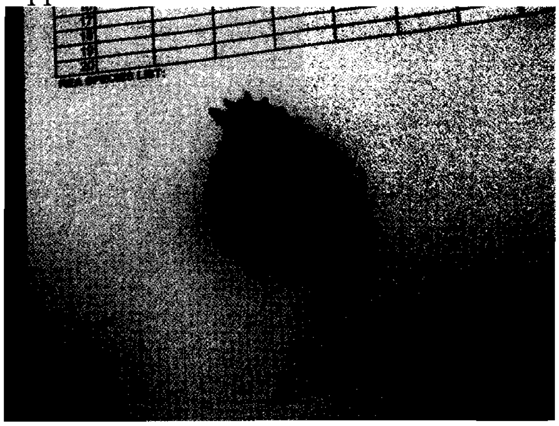


Porites (Coral)/*Halimeda* (Algae) Habitat

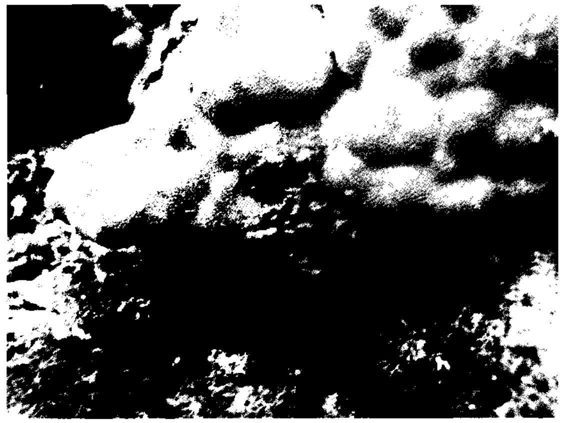
Melophlis isis (Sponge)

Holothuria whitmae (Sea cucumber)

Appendix 2n. Continued



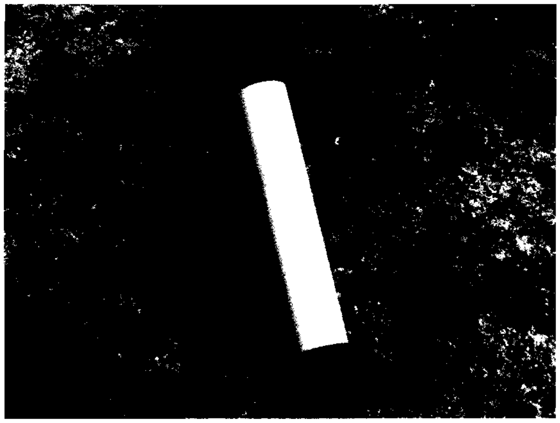
Astrea rhodostoma (Top Shell Snail)



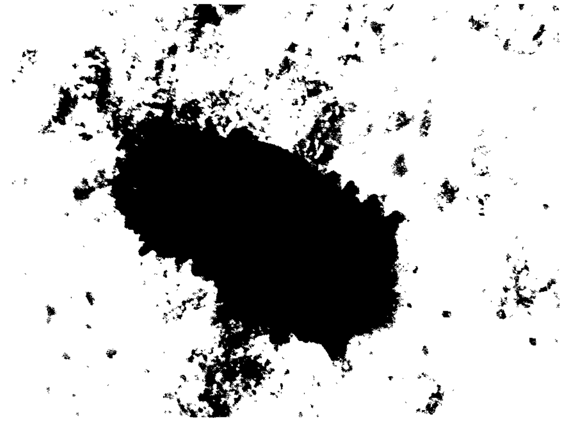
Unidentified Red Sponge

Sunken Reef Crest Habitat

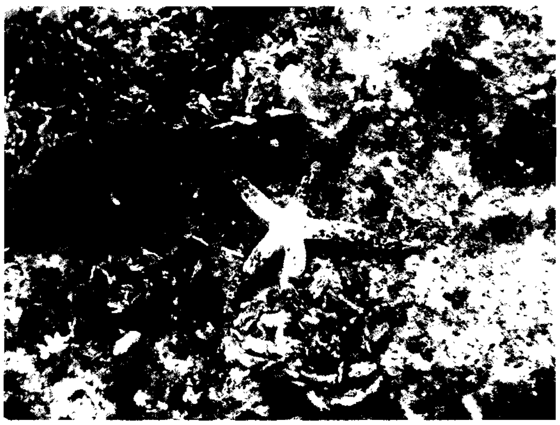
Appendix 2o. Photo sequence for marine survey station 15



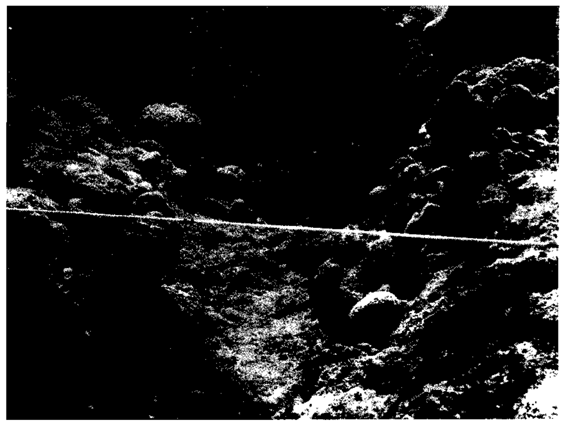
Conus imperialis (Snail)



Stichopus chloronotus (Sea Cucumber)

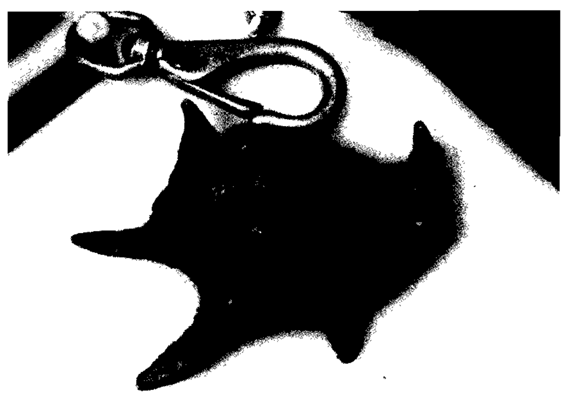


Linckia multifora (Sea Star)



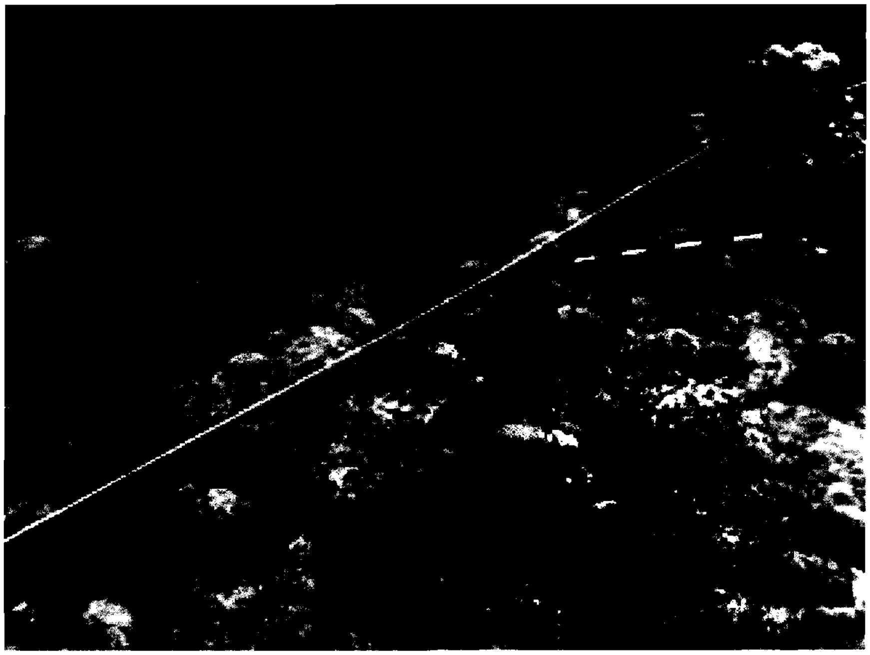
Channel

Porites (Coral) dominated habitat



Lambis chiragra (Snail)

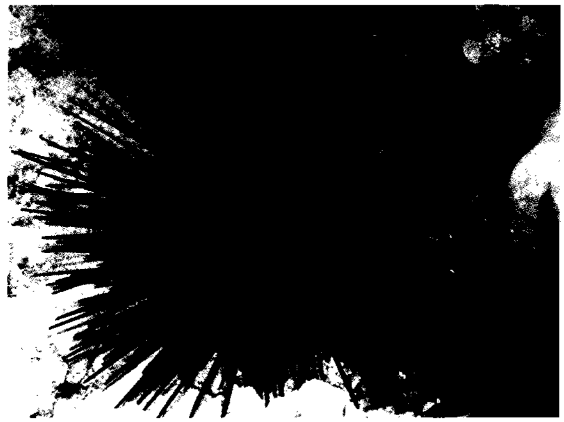
Appendix 2o. Continued



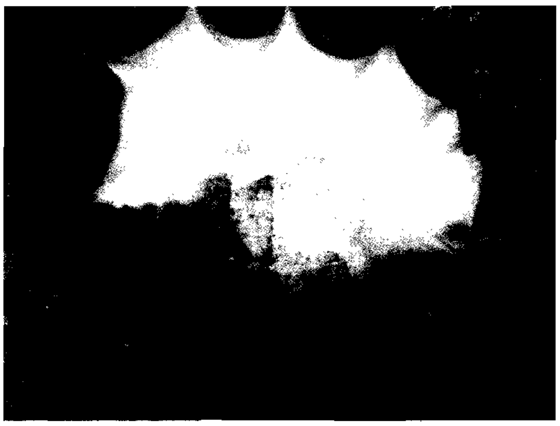
Harbor Reef Flat Habitat

Appendix 2p. Photo sequence for marine survey station 16

Eucidaris metularia (Urchin)

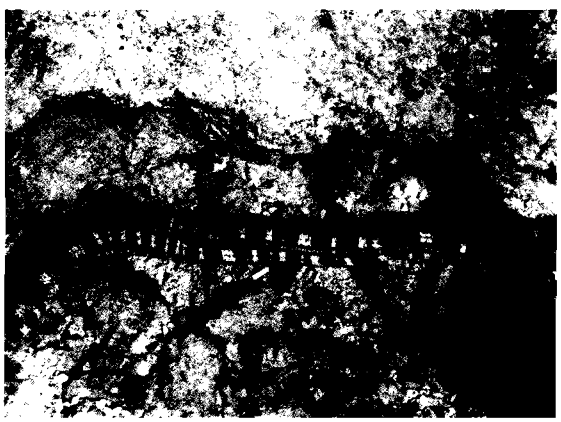


Diadema sp (Urchin)

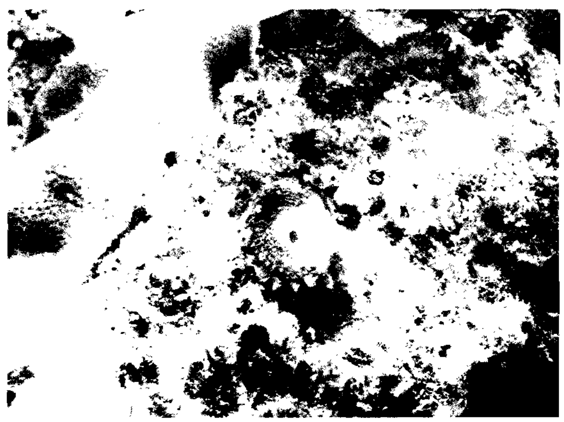


Lambis truncata (Finger Conch Snail)

Soft Coral Habitat



Euapta goddeffroyi (Synaptid)

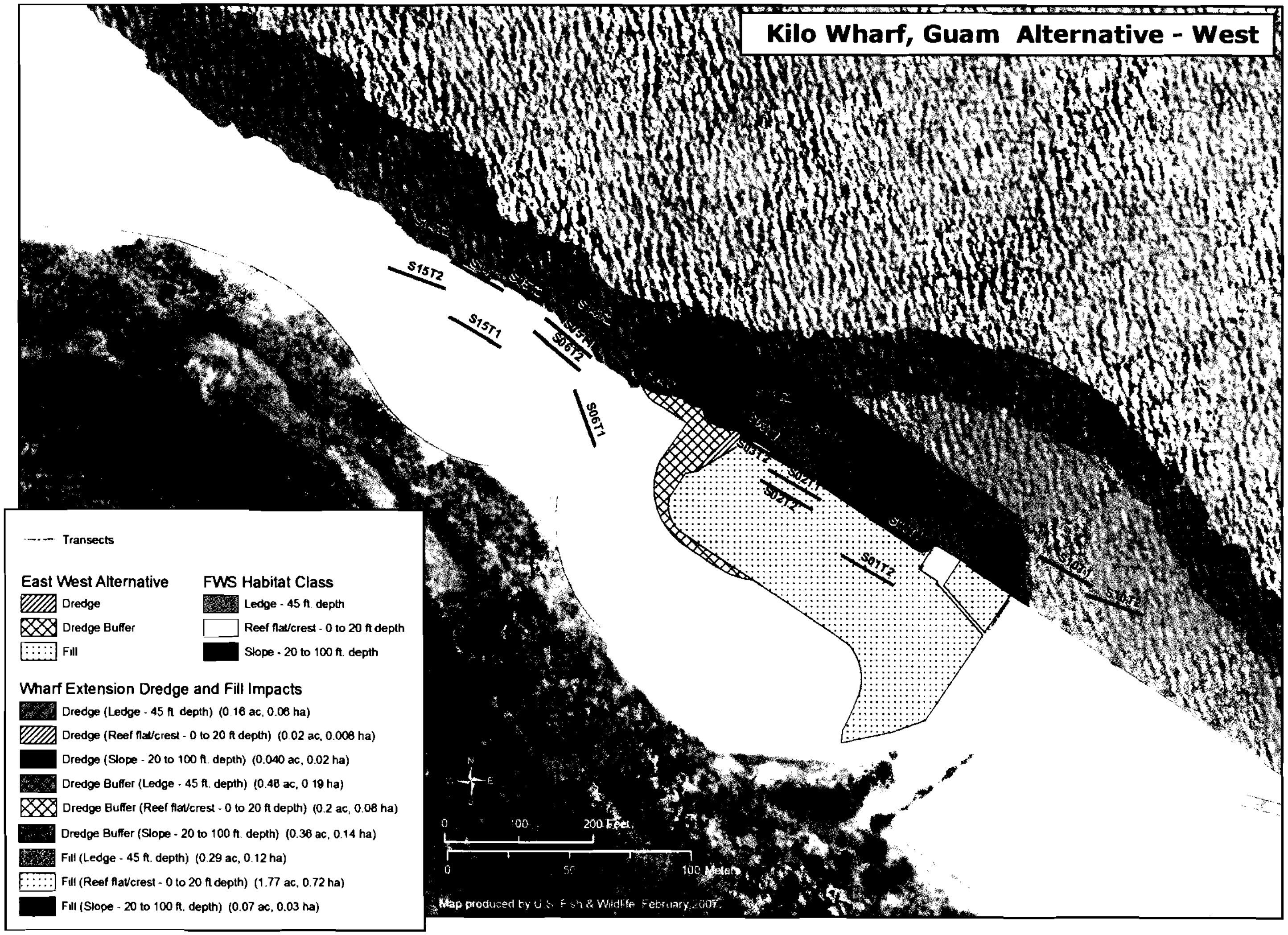


Astrea rhodostoma (Top-shell Snail)

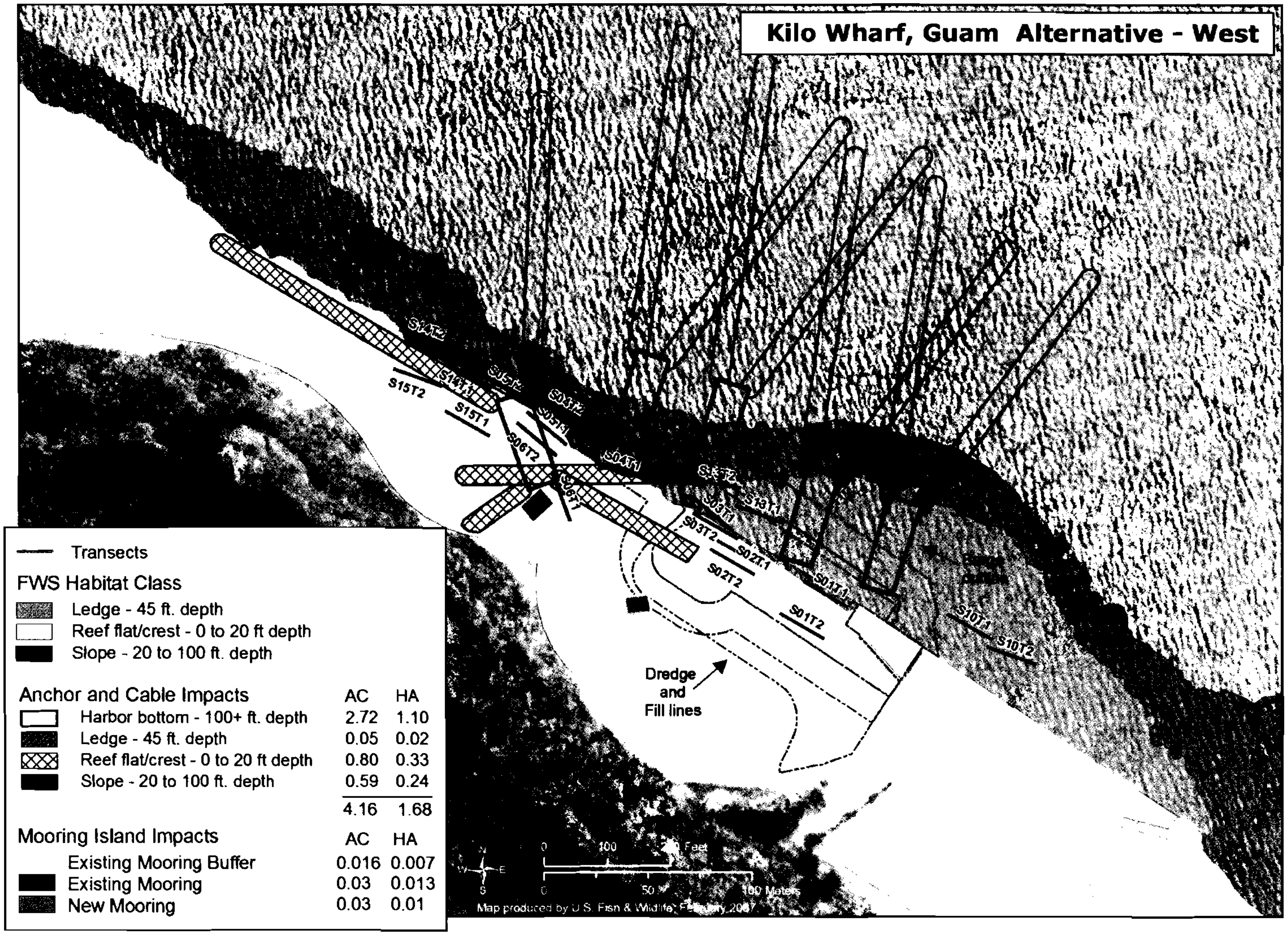
Appendix 2p. Continued

Ocean exposed reef flat (channel) habitat

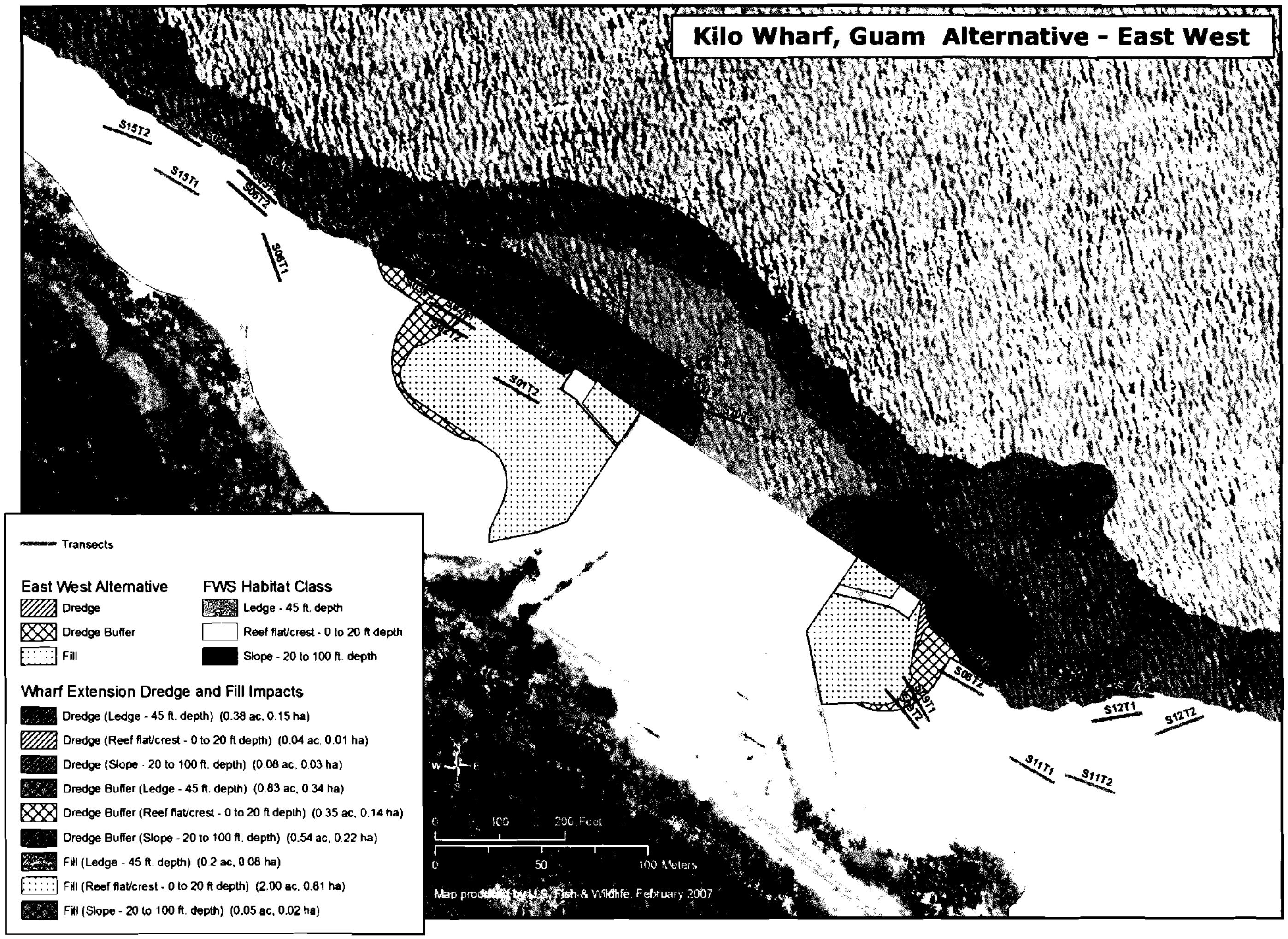
APPENDIX 3



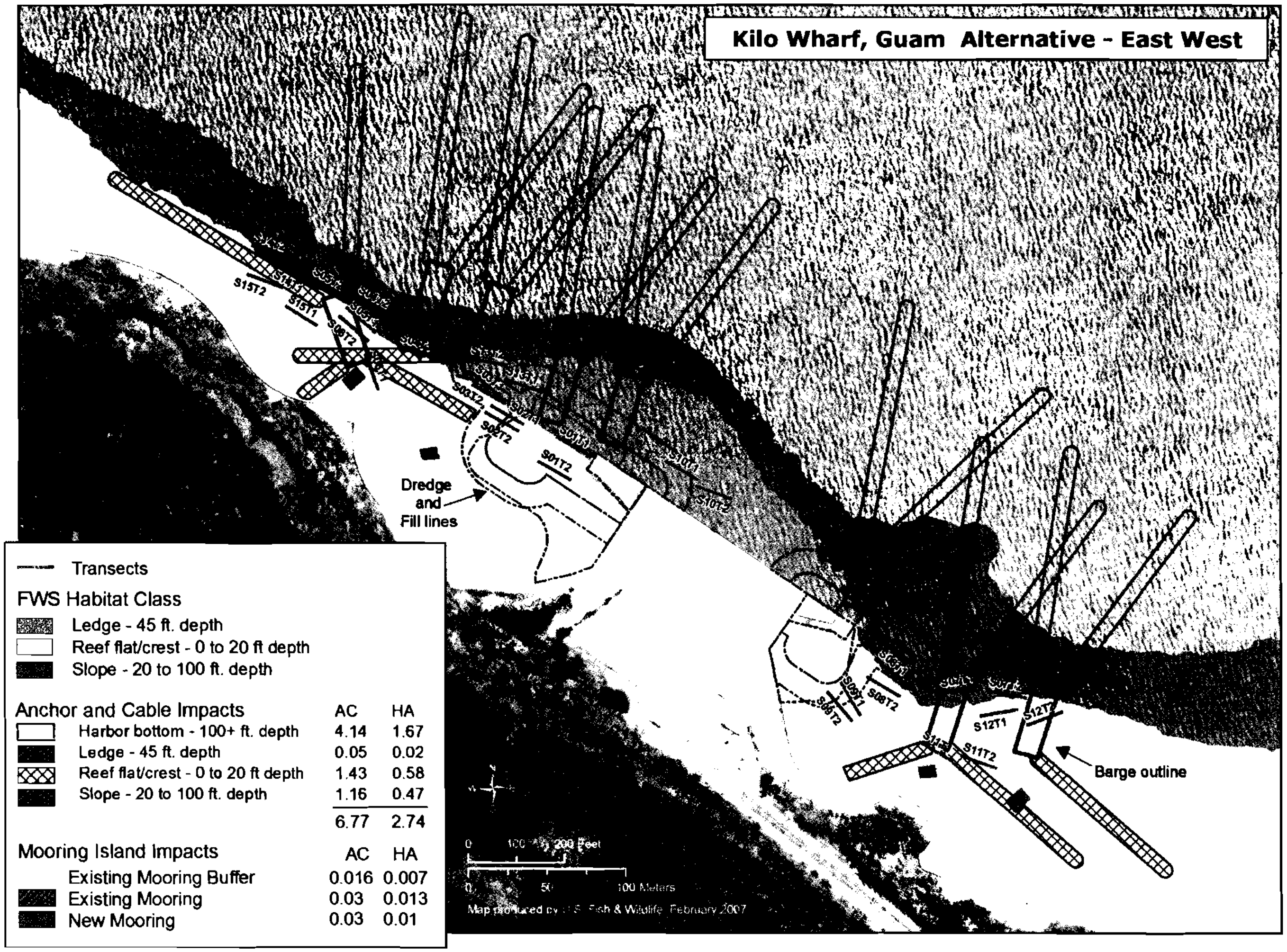
Appendix 3. Figure 1. West Alternative Construction Activities (Dredge and Fill) and Habitat Impacts



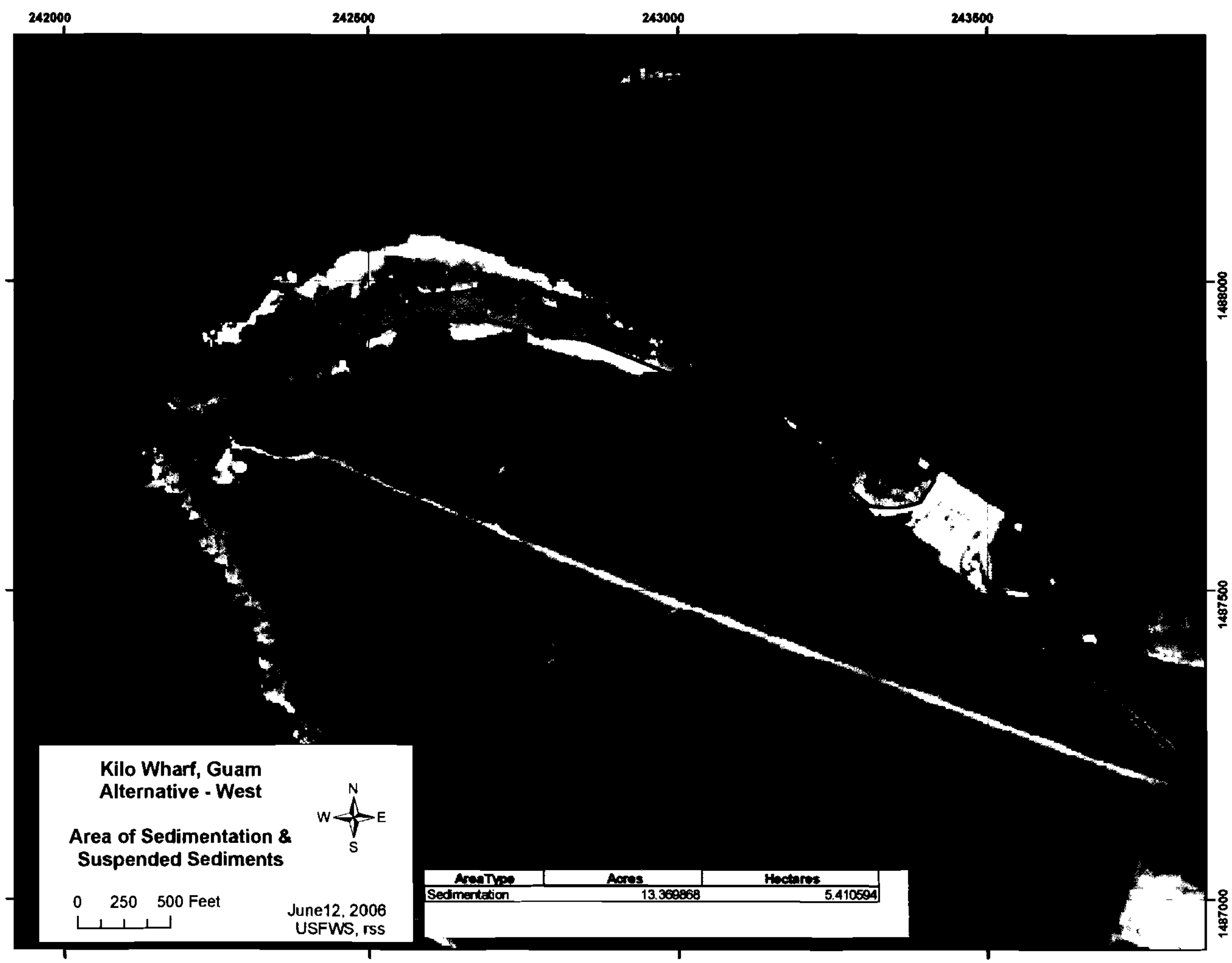
Appendix 3. Figure 2. West Alternative Construction Activities (Anchor, Cable and Mooring Islands) and Habitat Impacts



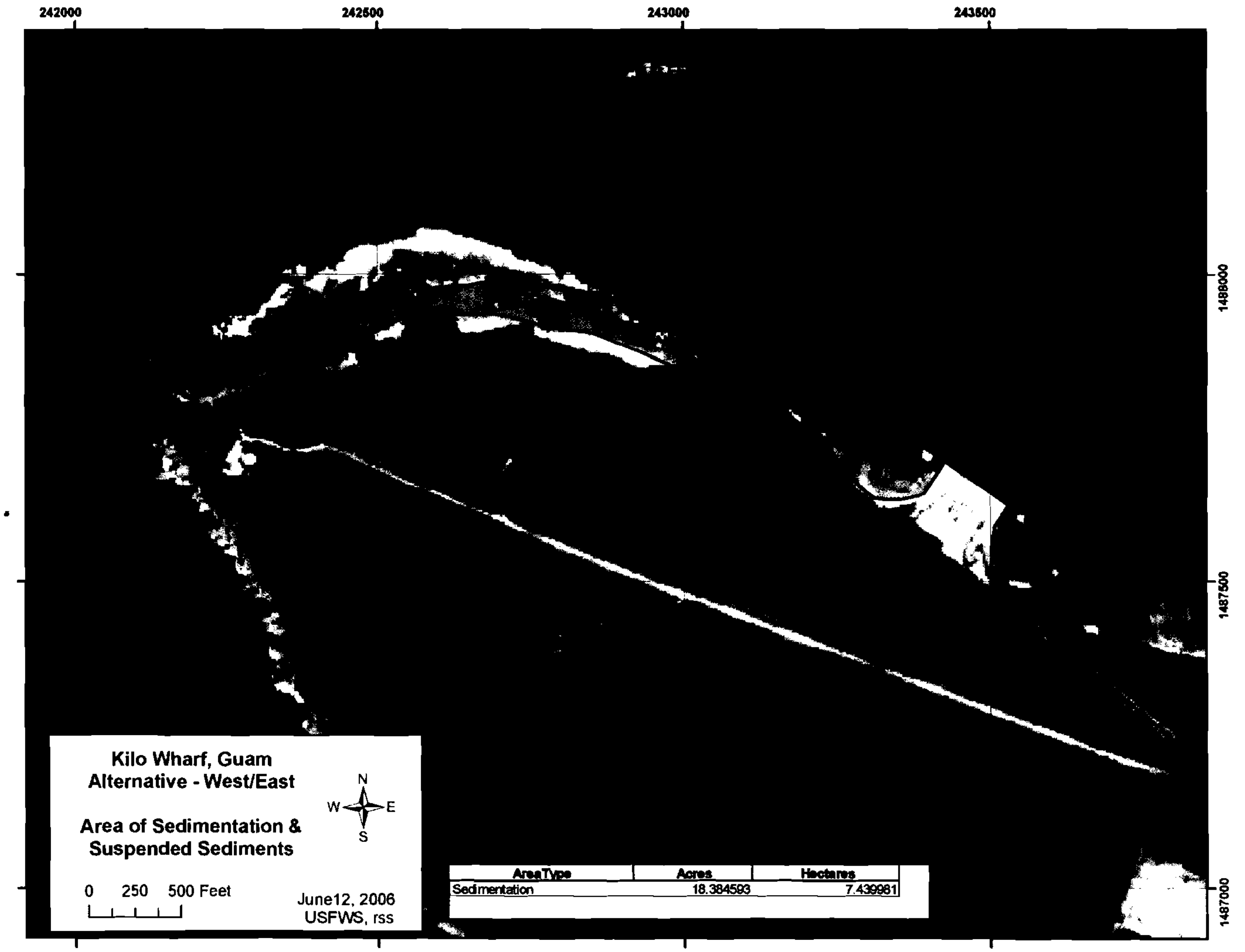
Appendix 3. Figure 3. West/East Alternative Construction (Dredge and Fill) Activities and Habitat Impacts



Appendix 3. Figure 4. West/East Alternative Construction (Anchor, Cable and Mooring Islands) Activities and Habitat Impacts



Appendix 3. Figure 5. West Alternative: Sedimentation and Suspended Sediment Impacts



AreaType	Acres	Hectares
Sedimentation	18.384593	7.439981

Appendix 3. Figure 6. West/East Alternative: Sedimentation and Suspended Sediment Impacts

APPENDIX 4

APPENDIX 4a

EARLY ALTERNATIVES DISMISSED FROM FURTHER CONSIDERATION

In November, 2004, the U.S. Navy (Navy) informed the federal natural resource trustees (Service and NMFS) about plans to expand the existing ammunition wharf at Apra Harbor. At a June, 2005 meeting with the Service, NMFS, and EPA, the Navy released information that described several proposed alternatives for the expansion and these included: (a) a 400-foot expansion to the west; (b) a 400-foot expansion to the east; (c) a 285-foot expansion to the west and a 115-foot expansion to the east; (d) an 821-foot expansion perpendicular to the existing wharf; and (e) an 860-foot parallel pullback of the existing wharf, with a new breakwater and shore protection. In December 2005, consultants (Helbert Hastert and Fee [HHF]) transmitted maps that illustrated four alternatives (*i.e.*, West, West/East, Pullback, and Outboard) to expand the existing Kilo Wharf. In January, 2006, the Navy confirmed that the four alternatives identified in these maps were currently under consideration as viable alternatives to expand the existing wharf and should be evaluated by the natural resource agencies during the upcoming marine investigation.

At the conclusion of the field work surveys of the marine habitats at each of the four alternative sites in January 2006, the Service, NMFS, DAWR and GEPA met with Navy representatives at the DAWR office in Mangilao, Guam. During the course of this meeting, the resource agencies learned that the West expansion is the Navy's preferred alternative to modify Kilo Wharf.

In February, 2006, at a meeting with the Navy, the Service, NMFS, DAWR, and GEPA discussed possible mitigation actions to offset ecological functions anticipated to be lost or degraded as a result of the proposed project. In addition, plans to coordinate the use of Habitat Equivalency Analysis were discussed as a means to appropriately scale potential mitigation projects. During March and April 2006, the Service and the Navy coordinated the exchange of various documents and information that related to the proposed construction project operations, which aided in the development of the Service's coordinated impact analysis. During this period, the Navy removed the Pull-back alternative from consideration, while retaining the West, West/East, and Outboard alternatives. Also, the Service hosted a meeting that included representatives from the Navy, consultants to the Navy, NMFS, GEPA, and DAWR to discuss project dredging-related sediment impacts to coral reef resources.

Alternative 1, Western Expansion (Preferred)

Kilo Wharf would be extended in a westerly direction by about 400 ft (121.9 m) long and about 127 ft (38.7 m) wide, expanding the existing wharf by about 50,800 ft^2 (4,719.5 m^2) (Appendix 3, Fig. 1 & 4) (Appendix 4). The approximate dredge area is about 96,700 ft^2 (8,983.72 m^2) or 2.22 acres (0.89 hectares). The approximate fill area or footprint of the new wharf expansion is about 44,600 cubic feet (ft^3) (4,143.48 cubic meters (m^3)) or 1.02 acres (ac) (0.41 hectares [ha]). The approximate fill volume is about 3,859,893 ft^3 (2,951,100 m^3). The depth of the coral reef flat is currently between 5 and 8 feet deep and this would be increased to a depth of -56 feet. Approximately 70,000 cubic yards (yd^3) (53,519 m^3) of coral reef materials would be removed from the dredge site. A 1:1 slope would be dredged landward and outside of the western caisson expansion footprint.

Prior to dredging activities, the deck and western breasting dolphin would be demolished and removed. The dolphin is about 40 ft by 40 ft or 1,600 ft^2 (148.6 m^2) or 0.04 ac (0.016 ha) in area. Similar to Kilo Wharf, the dolphin was constructed of concrete caissons and reaches depths of about 45 ft (13.7 m) below mean sea level (MLS), and about 18 ft (5.5 m) above MLS.

Dredging would be conducted using mechanical excavating equipment (*e.g.*, clamshell or crane) from a construction barge platform, approximately 260 ft long and 66 ft wide. Dredged materials would be placed on barges, known as dredge scows. The largest material dredge scow is about 220 ft long and about 50 ft wide, with a 4,000 yd^3 load capacity. Scows would not employ anchors, but would be tied off to the side of the construction barge. Dredged materials would be offloaded at the operational end of Kilo Wharf or Uniform Wharf at Inner Apra Harbor using a barge-mounted or land-based crane and bucket. Blasting methods are not considered under this alternative.

About four main anchors and wire anchor line would be used to moor the construction barge in place during project construction-related activities. Main anchors are 15 ft long and 10 ft wide, and weigh about 5 tons (4,535 kilograms), each. Piggy back anchors, additional small sized anchors (about 100 pounds each), would be attached to the existing anchor wire and in close proximity to the main anchor to stabilize the barge, if needed. Of the four main anchors, two would be deployed along the reef slope in the direction of the harbor bottom, and two would be placed on the reef flat, landward of the construction barge's operational position.

Factors that will be considered in the placement of construction barge anchors include: anchor design, barge size, wind/wave climate, and anchor position in relation to the elevation of the barge deck. Anchors will generally be deployed between 200 ft and 1,000 ft from the construction barge to achieve a stabilized state, allowing crane operations to occur. However, certain areas will likely require modified anchor geometry.

The construction barge main anchors and line would likely be deployed by a shallow draft tug using a heavy-duty winch to deploy or retrieve anchor and line during high tide conditions. Also, a tug may need to under-run an anchor in order to retrieve it. In addition, there is a small chance that a tug and anchor barge (drafts ranging between 3 to 12 ft) would be used in combination to set and retrieve anchors. Finally, a construction barge's position may be secured by tethering it to several "Dead-man" units on the shoreline, in the event a tug or anchor barge could not be used to deploy construction barge anchors.

Dredged materials would be disposed of at an upland confined disposal facility (CDF) for dewatering, at either the primary site at the Orote Airfield CDF, or at Field 5 (east of Kilo Wharf) or at Field 3 (southeast of Kilo Wharf). After the dewatering process is completed, suitable dried materials may be reused by the Navy or others as potential landfill cover, construction fill, beach replenishment, rip-rap or other approved use.

An additional mooring island, constructed of pre-cast concrete, will be placed on the reef to stabilize vessels berthed at Kilo Wharf during the wharf expansion period. The mooring island will be constructed on the reef flat, approximately 200 feet due west of the existing western mooring island, west of Kilo Wharf. The total construction period would range between 3 and 6 months. The footprint of the mooring island would be about 20 ft by 30 ft or 600 ft^2 (55.74 m^2) or 0.01 ac (0.004 ha) in area. Prior to placement of the mooring island, dredging would be required to sculpt the reef in a manner that would stabilize the mooring island in position. An area, approximately 30 ft by 40 ft or 1,200 ft^2 (111.48 m^2) or 0.026 ac (0.01 ha) in size would be dredged. The dredge depth is estimated to be – 5 feet. Approximately 210 yd^3 of coral reef materials would be removed from the site. The mooring island would not be removed after construction and may be used to stabilize vessels during future Kilo wharf vessel operations.

Two existing mooring islands, about 20 ft by 30 ft or 600 ft^2 (55.74 m^2) in size, located to the east and west of Kilo wharf, would be restored to prevent future erosion and scouring. Armor rocks (size unknown) would be placed around the existing mooring islands, resulting in a 3 ft^2 over-fill. The overall footprint, including mooring island and armor rock overfill, would be expanded to 23 ft by 33 ft or 759 ft^2 (70.5 m^2), or an additional 159 ft^2 (15 m^2) or 0.0037 ac (0.0015 ha) for each existing mooring island. Though specific refurbishment details are not yet available, it is possible that armor rocks would be set in place around the mooring island by either barge-mounted cranes or heavy equipment (*e.g.*, back-hoes) from a landward position.

Wharf expansion construction-related activities are expected to occur over a 36-month period. Construction will generally occur between Monday and Friday for a 10-hour period. However, it is feasible for construction activities to occur at night, in the event ammunition operations are carried out during the daylight period. Ordnance operations would be performed at the eastern end of the wharf, during construction of the western expansion section of the wharf. Vessels would be oriented in a bow-east facing position while tied off at the dock, and may drop a bow anchor to stabilize it in place.

Wharf improvements would include a variety of utility and infrastructure upgrades. Electrical power upgrades, including a 13.8 kilovolt (kV) circuit, would be installed along existing alignments from the Orote Power Plant to Kilo Wharf. A new transformer substation would be installed on the wharf to support ammunition vessel-related operations. New lighting would be added throughout the wharf to improve security. Telecommunications fiber optic systems would be added on the landside portion of Kilo Wharf and would be installed along the existing electrical alignment.

Alternative 2, West/East Expansion

A total of 76,000 yd^3 (58,106 m^3) of coral reef materials would be dredged from the footprint of the proposed west/east extension (Appendix 3, Fig. 2 & 5) (Appendix 4). The removal of coral reef materials would be distributed over two construction sites: 53,500 yd^3 (38,228 m^3) from the eastern expansion area and 22,500 yd^3 (14,527 m^3) from the western expansion area. Coral reef materials would be dredged down to a depth of -56 feet. Dredged materials would be removed from an area approximately 105,500 ft^2 (9,801.27 m^2) or 2.42 ac (0.98 ha) in area, permanently modifying the coral reef habitat to the west and east of the existing wharf. From the existing Kilo Wharf, the wharf would extend about 285 ft (86.9 m) to the west and about 115 ft (35.0 m) to the east. The approximate width of the wharf for both western and eastern expansions would be about 127 ft (38.7 m). This would expand the existing footprint of the wharf by about 36,195 ft^2 (3,362.6

m^2) or 0.83 ac (0.33 ha) to the west and about 14,605 ft^2 (1,356.9 m^2) or 0.34 ac (0.137 ha) to the east. The approximate fill volume is about 3,859,893 ft^3 (2,951,100 m^3).

The existing deck and mooring dolphins would be demolished and removed first. Afterwards, the western expansion section of the wharf would be constructed and ordnance operations would be carried out at the eastern end of Kilo Wharf. Similarly, ordnance operations would be performed at the newly constructed western end of the wharf, during construction of the eastern expansion section of the wharf. The time-frame to carry out construction-related activities at the western and eastern sites is: between 16 and 20 months for the western site, and between 12 and 18 months for the eastern site. Vessels docking at Kilo Wharf during the construction period would be oriented in a bow-east position.

Two newly constructed mooring islands would be placed on the reef to stabilize vessels berthed at Kilo Wharf during the wharf expansion period. They would be constructed and placed on the reef in a manner similar to the description provided in the western expansion alternative. One new mooring island would be placed on the reef flat approximately 200 feet due east of the existing eastern mooring island, located east of Kilo Wharf; and one would be placed 200 feet due west of the existing western mooring island, located west of Kilo Wharf. Also, existing western and eastern mooring islands would be restored and other wharf improvements, including utility and infrastructure upgrades would be carried out.

Alternative 3, Outboard Expansion

A new wharf, constructed adjacent to the outboard or harbor side of the existing wharf, would extend about 800 ft (243.8 m) long and about 127 ft (38.7 m) wide (Appendix 3, Fig. 3 & 6) (Appendix 4). The east end of the new wharf would be even with the eastern boundary of the existing wharf; and the western end of the new wharf would extend about 400 ft beyond the western boundary of the existing wharf. The approximate area of the wharf-expanded fill would be about 101, 600 ft^2 (9,439 m^2) or 2.33 ac (0.94 ha). The approximate fill volume is about 7,769,227 ft^3 (5,940,000 m^3). A total of 39,000 yd^3 (29,818 m^3) of coral reef materials would be dredged over an area approximately 152,800 ft^2 (14,196 m^2) or 3.51 ac (1.42 ha). The area within the footprint of the new wharf would be dredged from an existing depth of about -45 ft, to a depth of about -60 ft. Also, the dredge area includes a 50-ft buffer that extends beyond the footprint of the new wharf. The buffer area would include a slope, dredged to a 1:1 angle.

The length of the construction period is approximately 42 months. During the construction period, ordinance off/on-loading operations would be performed by barge between the T-AE vessel, anchored in the outer harbor, and the serviceable portion of the old or new wharf. Also, smaller, lighter loads may be transported by helicopter to the top of Orote Point. Also, existing western and eastern mooring islands would be restored and other wharf improvements, including utility and infrastructure upgrades would be carried out. Also, Kilo Wharf would remain intact, eliminating the need to demolish any existing structures.

ANTICIPATED IMPACTS
FROM
DISMISSED ALTERNATIVES

The dimensions for each of the proposed project features and associated construction activities are site-dependent. Estimates of direct habitat impact by project construction-related activities are described below for each alternative (West, West/East, and Outboard) (Appendix 3, Figures 1 – 3). Additionally, we anticipate indirect project construction-related sedimentation and suspended sediment impacts to coral reef resources beyond the project site are anticipated for each alternative (Appendix 3, Figures 4 – 6).

General Impacts

Dredging and filling-related activities associated with the proposed project will permanently alter habitat features and destroy coral reef organisms that occur within the project footprint and construction area of operation, for each proposed alternative. Also, it is anticipated that wind-driven surface currents will transport suspended dredged sediment to areas down-current of the proposed dredge sites, and that some of this sediment will settle-out and smother sessile organisms (*e.g.*, corals, giant clams, macro-algae and turf algae) (U.S. Navy, 1986[1]; G. Davis Pers. Comm., 2006). It is also expected that dredging-related sedimentation and suspended sediments to disrupt or reduce coral reproduction processes, such as: (1) gamete production, (2) egg fertilization, (3) embryo development and larval survival, (4) larval settlement and metamorphasis, (5) recruitment survival, and (6) juvenile growth and survival (Fabricius 2004, Richmond 1997, Richmond 1993, Hodgson 1990, Babcock and Davies 1991) and (7) reduce adult coral fecundity (Kojis and Quinn 1984) over a broad area. Finally, the recovery of coral reef organisms within project areas that will be subjected to long-term exposure to resuspended sediments mobilized by propeller turbulence should be anticipated.

All proposed alternatives have the potential to impact both green and hawksbill sea turtles in Apra Harbor directly and indirectly. Direct impacts include loss of resting habitat and foraging resources from dredging and filling. The loss of foraging resources, including sponges, coelenterates, bryozoa, mollusks, urochordates, and macro-algae may also occur as a result of the indirect impacts of sedimentation over varying periods of time. Although sea turtle nesting habitat is not expected to be directly impacted, contamination of harbor waters from project-related activities could degrade nearby potential nesting habitat. Measures to protect sea turtles from project-related impacts will be recommended in a subsequent mitigation report and addressed through ESA section 7 consultation.

Other indirect impacts to coral reef resources may include: introductions of alien species and exposure to petroleum products. Discharged vessel ballast water is a primary pathway for the introduction of alien species that could displace indigenous coral reef organisms (Godwin *et al.* 2004), and harbors are particularly vulnerable marine environments for this type of impact. Also,

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[1] Current Measurement and Numerical Circulation Model Study for Kilo Wharf Extention Apra Harbor, Guam (Helber, Hastert and Fee, 2005) and Marine Ecosystem Impact Analysis Kilo Wharf Extension Outer Apra Harbor, Guam (Helber, Hastert and Fee, 2006) contained insufficient analyses of surface current-transported sediments beyond the identified dredge sites to merit considering their inclusion in this report.

exposure to petroleum products, accidentally released into the harbor, may negatively impact coral reef organisms (Te 1991, Rinkevich and Loya 1983, Loya and Rinkevich 1980).

Descriptions of anticipated site-specific impacts are provided below. Table A through C present summaries of project-related impacts to various habitats for each of the alternatives under consideration.

Western Expansion (Preferred)

About 70,000 yd^3 (53,519 m^3) of coral reef materials will be dredged from the fringing reef, west of Kilo Wharf and this will permanently modify an area of coral reef habitat that is about 2.2 ac (0.8981 ha) in size (Table A and Appendix 3 - Figure 1). The areas of coral reef habitat that would be affected by dredging operations are as follows: reef flat and crest (1.48 ac), sunken reef crest (0.042 ac), reef slope (0.09 ac), and reef ledge (0.6 ac) habitat. The Kilo Wharf western expansion will be constructed on about 1.17 ac (0.473 ha), within the 2.2-ac dredge site. Coral reef resources represented in Tables 1-4 (Survey Stations 1, 2, 3 & 13) would be affected by dredging-related activities.

Barges and tugs will likely be used to perform dredging and filling activities for the western expansion alternative; dredging and placement of the new mooring island; and refurbishment activities associated with the existing mooring island. Tug operations will involve the deployment and retrieval of anchors and anchor wire to secure construction barges in place. Anchor placement will have direct physical impacts to coral reef resources. Likewise, coral reef resources will be vulnerable to the effects of scouring and abrasions from anchor wires that are influenced by tides, currents, swells, and vessel movement. Because barges will be moved multiple times over the course of the construction period, we would expect anchor-related impacts are expected to occur over a broad area. It is anticipated that construction barges will be anchored at about 5 different sites for dredging and filling to construct the west expansion, install the new mooring island, and refurbish the existing mooring islands.

Anchor and anchor cable/wire-related impacts to coral reef resources have been recently documented in association with the Cape Flattery container vessel grounding on the reef, fronting Barbers Point Deep Draft Harbor, Oahu (2005). Though it is difficult to directly correlate Cape Flattery-related anchor and wire impacts to the Kilo Wharf construction (K. Foster, Pers. Comm.), we anticipate that anchor deployment and retrieval impacts may occur up to 25 ft (7.62 m) from final placement on the reef (K. Foster, Pers. Comm.). Also, we anticipate up to 25 ft (7.26 m) of impacts to coral reef resources to occur on either side of the wire (K. Foster, Pers. Comm.). Therefore, we anticipate about 4.15 ac (1.68 ha) of coral reef resources, distributed over several habitat zones: reef flat and crest (0.7 ac), sunken reef crest (0.0049 ac), reef slope (0.79 ac), reef ledge (0.032 ac), and harbor bottom (2.63 ac), will be affected by construction barge and tug operations. Coral reef resources represented in Tables 1-4 (Survey Stations 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 13, 14, and 15) would be affected by barge-related activities.

Construction of a new mooring island would permanently modify about 0.027 ac (0.011 ha) of reef flat habitat, due to dredging-related activities. Within the dredged area, fill-related placement of the new mooring island would result in the permanent loss of about 600 ft^2 (55.74 m^2) or 0.01 ac

(0.004 ha) of reef flat habitat. Coral reef resources represented in Tables 1-4 (Survey Station 6) would be affected by the mooring island construction-related activities.

Armor rock overfill at the two existing mooring islands would impact about 0.0037 ac (0.0015 ha) or a total of about 0.008 ac (0.003 ha) of reef flat habitat that would be permanently lost. Coral reef resources represented in Tables 1-4 (Survey Station 2, 6, and 11) would be affected by construction-related activities.

The total area that may be exposed to dredging-induced elevated turbidity levels is about 13.37 acres (5.4 hectares) (Table A and Appendix 3 - Figure 4), based upon monitoring and observations conducted during the original construction of Kilo Wharf (U.S. Navy, 1986; Davis Pers. Comm., 2006). The proposed time-frame to perform wharf expansion construction activities could be as much as 36 months. Coral reproduction processes would likely be degraded during the time of exposure to elevated levels of fine sediments in the water column. Coral reef resources represented in Tables 1-4 (Survey Stations 4, 5, 6, 13, 14, 15, and 16), as well as undocumented resources between Survey Stations 15 and 16, would be affected by construction-related elevated turbidity levels.

Also, we anticipate about 1.34 acres (about 10% of the affected 13.37 acres) of reef flat habitat may be subject to fine sediments settling out on the reef flat and remaining in place for a period of up to ten years (Rongo, 2004). Therefore, we may anticipate lethal and sub-lethal injuries to affected coral reef organisms, due to smothering, abrasions, and scouring, resulting from long periods of exposure to sediments. Coral reef resources represented in Tables 1-4 (Survey Stations 4, 5, 6, 13, 14, 15, and 16), as well as undocumented resources between Survey Stations 15 and 16, would be affected by construction-related sedimentation.

Table A. Summary of project-related impacts to coral reef habitat for the western expansion alternative.

Construction Activity	Habitat Type	Type of Injury	Injury Affects	Duration of Injury	Acreage
(1) Wharf Dredging	Reef flat/crest	Dredge	BS and BC[1]	Permanent	1.48
	Sunken Crest	Dredge	BS and BC	Permanent	0.042
	Reef slope	Dredge	BS and BC	Permanent	0.09
	Reef ledge	Dredge	BS and BC	Permanent	0.6
				Subtotal	2.212
(2) Barge/Tug Operations	Reef flat/crest	Anchor/Wire	BS and BC	100 years*	0.7
	Sunken Crest	Anchor/Wire	BS and BC	100 years*	0.005
	Reef slope	Anchor/Wire	BS and BC	100 years*	0.79
	Reef ledge	Anchor/Wire	Calc. Algae[2]	5 years**	0.032
	Harbor Bottom	Anchor/Wire	Infauna[3]	1 year***	2.63
				Subtotal	4.157
(3) New Mooring Island	Reef flat	Dredge	BS and BC	Permanent	0.027
(4) Existing Mooring Islands	Reef flat	Fill	BS and BC	Permanent	0.008
(5) Wharf Dredging	Reef flat/slope	Sup.Seds.[5]	Degraded CRP[4]	36 Months	13.37
(6) Wharf Dredging	Reef flat	Sedimentation	BS and BC	10 years	1.34
				Total	21.114

[1] BS and BC = BS - Benthic Substrate (Sand/Rocks etc.,) and BC – Biological Community (Algae, Coral, Macro-invertebrates, and Reef Fish)
[2] Calc. Algae = (Calcareous Algae, such as *Halimeda*). [3] Infauna = crustaceans, mollusks, and marine worms. [4] Degraded Coral Reproduction Processes [5] Suspended Sediment* Approximate time for *Porites rus* colony to recover. ** Approximate time for *Halimeda* sp meadow to recover. *** Approximate time for Infauna to recolonize benthic habitat.

West/East Expansion Alternative

About 76,000 yd^3 (58,106 m^3) of coral reef materials will be dredged from the fringing reef located west and east of Kilo Wharf and this will permanently modify about 2.47 ac (0.98 ha) of coral reef habitat (Table B and Appendix 3 – Figure 2). The areas of coral reef habitat that would be permanently modified by dredging operations are as follows: reef flat and crest (1.57 ac), sunken crest (0.19 ac), reef slope (0.11 ac), and reef ledge (0.63 ac) habitat. Within this dredged area, approximately 1.17 ac (0.47 ha) will be filled. Coral reef resources represented in Tables 1-4 (Survey Stations 1, 2, 3, 7, 8, 9, 10 & 13) would be affected by dredging-related activities.

Because barges will be moved multiple times over the course of the construction period, and it is expected that anchor-related impacts will occur over a broad area. It is anticipated that the construction barges will be anchored at about 5 different sites for dredging and filling to construct the west and east expansions, install the new mooring islands and refurbish the existing mooring islands. Anchor deployment and retrieval impacts are anticipated to occur up to 25 ft (7.62 m) from final placement on the reef. Also, it is expected that up to 25 ft (7.26 m) of impacts to coral reef resources will occur on either side of the wire. Therefore, we anticipate about 5.55 ac (2.25 ha) of coral reef resources, distributed over several habitat zones: reef flat and crest (1.04 ac), sunken reef crest (0.0049 ac), reef slope (0.87 ac), reef ledge (0.032 ac), and harbor bottom (3.6 ac), will be affected by construction barge and tug operations. Coral reef resources represented in

Tables 1-4 (Survey Stations 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 13, 14, and 15) would be affected by construction barge-related activities.

Construction of the two new mooring islands would modify about 0.052 ac (0.022 ha) of reef flat habitat. Within the dredged area, placement of the new mooring islands would fill an area about 1,200 ft^2 (111.48 m^2) or 0.027 ac (0.008 ha) in size. Coral reef resources represented in Tables 1-4 (Survey Stations 6 and 11) would be affected by the mooring island construction-related activities.

Armor rock overfill at the two existing mooring islands would impact about 0.016 ac (0.01 ha) of reef flat habitat that would be permanently lost. Coral reef resources represented in Tables 1-4 (Survey Station 2, 6, and 11) would be affected by construction-related activities.

The total area that may be exposed to dredging-induced elevated suspended sediments is about 18.38 ac (7.43 ha). The proposed time-frame to perform wharf expansion construction activities could be up to about 38 months. Therefore, we would anticipate turbidity levels to disrupt coral reproduction processes during this period, over the affected area. Coral reef resources represented in Tables 1-4 (Survey Stations 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16), as well as undocumented resources between Survey Stations 15 and 16, would be affected by construction-related elevated turbidity levels.

Also, it is anticipated that about 1.83 ac (about 10 % of the affected area of 18.38 ac) of reef flat habitat may be vulnerable to sedimentation from fine sediments settling out on the reef (Table B and Appendix 3 – Figure 5). If left in place, settled sediments would likely smother, abrade, and scour coral reef organisms that occur within this area. Coral reef resources represented in Tables 1-4 (Survey Stations 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16), as well as undocumented resources between Survey Stations 15 and 16, would be affected by construction-related sedimentation.

Table B. Summary of project-related impacts to coral reef habitat for the west/east expansion alternative.

Construction Activity	Habitat Type	Type of Injury	Injury Affects	Duration of Injury	Acreage
(1) Wharf Dredging	Reef flat/crest	Dredge	BS and BC[1]	Permanent	1.54
	Sunken crest	Dredge	BS and BC	Permanent	0.19
	Reef slope	Dredge	BS and BC	Permanent	0.11
	Reef ledge	Dredge	BS and BC	Permanent	0.63
				Subtotal	2.47
(2) Barge/Tug Operations	Reef flat/crest	Anchor/Wire	BS and BC	100 years*	1.04
	Sunken crest	Anchor/Wire	BS and BC	100 years*	0.005
	Reef slope	Anchor/Wire	BS and BC	100 years*	0.87
	Reef ledge	Anchor/Wire	Calc. Algae[2]	5 years**	0.032
	Harbor Bottom	Anchor/Wire	Infauna[3]	1 year***	3.6
				Subtotal	5.547
(3) New Mooring Islands	Reef flat	Dredge	BS and BC	Permanent	0.052
(4) Existing Mooring Islands	Reef flat	Fill	BS and BC	Permanent	0.007
(5) Wharf Dredging	Reef flat/slope	Susp.Sed.	Degraded CRP[4]	38 Months	18.38
(6) Wharf Dredging	Reef flat	Sedimentation	BS and BC	10 years	1.83
				Total	28.286

[1] BS and BC = BS - Benthic Substrate (Sand/Rocks etc.,) and BC – Biological Community (Algae, Coral, Macro-invertebrates, and Reef Fish)
[2] Calc. Algae = (Calcareous Algae, such as *Halimeda*).[3] Infauna = crustaceans, mollusks, and marine worms. [4] Degraded Coral Reproduction Processes. [5]Suspended Sediment. * Approximate time for *Porites rus* colony to recover. ** Approximate time for *Halimeda* sp meadow to recover. *** Approximate time for Infauna to recolonize benthic habitat.

Outboard Alternative

About 39,000 yd^3 (29,818 m^3) of coral reef materials will be dredged from the fringing reef located west of Kilo Wharf over an area of about 152,800 ft^2 (14,196 m^2) or 4.076 ac (1.65 ha) Table C and Appendix 3 – Figure 3). The distribution of coral reef habitat that would be permanently modified by dredging operations is: reef flat and crest (0.196 ac), sunken crest (0.65 ac), reef slope (0.34 ac), and reef ledge (2.89 ac) habitat. Within this dredged area, approximately 50,800 ft^3 (4, 719.5 m^2) or 1.17 ac (0.47 ha) will permanently lost to wharf-related fill. Approximately 7,769,227 ft^3 (5,940,000 m^3) of Apra Harbor would be permanently displaced due to construction of the wharf structure. Coral reef resources represented in Tables 1-4 (Survey Stations 1, 2, 3, 4, 8, 10 and 13) would be affected by dredging-related activities.

Barges will be moved multiple times over the course of the construction period, and it is expected that anchor-related impacts would occur over a broad area. It is anticipated that construction barges will be anchored at about 7 different sites for dredging and filling to construct the outboard expansion, install the new mooring islands, and refurbish the existing mooring islands. It is anticipated that anchor deployment and retrieval impacts may occur up to 25 ft (7.62 m) from final placement on the reef. Also, it is expected that up to 25 ft (7.62 m) of impacts to coral reef resources will occur on either side of the wire. Therefore, we anticipate about 5.38 ac (2.18 ha) of coral reef resources, distributed over several habitat zones: reef flat and reef crest (0.69 ac), sunken reef crest (0.023 ac), reef slope (0.60 ac), and harbor bottom (4.07 ac), to be affected by construction barge and tug operations. Coral reef resources represented in Tables 1-4 (Survey Stations 2, 3, 4, 5, 6, 7, 9, 11, 13, and 15) would be affected by construction barge-related activities.

Armor rock overfill at the two existing mooring islands would impact about 0.016 ac (0.01 ha) of reef flat habitat that would be permanently lost. Coral reef resources represented in Tables 1-4 (Survey Station 2, 6, 11) would be affected by construction-related activities.

The total area that may be exposed to dredging-induced suspended sediments is about 18.19 ac (7.36 ha). The proposed time-frame to perform wharf expansion construction activities could be up to about 42 months. Therefore, we would anticipate turbidity levels to disrupt coral reproduction processes during this period, over the affected area. Coral reef resources represented in Tables 1-4 (Survey Stations 3, 4, 5, 6, 8, 14, 15, and 16), as well as undocumented resources between Survey Stations 15 and 16, would be affected by construction-related elevated turbidity levels.

Also, it is anticipated that about 1.81 ac (about 10% of the affected area of 18.19 ac) of reef flat habitat may be vulnerable to sedimentation from fine sediments settling out on the reef (Table C and Appendix 3 – Figure 6.) If left in place, settled sediments would likely smother, abrade, and scour coral reef organisms that occur within this area. Coral reef resources represented in Tables 1-4 (Survey Stations 3, 4, 5, 6, 8, 14, 15, and 16), as well as undocumented resources between Survey Stations 15 and 16, would be affected by construction-related sedimentation.

Table C. Summary of project-related impacts to coral reef habitat for the Outboard expansion alternative.

Construction Activity	Habitat Type	Type of Injury	Injury Affects	Duration of Injury	Acreage
(1) Wharf Dredging	Reef flat/crest	Dredge	BS and BC[1]	Permanent	0.196
	Sunken crest	Dredge	BS and BC	Permanent	0.65
	Reef slope	Dredge	BS and BC	Permanent	0.34
	Reef ledge	Dredge	BS and BC	Permanent	2.89
				Subtotal	4.076
(2) Barge/Tug Operations	Reef flat/crest	Anchor/Wire	BS and BC	100 years*	0.69
	Sunken crest	Anchor/Wire	BS and BC	100 years*	0.023
	Reef slope	Anchor/Wire	BS and BC	100 years*	0.60
	Harbor Bottom	Anchor/Wire	Infauna[3]	1 year***	4.07
				Subtotal	5.383
(3) New Mooring Islands	Reef flat	Dredge	BS and BC	Permanent	0.016
(4) Existing Mooring Islands	Reef flat	Fill	BS and BC	Permanent	0.007
(5) Wharf Dredging	Reef flat/slope	Susp.Sed.	Degraded CRP[4]	38 Months	18.19
(6) Wharf Dredging	Reef flat	Sedimentation	BS and BC	10 years	1.81
				Total	29.475

[1] BS and BC = BS - Benthic Substrate (Sand/Rocks etc.,) and BC – Biological Community (Algae, Coral, Macro-invertebrates, and Reef Fish)
[2] Calc. Algae = (Calcareous Algae, such as *Halimeda*).[3] Infauna = crustaceans, mollusks, and marine worms. [4] Degraded Coral Reproduction Processes. [5]Suspended Sediment. * Approximate time for *Porites rus* colony to recover. ** Approximate time for *Halimeda* sp meadow to recover. *** Approximate time for Infauna to recolonize benthic habitat.

Each alternative under consideration is anticipated to result in permanent and temporary impacts. Table D shows a summary comparison of these impacts in relation to the various reef habitats at the project site.

Table D. Comparison summary of project-related impacts to coral reef habitat for each alternative

		Type of Impact		
Alternative	Habitat Type	Permanent (ac)	Temporary (ac)	Total (ac)
Western Expansion	Reef flat/crest	1.48	0.7	2.18
	Sunken crest	0.042	0.005	0.047
	Reef Slope	0.09	0.79	0.88
	Reef Ledge	0.6	0.032	0.632
	Reef flat	0.035	1.34	1.375
	Reef flat/slope	0.0	13.37	13.37
	Harbor bottom	0.0	2.63	2.63
	Subtotal	2.625	18.867	21.114
West/East Expansion	Reef flat/crest	1.54	1.04	2.58
	Sunken crest	0.19	0.005	0.195
	Reef Slope	0.11	0.87	0.98
	Reef Ledge	0.63	0.032	0.662
	Reef flat	0.059	1.83	1.889
	Reef flat/slope	0.0	18.38	18.38
	Harbor bottom	0.0	3.6	3.6
	Subtotal	3.06	25.757	28.286
Outboard Expansion	Reef flat/crest	0.196	0.69	0.886
	Sunken crest	0.65	0.023	0.673
	Reef Slope	0.34	0.6	0.94
	Reef Ledge	2.89	0.0	2.89
	Reef flat	0.016	1.81	1.826
	Reef flat/slope	0.0	18.19	18.19
	Harbor bottom	0.0	4.07	4.07
	Subtotal	4.092	25.383	29.475

SUMMARY

This report documents existing fish and wildlife resources at the proposed Kilo Wharf project site and evaluates project plans to expand the wharf in relation to anticipated project-related impacts to these resources. The proposed action is necessary to provide berthing and operations support for the new T-AKE vessel that may berth at Kilo Wharf in 2008. Federal and territorial resource agencies have cooperated closely in the development of this report, including the collection of field data that serves as the basis for the biological resource summary contained within this report.

Fringing coral reefs are the dominant form of reef habitat on Guam and these reefs support thousands of species of animals and plants. It is well documented that complex biological communities on Guam enable a variety of ecological functions. However, these coral reefs are exceedingly vulnerable to natural and anthropogenic influences that may degrade or completely alter entire communities.

A diverse assemblage of marine organisms was evaluated at the community level to assess the relative contribution to coral reef resources that occur around Kilo Wharf and within the channel at Orote Island. The distribution and relative abundance of algae, corals, other macro-invertebrates, and reef fishes were then compiled for sixteen survey stations.

Information obtained from the Navy describes several alternatives to expand the existing wharf, including the western, west/east, and outboard expansion alternatives. For each alternative, the existing environment around Kilo Wharf will be significantly altered by construction-related dredging and filling activities. Additionally, significant indirect impacts to resources beyond the immediate project site are anticipated.

The Western expansion alternative is anticipated to result in less impact than either the West/East or Outboard expansion alternatives. Adverse impacts to coral reef species are anticipated to result from the proposed project, including the unavoidable direct loss of organisms and reef habitat and the indirect loss and degradation of reef habitat. The proposed project has the potential to impact listed species, such as sea turtles and marine mammals. Measures to protect listed species will be addressed through the ESA section 7 consultation process.

Recommendations for measures to avoid or minimize impacts and to off-set unavoidable impacts to fish and wildlife resources will be developed by the resource agencies and transmitted to the Navy in a follow-up report. Habitat Equivalency Analysis (HEA) will be used to scale anticipated resource losses and relative mitigation requirements designed to off-set these losses. The federal and territorial resource agencies will continue to coordinate with the Navy to identify appropriate mitigation projects. Likewise, the resource agencies will continue to collaborate on several levels including: (a) Future field work and other data collection efforts to evaluate potential mitigation sites; (b) Development of performance criteria and recovery goals at potential mitigation sites; (c) Identification of actions to achieve recovery goals; and (d) Identification of methods to monitor potential mitigation projects.

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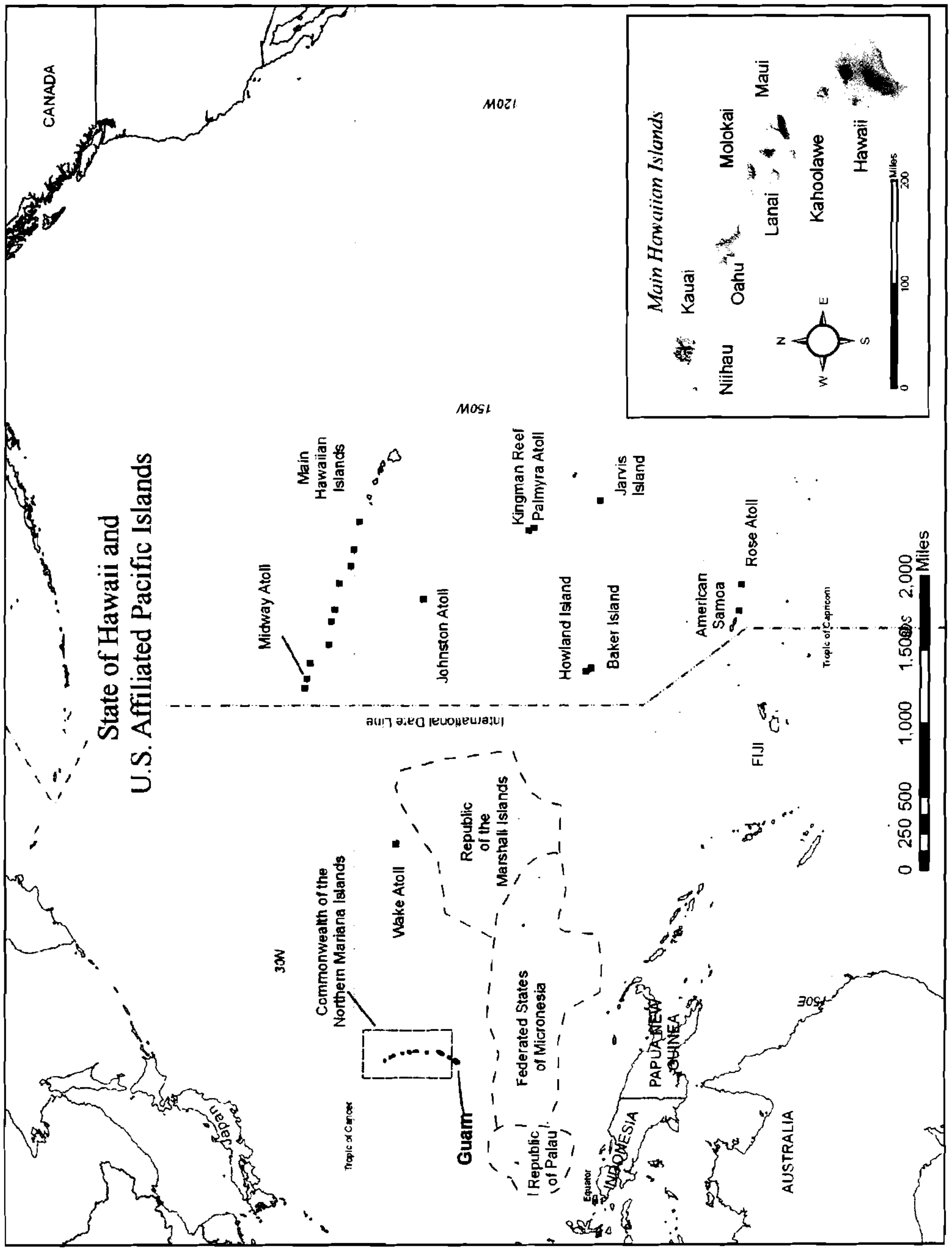


Figure 1. Pacific Area Map

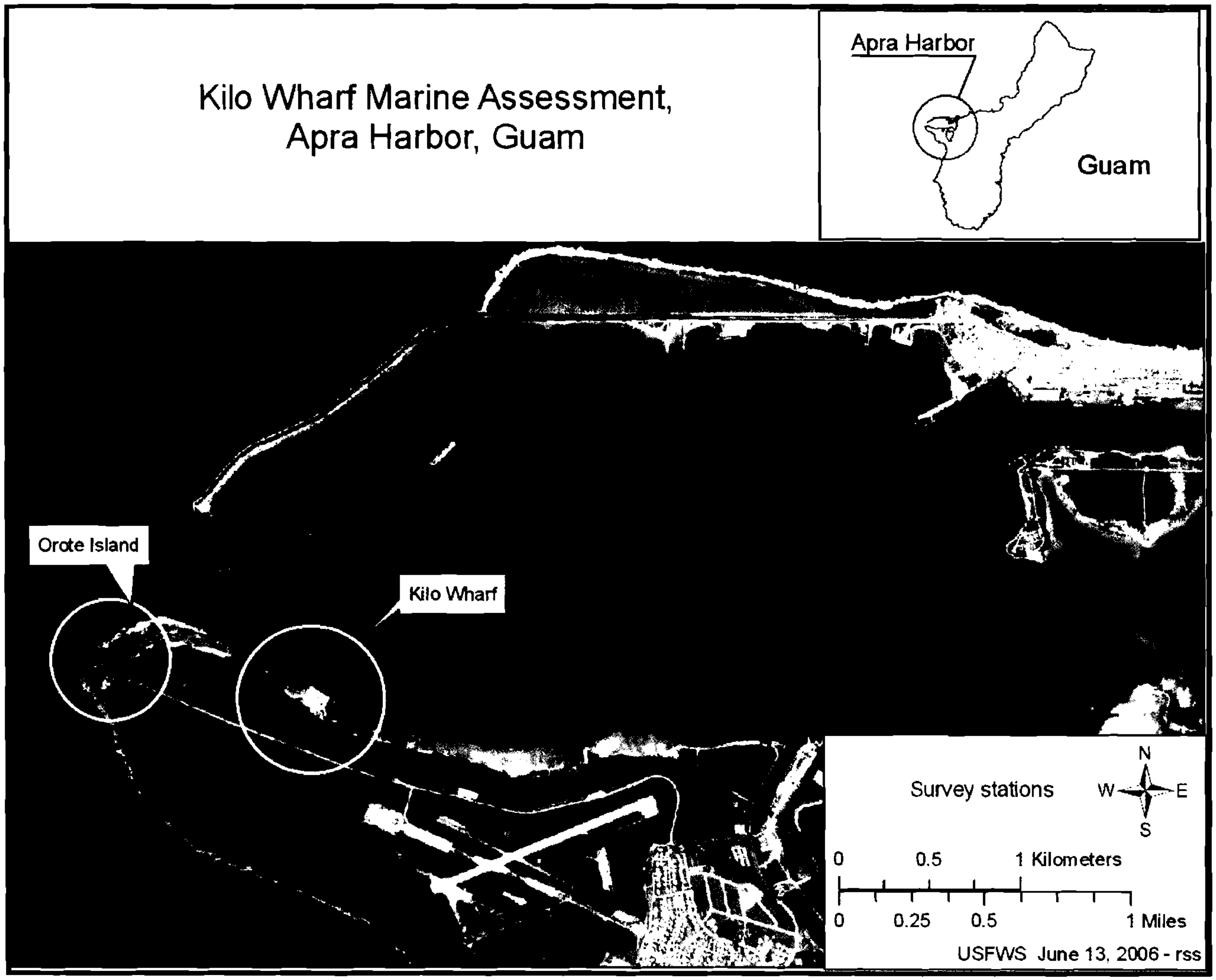


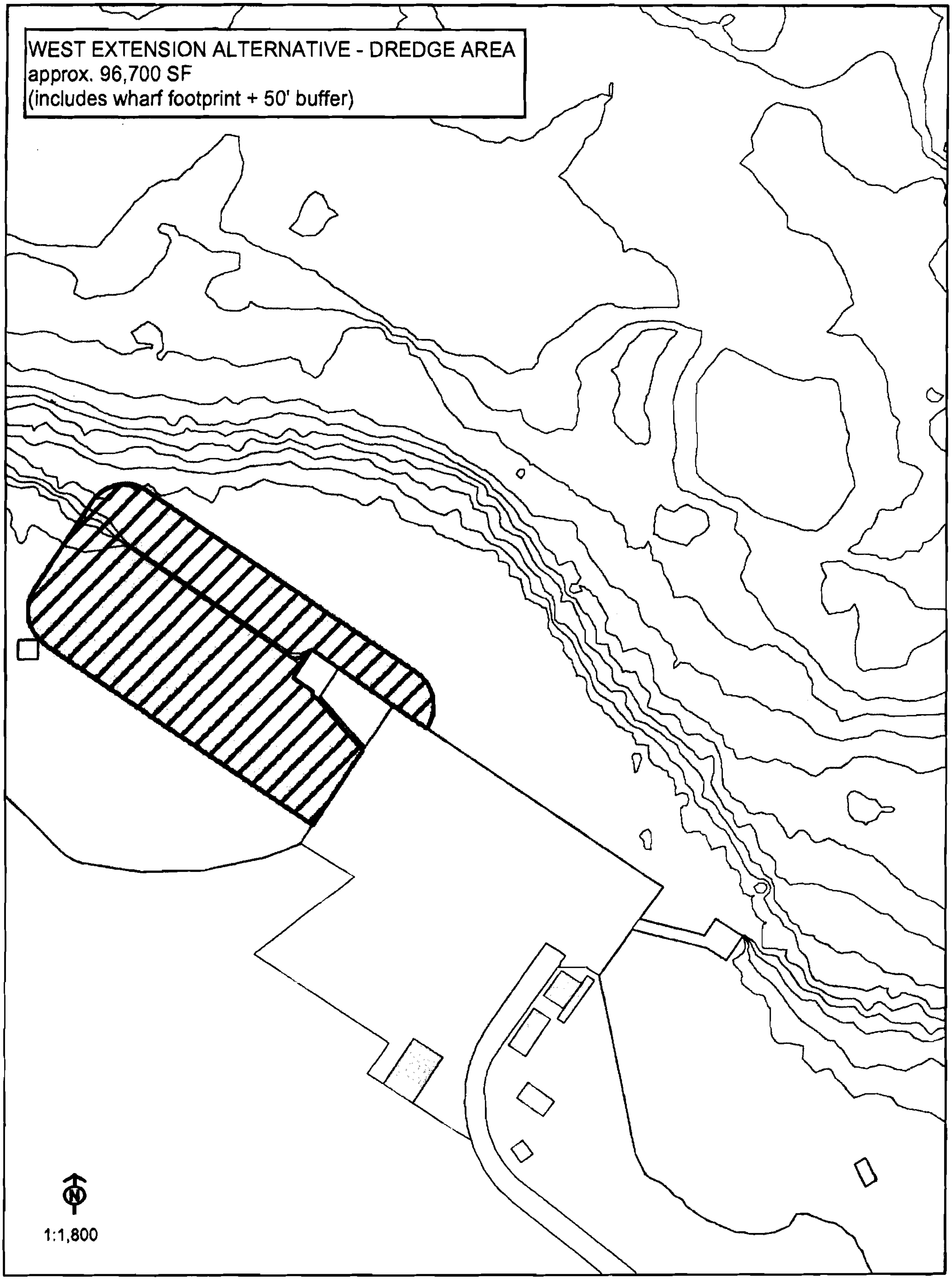
Figure 2. Apra Harbor, Guam

APPENDIX 4b

Direct Project Impacts

Alternatives	Area Dredged (approx SF)	Area Filled (approx SF)
West	**96700**	**44600**
West-East (Total)	**105500**	**42000**
West-East (West Subtotal)	70,700	30,000
West-East (East Subtotal)	34,800	12,000
Outboard	**152800**	**101600**
Pullback	**277700**	**76600**

Source: HHF, 3 Mar 06; rev. 6 Jun 06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(includes wharf footprint + 50' buffer)
N
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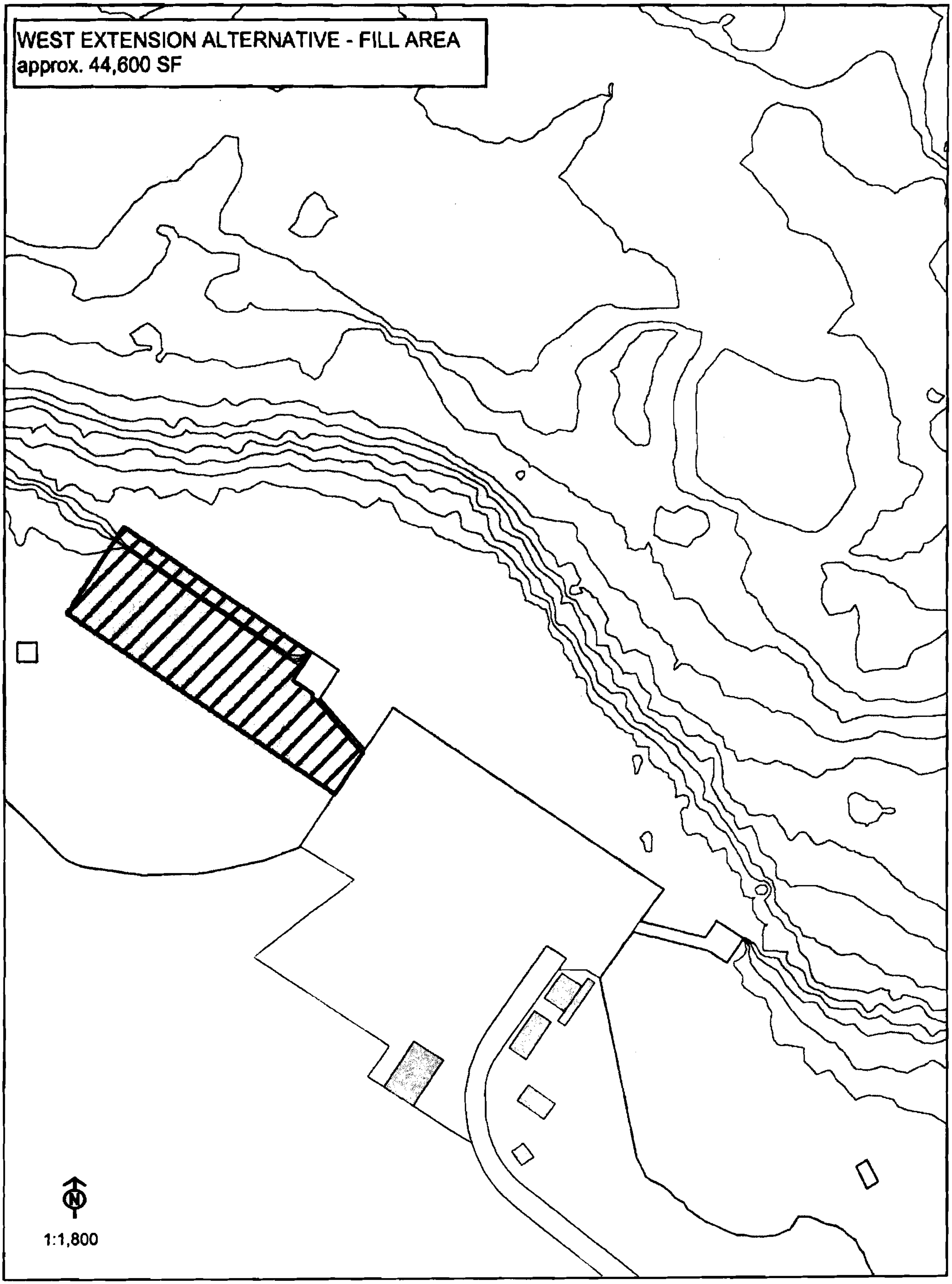
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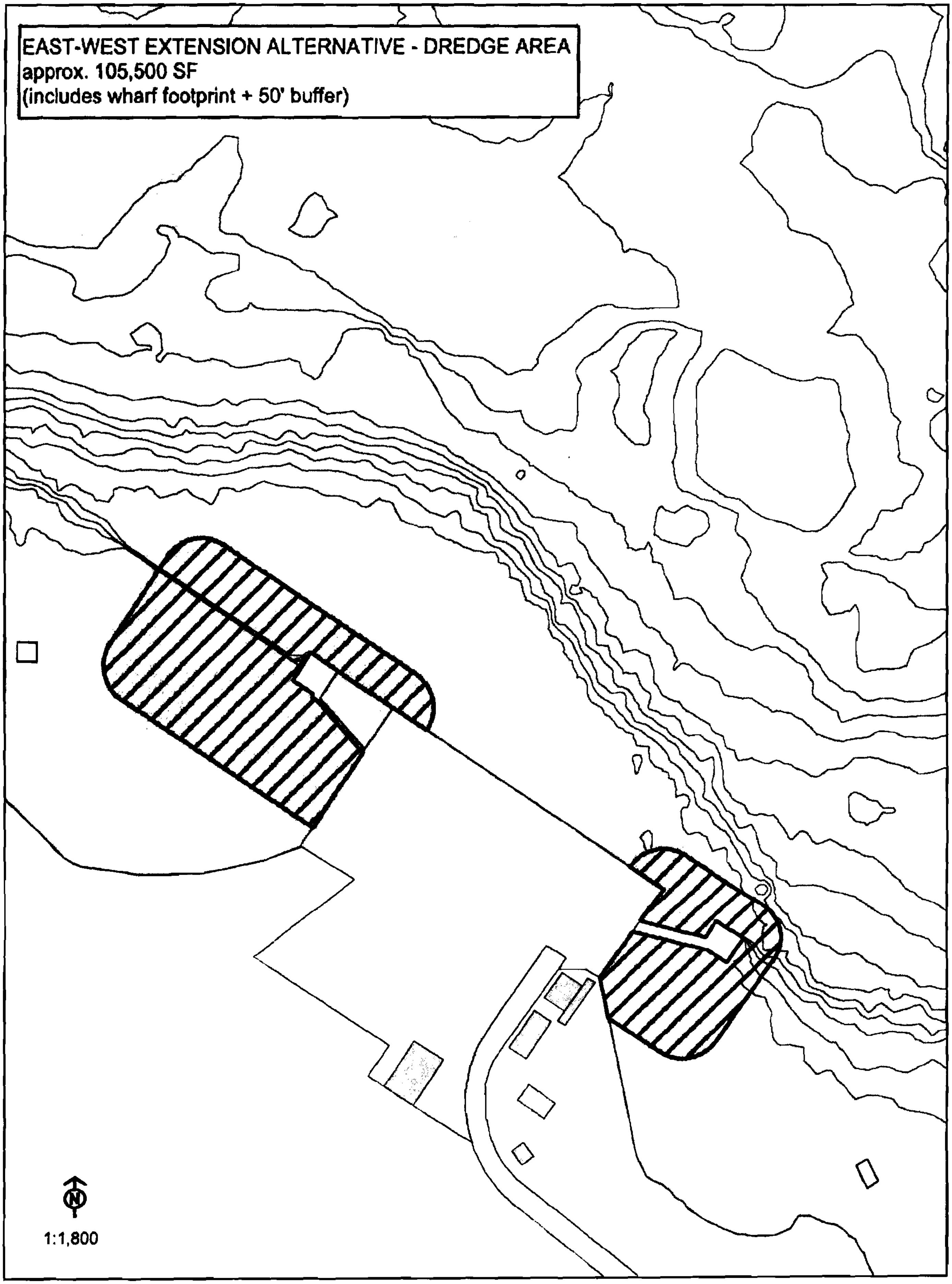
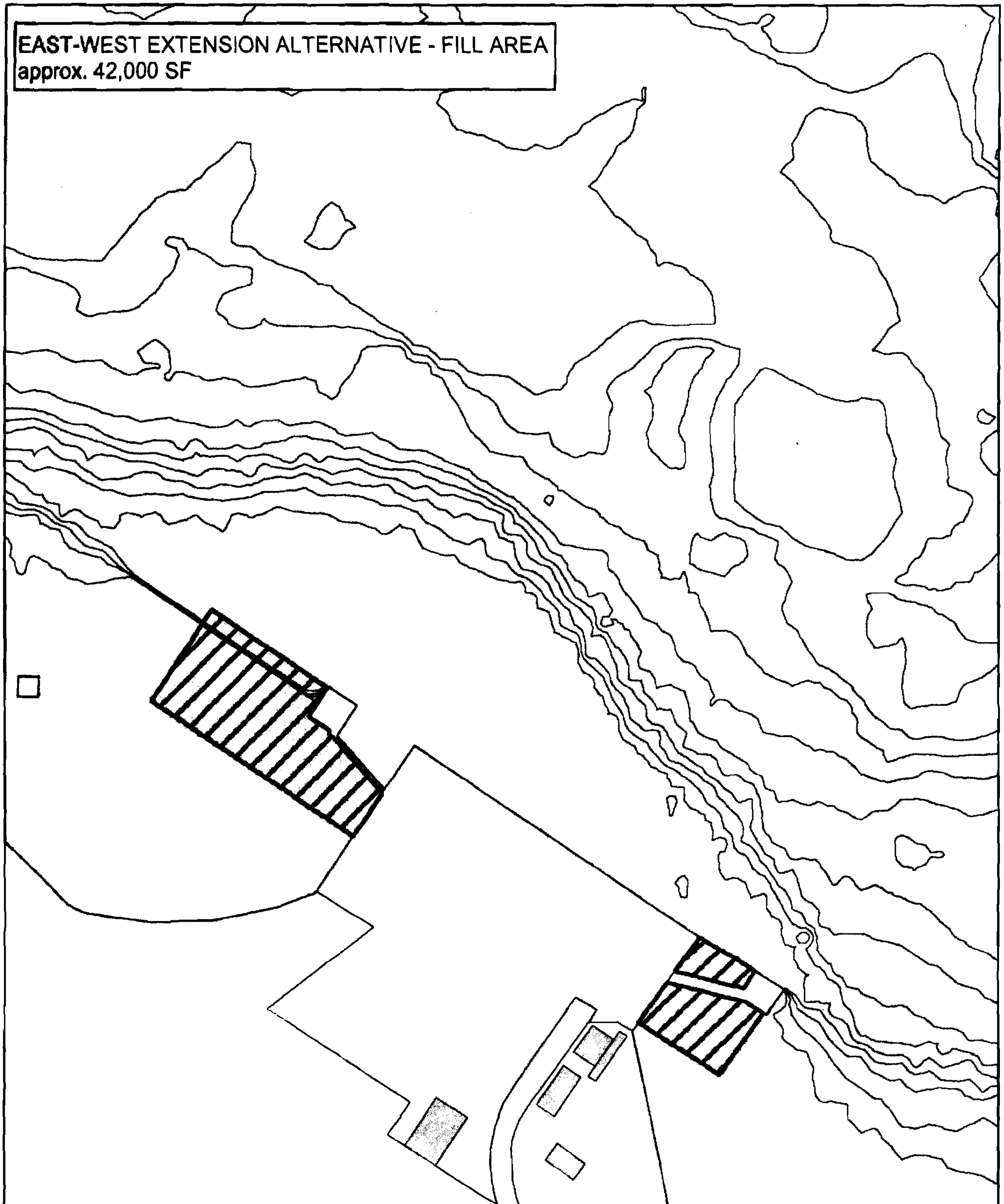
approx. 44,600 SF
N
1:1,800


EAST-WEST EXTENSION ALTERNATIVE - DREDGE AREA
approx. 105,500 SF
(includes wharf footprint + 50' buffer)
N
1:1,800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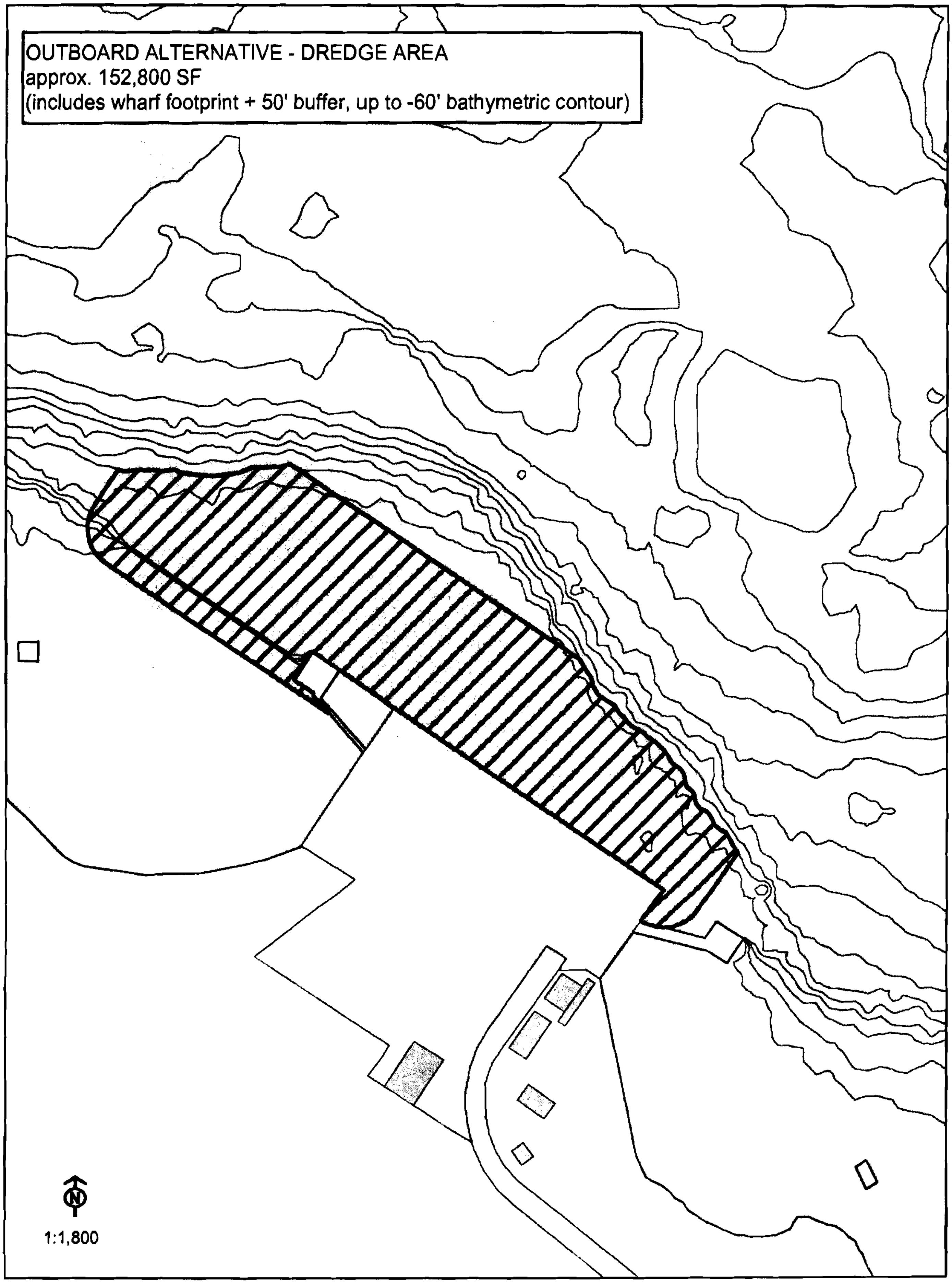
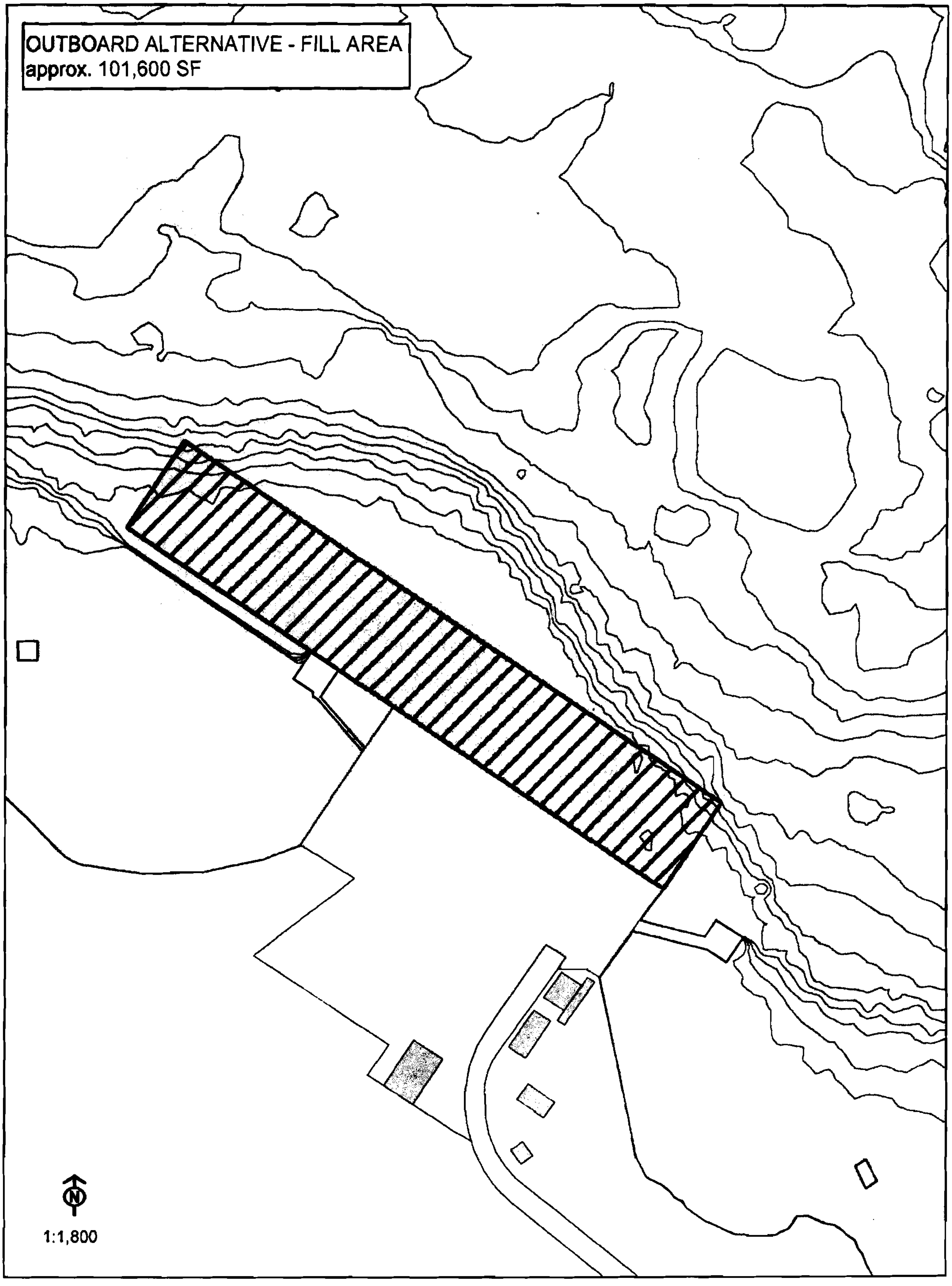

OUTBOARD ALTERNATIVE - DREDGE AREA
approx. 152,800 SF
(includes wharf footprint + 50' buffer, up to -60' bathymetric contour)
N
1:1,800


OUTBOARD ALTERNATIVE - FILL AREA
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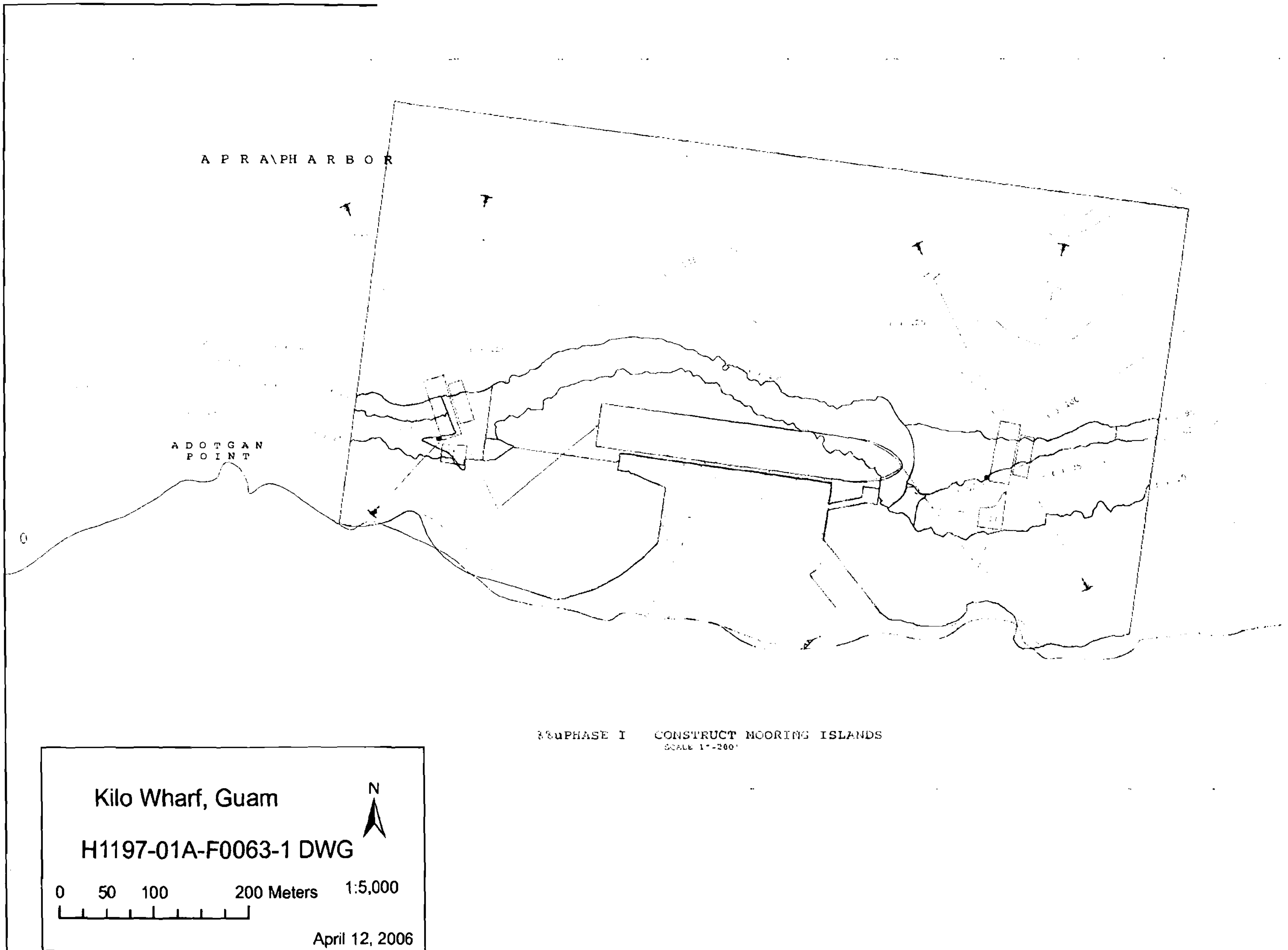
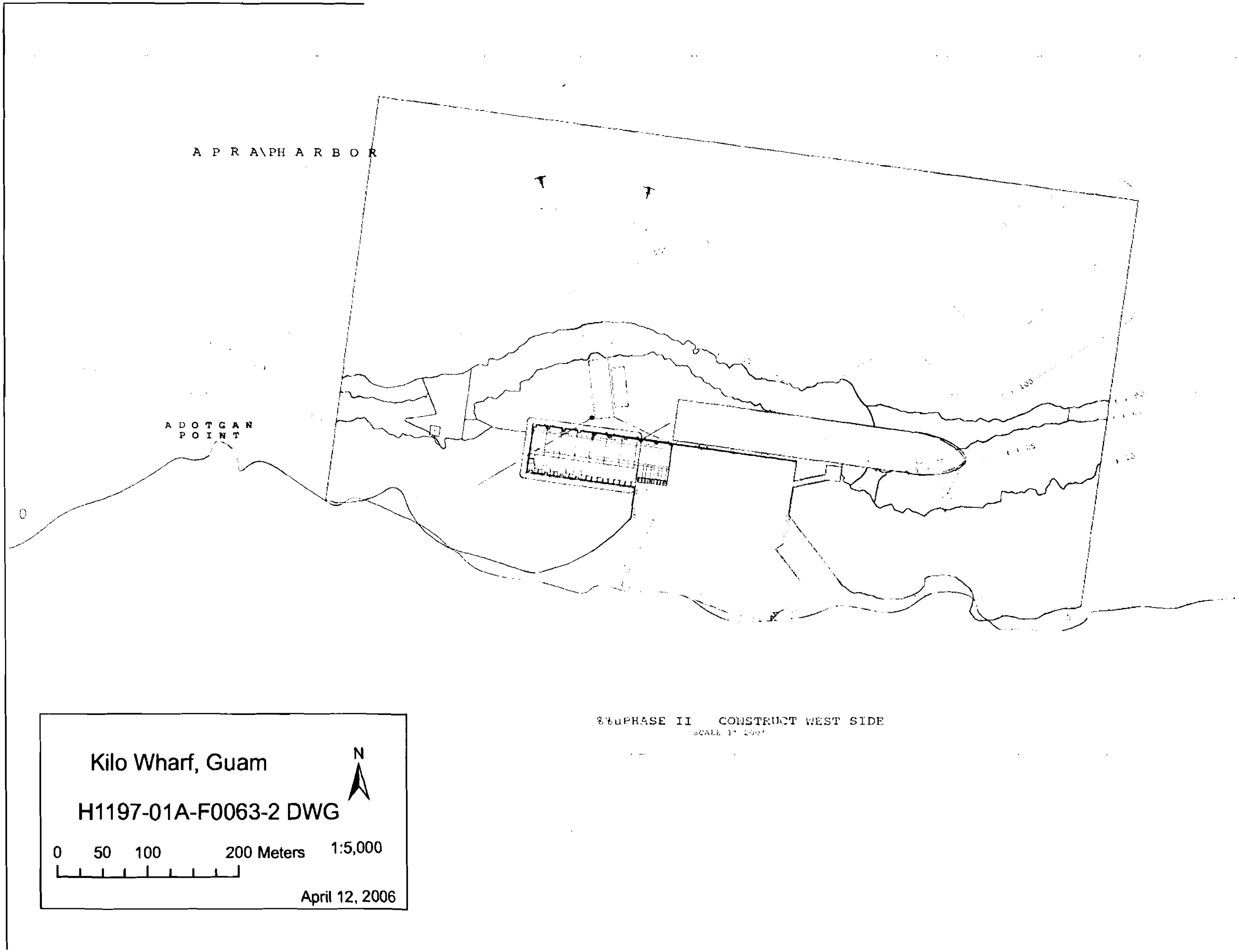


A P R A\PH A R B O R
A D O T G A N
P O I N T
0
%%uPHASE I CONSTRUCT MOORING ISLANDS
Kilo Wharf, Guam
N
H1197-01A-F0063-1 DWG
0 50 100 200 Meters
1:5,000
April 12, 2006



A P R A\PH A R B O R
A D O T G A N
P O I N T
PHASE II CONSTRUCT WEST SIDE
Kilo Wharf, Guam
H1197-01A-F0063-2 DWG
N
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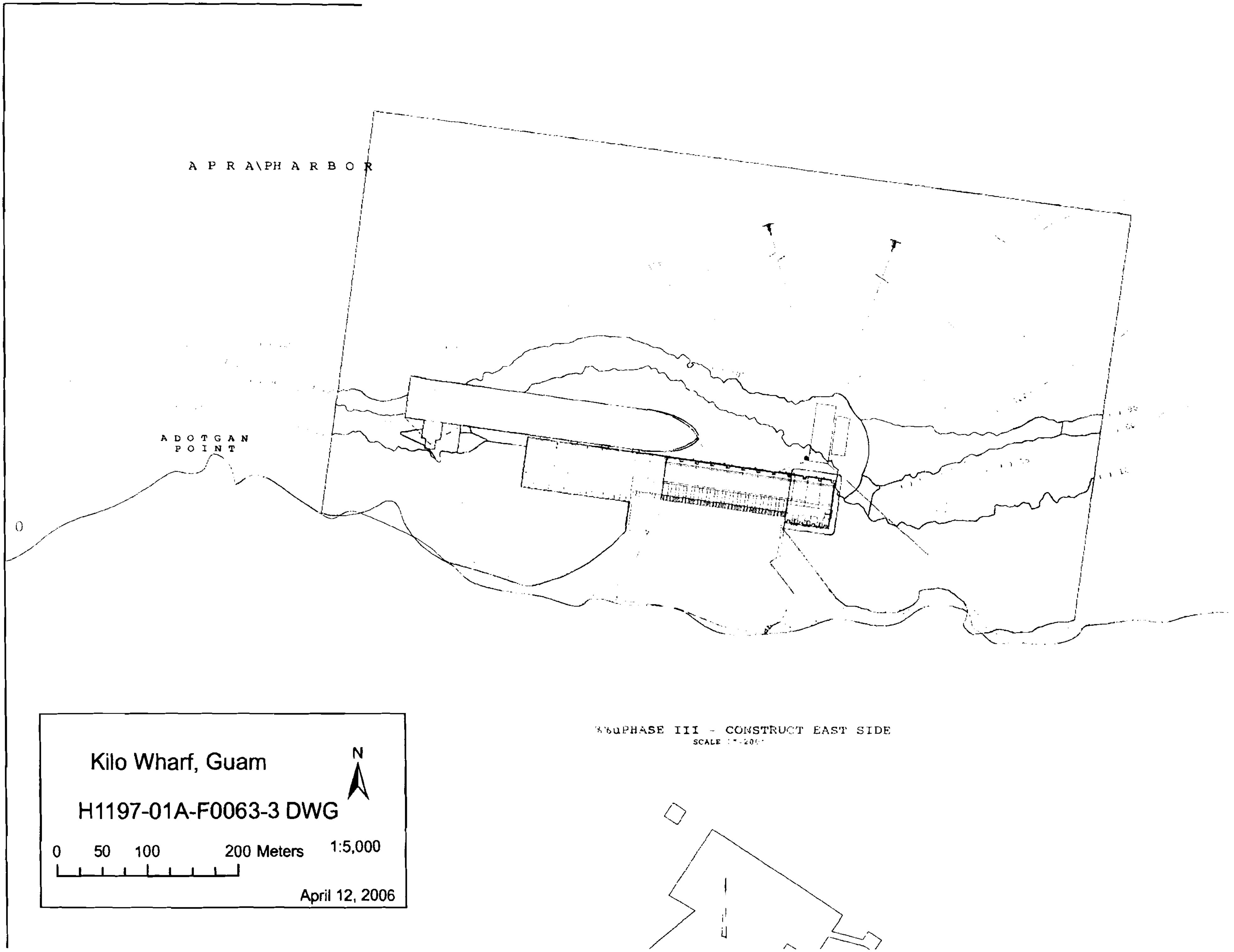
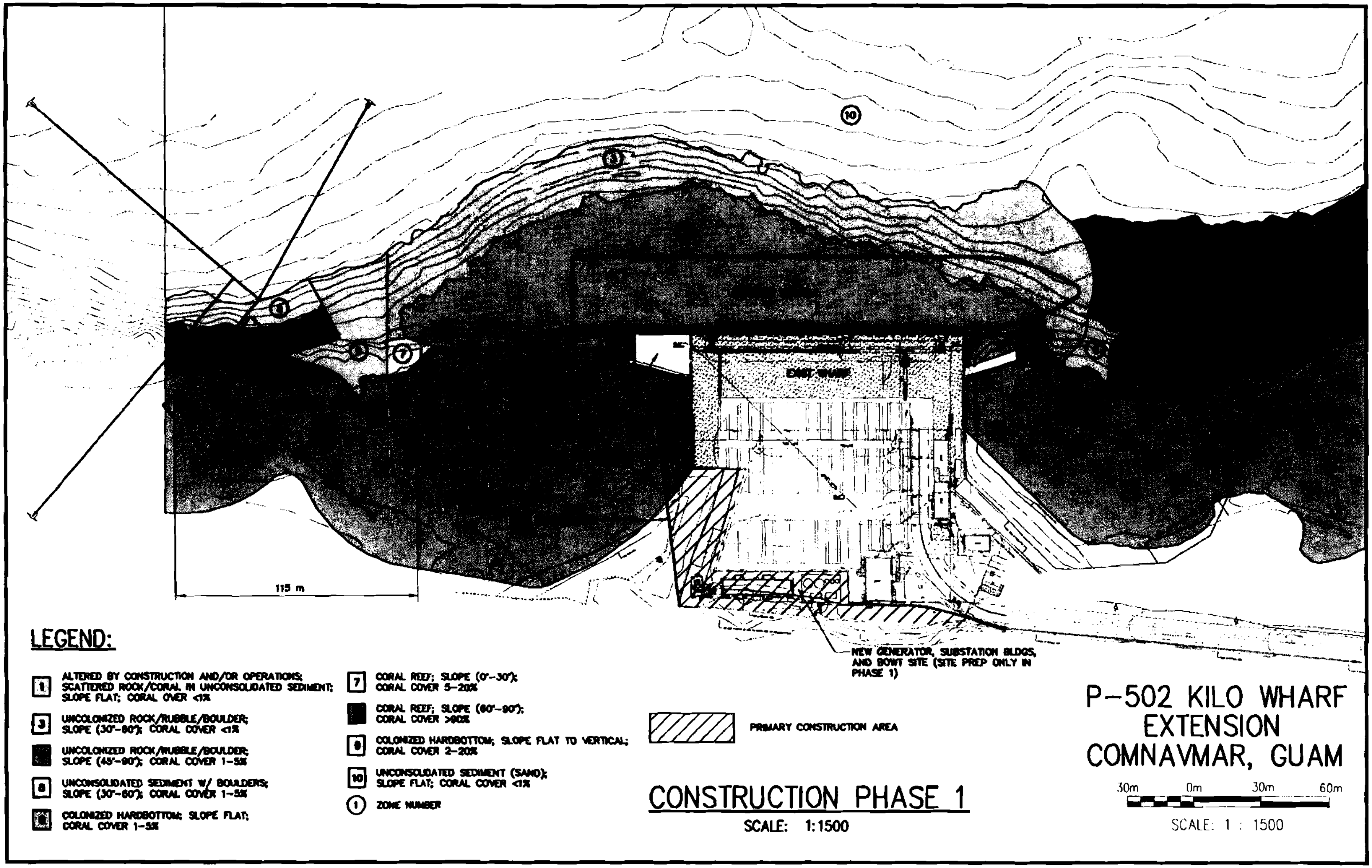
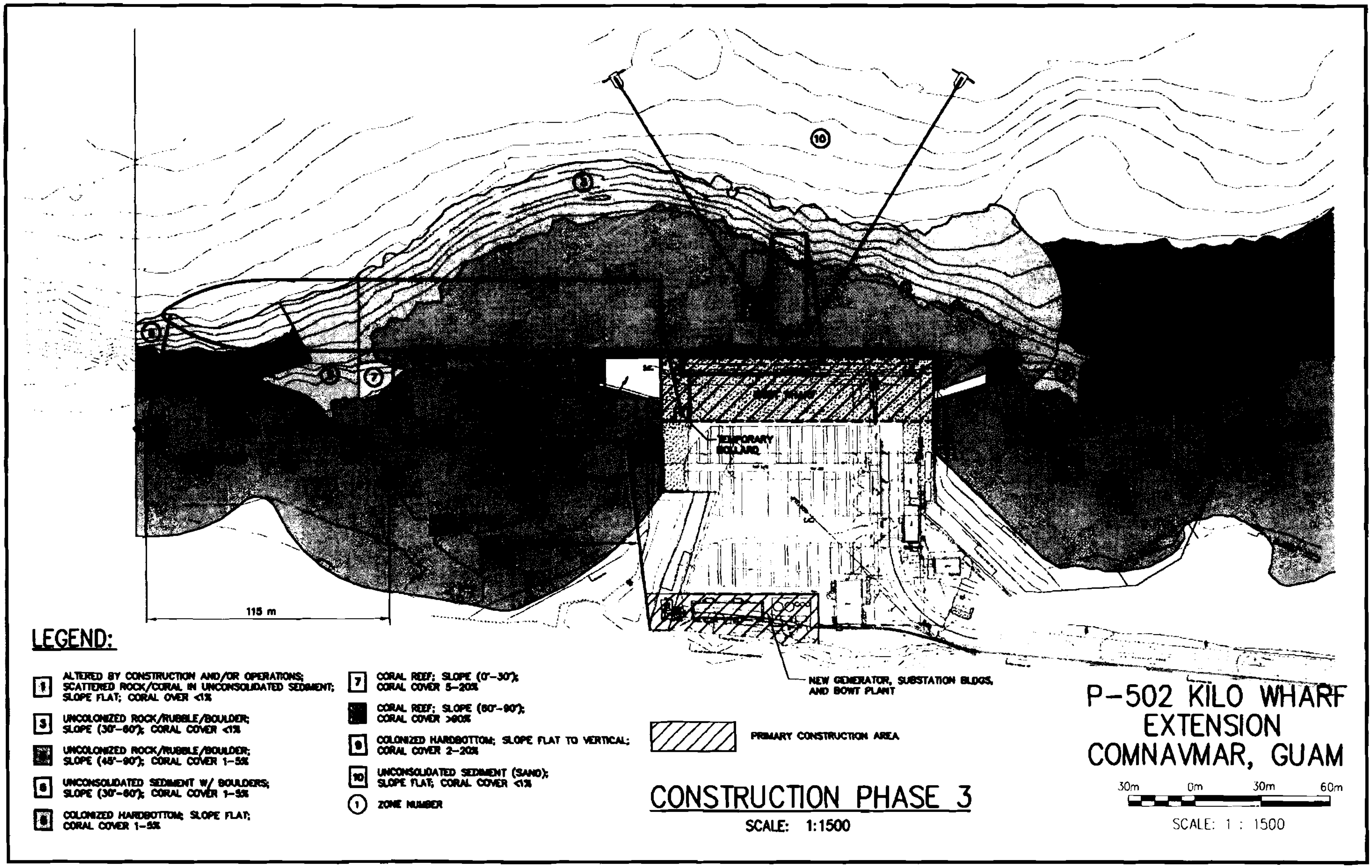
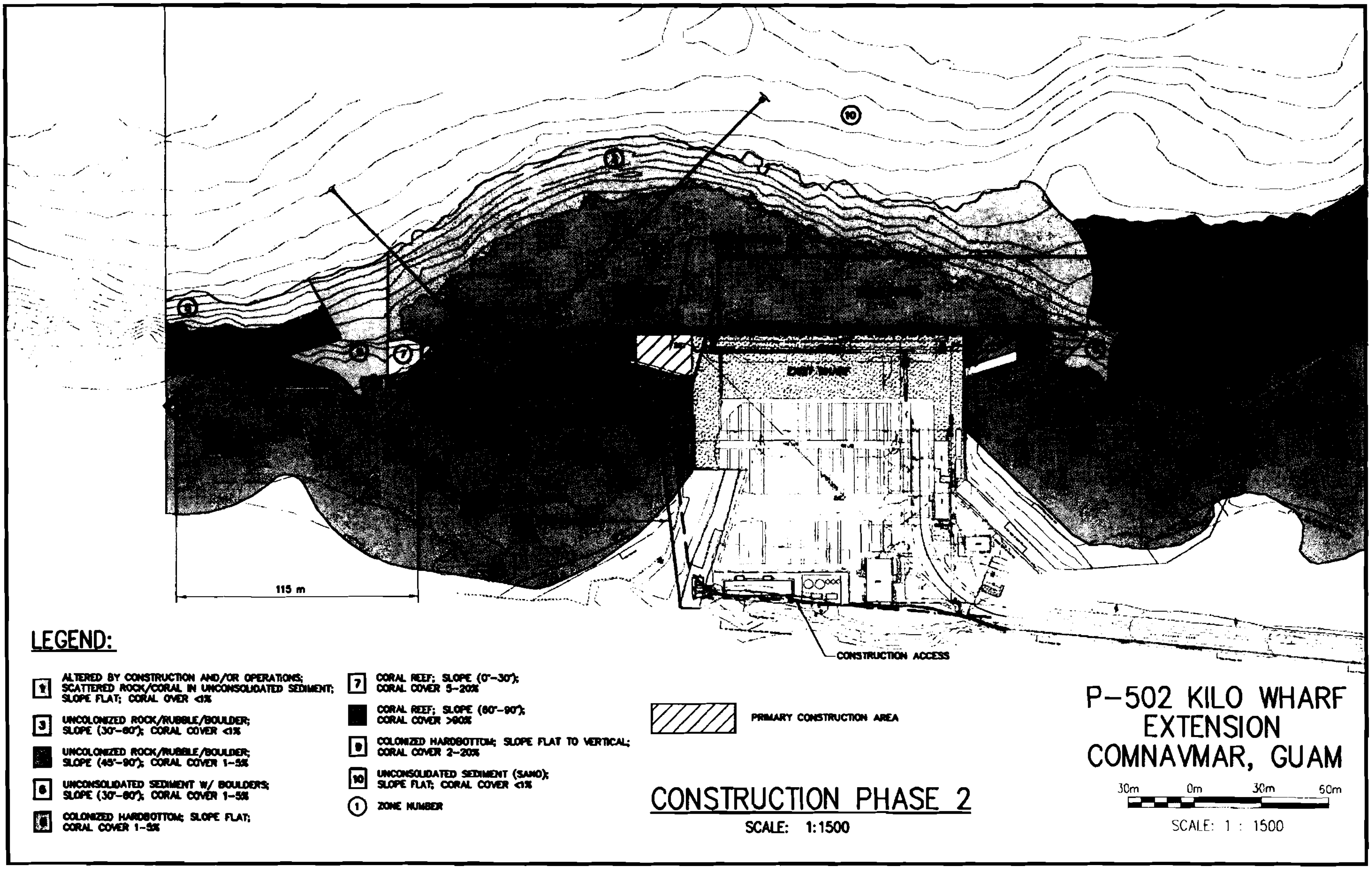
1:5,000
April 12, 2006


A P R A \ P H A R B O R
A D O T G A N
P O I N T
PHASE III - CONSTRUCT EAST SIDE
Kilo Wharf, Guam
N
H1197-01A-F0063-3 DWG
0 50 100 200 Meters
1:5,000
April 12, 2006


115 m
EAST WHARF
NEW GENERATOR, SUBSTATION BLDGS, AND BOWT SITE (SITE PREP ONLY IN PHASE 1)
LEGEND:
1 ALTERED BY CONSTRUCTION AND/OR OPERATIONS; SCATTERED ROCK/CORAL IN UNCONSOLIDATED SEDIMENT; SLOPE FLAT; CORAL OVER <1%
3 UNCOLONIZED ROCK/RUBBLE/BOULDER; SLOPE (30°-60°); CORAL COVER <1%
UNCOLONIZED ROCK/RUBBLE/BOULDER; SLOPE (45°-90°); CORAL COVER 1-5%
8 UNCONSOLIDATED SEDIMENT W/ BOULDERS; SLOPE (30°-60°); CORAL COVER 1-5%
COLONIZED HARDBOTTOM; SLOPE FLAT; CORAL COVER 1-5%
7 CORAL REEF; SLOPE (0°-30°); CORAL COVER 5-20%
CORAL REEF; SLOPE (60°-90°); CORAL COVER >90%
9 COLONIZED HARDBOTTOM; SLOPE FLAT TO VERTICAL; CORAL COVER 2-20%
10 UNCONSOLIDATED SEDIMENT (SAND); SLOPE FLAT; CORAL COVER <1%
1 ZONE NUMBER
PRIMARY CONSTRUCTION AREA
CONSTRUCTION PHASE 1
SCALE: 1:1500
P-502 KILO WHARF EXTENSION
COMNAVMAR, GUAM
30m 0m 30m 60m
SCALE: 1 : 1500


10
7
TEMPORARY BOLLARD
115 m
NEW GENERATOR, SUBSTATION BLDGS, AND BOWT PLANT
PRIMARY CONSTRUCTION AREA
LEGEND:
1 ALTERED BY CONSTRUCTION AND/OR OPERATIONS; SCATTERED ROCK/CORAL IN UNCONSOLIDATED SEDIMENT; SLOPE FLAT; CORAL OVER <1%
3 UNCOLONIZED ROCK/RUBBLE/BOULDER; SLOPE (30°-60°); CORAL COVER <1%
UNCOLONIZED ROCK/RUBBLE/BOULDER; SLOPE (45°-90°); CORAL COVER 1-5%
6 UNCONSOLIDATED SEDIMENT W/ BOULDERS; SLOPE (30°-60°); CORAL COVER 1-5%
COLONIZED HARDBOTTOM; SLOPE FLAT; CORAL COVER 1-5%
7 CORAL REEF; SLOPE (0°-30°); CORAL COVER 5-20%
CORAL REEF; SLOPE (60°-90°); CORAL COVER >90%
9 COLONIZED HARDBOTTOM; SLOPE FLAT TO VERTICAL; CORAL COVER 2-20%
10 UNCONSOLIDATED SEDIMENT (SAND); SLOPE FLAT; CORAL COVER <1%
1 ZONE NUMBER
CONSTRUCTION PHASE 3
SCALE: 1:1500
P-502 KILO WHARF EXTENSION
COMNAVMAR, GUAM
30m 0m 30m 60m
SCALE: 1 : 1500



115 m
CONSTRUCTION ACCESS
LEGEND:
ALTERED BY CONSTRUCTION AND/OR OPERATIONS; SCATTERED ROCK/CORAL IN UNCONSOLIDATED SEDIMENT; SLOPE FLAT; CORAL OVER <1%
3 UNCOLONIZED ROCK/RUBBLE/BOULDER; SLOPE (30°-60°); CORAL COVER <1%
UNCOLONIZED ROCK/RUBBLE/BOULDER; SLOPE (45°-90°); CORAL COVER 1-5%
6 UNCONSOLIDATED SEDIMENT W/ BOULDERS; SLOPE (30°-60°); CORAL COVER 1-5%
COLONIZED HARDBOTTOM; SLOPE FLAT; CORAL COVER 1-5%
7 CORAL REEF; SLOPE (0°-30°); CORAL COVER 5-20%
CORAL REEF; SLOPE (60°-90°); CORAL COVER >90%
9 COLONIZED HARDBOTTOM; SLOPE FLAT TO VERTICAL; CORAL COVER 2-20%
10 UNCONSOLIDATED SEDIMENT (SAND); SLOPE FLAT; CORAL COVER <1%
1 ZONE NUMBER
PRIMARY CONSTRUCTION AREA
CONSTRUCTION PHASE 2
SCALE: 1:1500
P-502 KILO WHARF
EXTENSION
COMNAVMAR, GUAM
30m 0m 30m 60m
SCALE: 1 : 1500

West_FWS_HabClass

HabClass	AreaType	Acres	Hectares
Reef flat/crest - 0 to 10 ft depth	Dredge Buffer	1.47775828132	0.59802755915
Reef flat/crest - 0 to 10 ft depth	New Mooring	0.02684184267	0.01086250834
Reef flat/crest - 0 to 10 ft depth	Existing Mooring Buffer	0.00797734382	0.00322831651
Reef flat/crest - 0 to 10 ft depth	Line Buffer	0.32947958173	0.13333565614
Sunken reef crest - 10 to 20 ft. depth	Dredge Buffer	0.04226302781	0.01710324055
Sunken reef crest - 10 to 20 ft. depth	Line Buffer	0.00491490943	0.00198899328
Ledge - 45 ft. depth	Dredge Buffer	0.60659280161	0.24547939750
Ledge - 45 ft. depth	Line Buffer	0.03265428013	0.01321471833
Reef flat/crest - 0 to 10 ft depth	Existing Mooring Buffer	0.00805778575	0.00326087020
Reef flat/crest - 0 to 10 ft depth	Line Buffer	0.38189895554	0.15454902410
Slope - 20 to 100 ft. depth	Dredge Buffer	0.09242356782	0.03740249090
Slope - 20 to 100 ft. depth	Line Buffer	0.79939459093	0.32350351343
Harbor bottom - 100+ ft. depth	Line Buffer	2.63577994268	1.06666229891
Reef flat/crest - 0 to 10 ft depth	Dredge Buffer	0.00000003329	0.00000001347
Sunken reef crest - 10 to 20 ft. depth	Dredge Buffer	0.00000003329	0.00000001347
Reef flat/crest - 0 to 10 ft depth	Dredge Buffer	0.00008044195	0.00003255370
Reef flat/crest - 0 to 10 ft depth	Existing Mooring Buffer	0.00008044195	0.00003255370

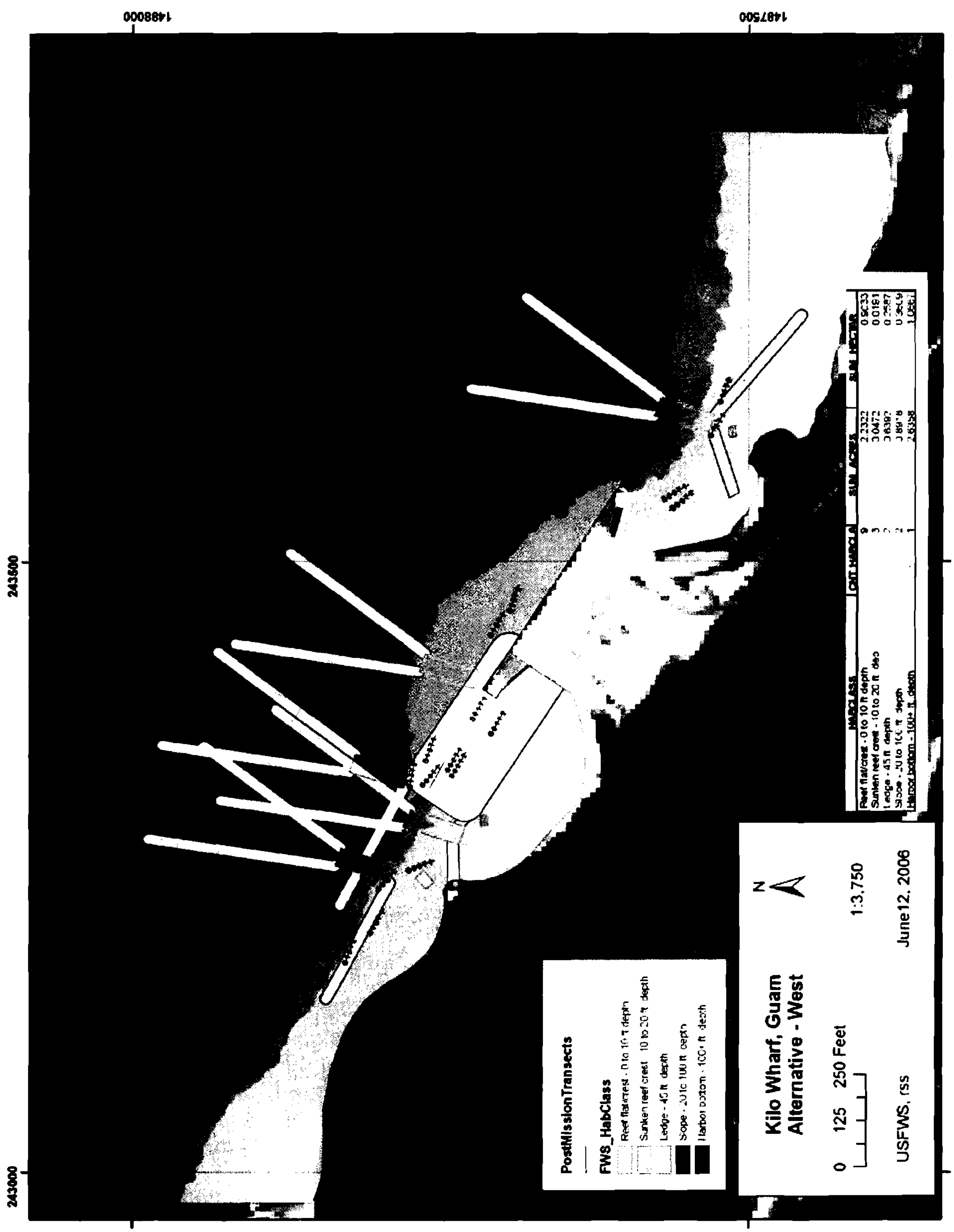
WestEast_FWS_Habclass

HabClass	AreaType	Acres	Hectares
Reef flat/crest - 0 to 10 ft depth	Dredge Buffer	1.10437784223	0.44692585636
Reef flat/crest - 0 to 10 ft depth	New Mooring	0.02684184185	0.01086250801
Reef flat/crest - 0 to 10 ft depth	Existing Mooring Buffer	0.00805778606	0.00326087033
Reef flat/crest - 0 to 10 ft depth	Line Buffer	0.41046196284	0.16610806305
Sunken reef crest - 10 to 20 ft. depth	Dredge Buffer	0.00552008485	0.00223389908
Sunken reef crest - 10 to 20 ft. depth	Line Buffer	0.00491490920	0.00198899319
Ledge - 45 ft. depth	Dredge Buffer	0.63616863319	0.25744831189
Ledge - 45 ft. depth	Line Buffer	0.03265428064	0.01321471853
Reef flat/crest - 0 to 10 ft depth	Dredge Buffer	0.47370547383	0.19170180391
Reef flat/crest - 0 to 10 ft depth	New Mooring	0.02680436547	0.01084734185
Reef flat/crest - 0 to 10 ft depth	Existing Mooring Buffer	0.00805778575	0.00326087020
Reef flat/crest - 0 to 10 ft depth	Line Buffer	0.62203226220	0.25172752552
Sunken reef crest - 10 to 20 ft. depth	Dredge Buffer	0.02070507242	0.00837904553
Slope - 20 to 100 ft. depth	Dredge Buffer	0.10955274746	0.04433442397
Slope - 20 to 100 ft. depth	Line Buffer	0.86653695066	0.35067506240
Harbor bottom - 100+ ft. depth	Line Buffer	3.60132724227	1.45740542796
Sunken reef crest - 10 to 20 ft. depth	Dredge Buffer	0.00163286266	0.00066079607
Sunken reef crest - 10 to 20 ft. depth	Dredge Buffer	0.06961613530	0.02817265042
Reef flat/crest - 0 to 10 ft depth	Dredge Buffer	0.00000003329	0.00000001347
Sunken reef crest - 10 to 20 ft. depth	Dredge Buffer	0.00000003329	0.00000001347
Reef flat/crest - 0 to 10 ft depth	Dredge Buffer	0.00000013987	0.00000005660
Sunken reef crest - 10 to 20 ft. depth	Dredge Buffer	0.00000013987	0.00000005660
Reef flat/crest - 0 to 10 ft depth	New Mooring	0.00003747827	0.00001516692
Reef flat/crest - 0 to 10 ft depth	Line Buffer	0.00003747827	0.00001516692

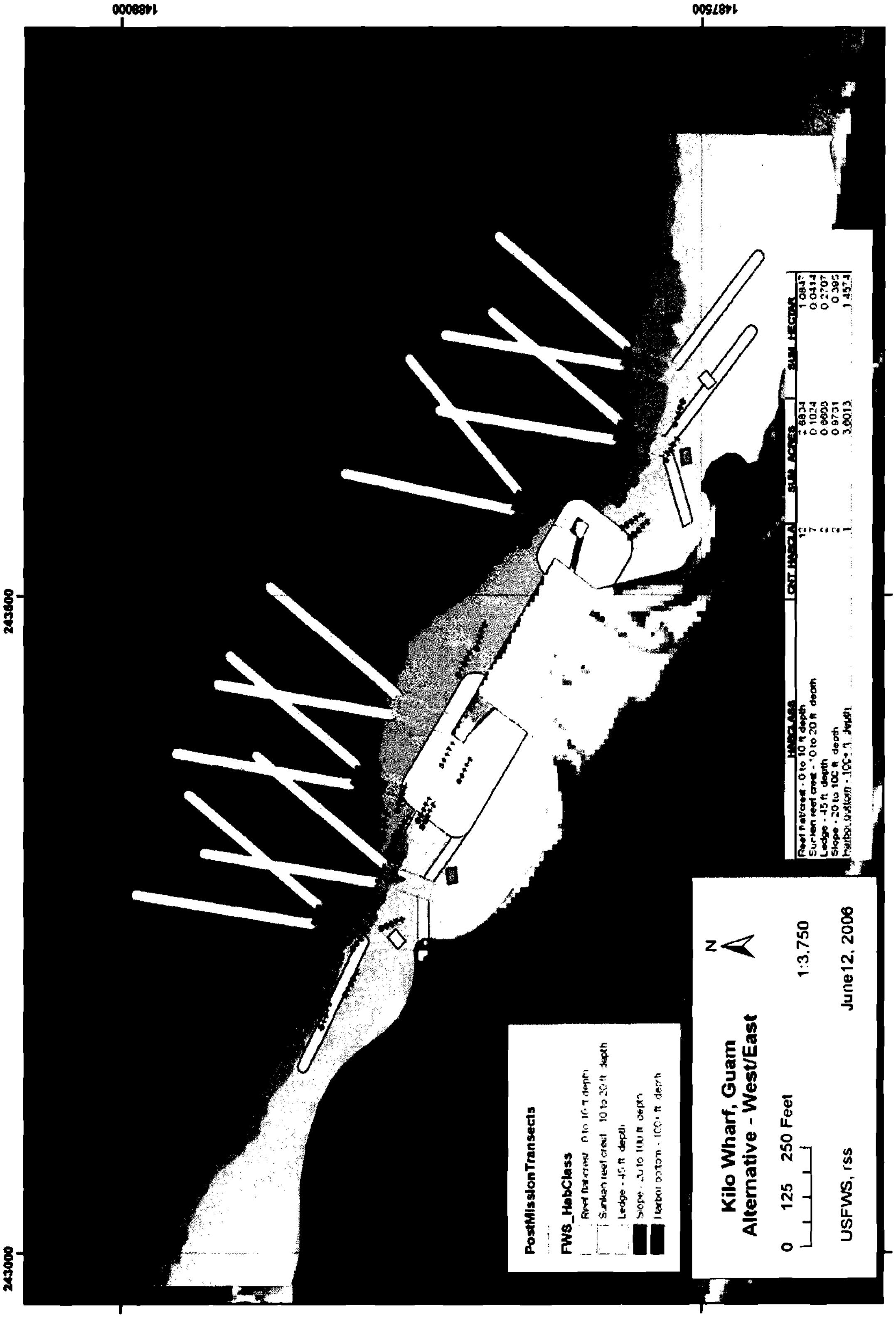
Outboard_FWS_HabClass

HabClass	AreaType	Acres	Hectares
Reef flat/crest - 0 to 10 ft depth	Dredge Buffer	0.19617639066	0.07938976864
Reef flat/crest - 0 to 10 ft depth	Existing Mooring Buffer	0.00805778606	0.00326087033
Reef flat/crest - 0 to 10 ft depth	Line Buffer	0.31431526335	0.12719887422
Sunken reef crest - 10 to 20 ft. depth	Dredge Buffer	0.02431500999	0.00983993544
Sunken reef crest - 10 to 20 ft. depth	Line Buffer	0.02356801800	0.00953763850
Ledge - 45 ft. depth	Dredge Buffer	2.89015880171	1.16960577085
Ledge - 45 ft. depth	Line Buffer	0.00364427193	0.00147478453
Reef flat/crest - 0 to 10 ft depth	Existing Mooring Buffer	0.00805778575	0.00326087020
Reef flat/crest - 0 to 10 ft depth	Line Buffer	0.38189894972	0.15454902174
Slope - 20 to 100 ft. depth	Dredge Buffer	0.34725295108	0.14052828353
Slope - 20 to 100 ft. depth	Line Buffer	0.60498295188	0.24482791443
Harbor bottom - 100+ ft. depth	Line Buffer	4.07471869906	1.64898015368
Sunken reef crest - 10 to 20 ft. depth	Dredge Buffer	0.04571671715	0.01850089904
Reef flat/crest - 0 to 10 ft depth	Dredge Buffer	0.00000003329	0.00000001347
Sunken reef crest - 10 to 20 ft. depth	Dredge Buffer	0.00000003329	0.00000001347

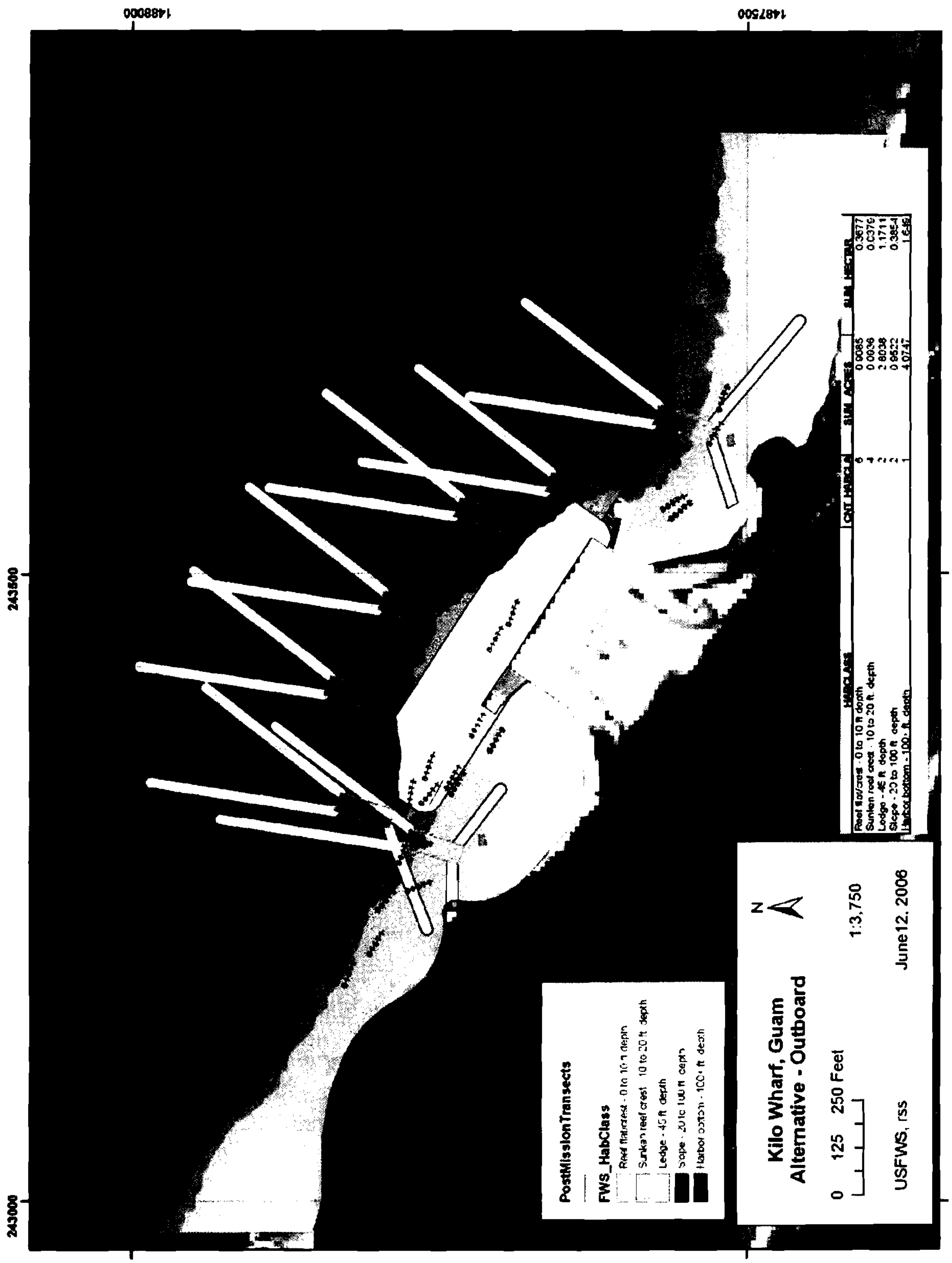
APPENDIX 4c



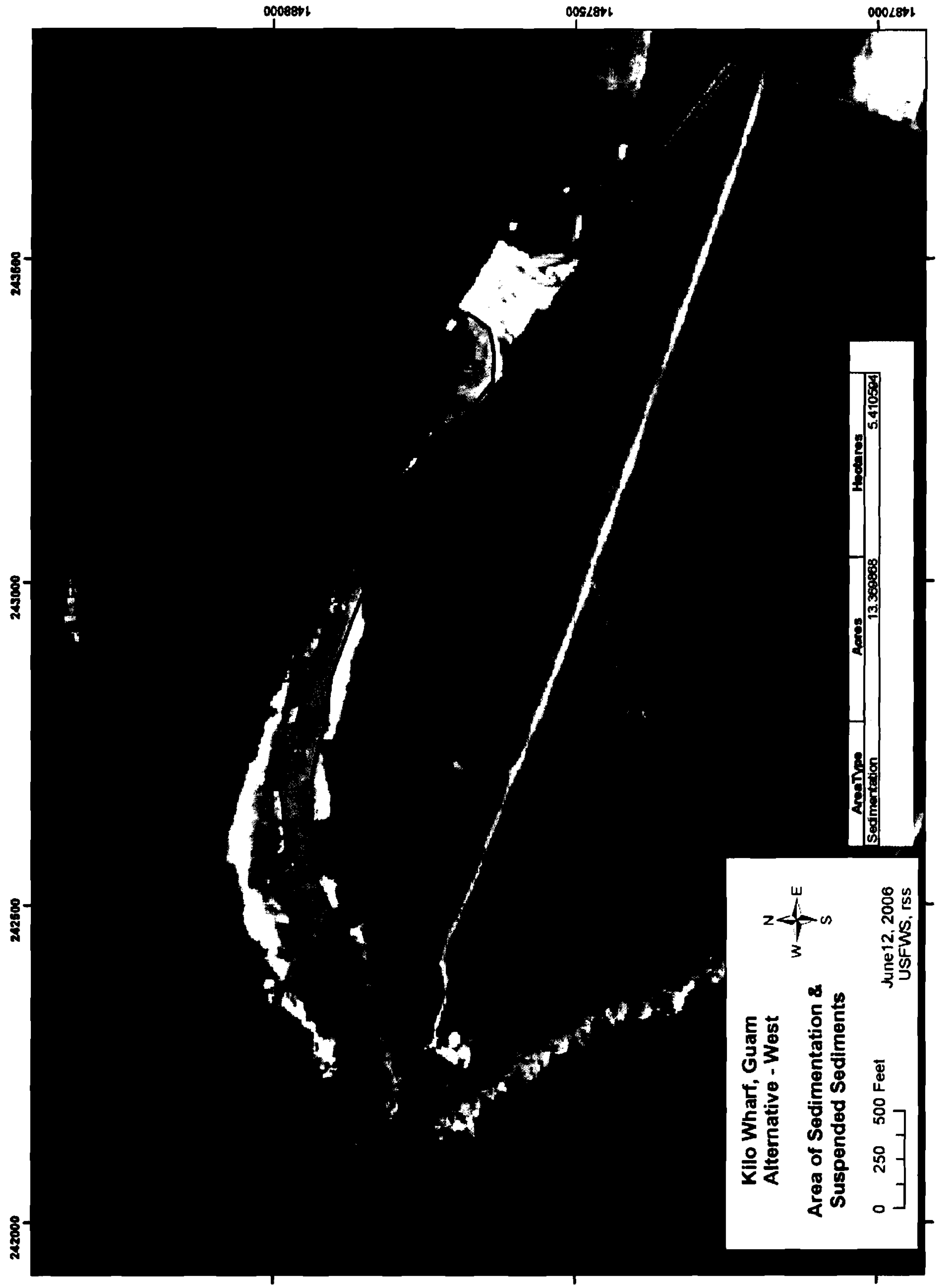
Appendix 3. Figure 1. West Alternative Construction Activities and Habitat Impacts



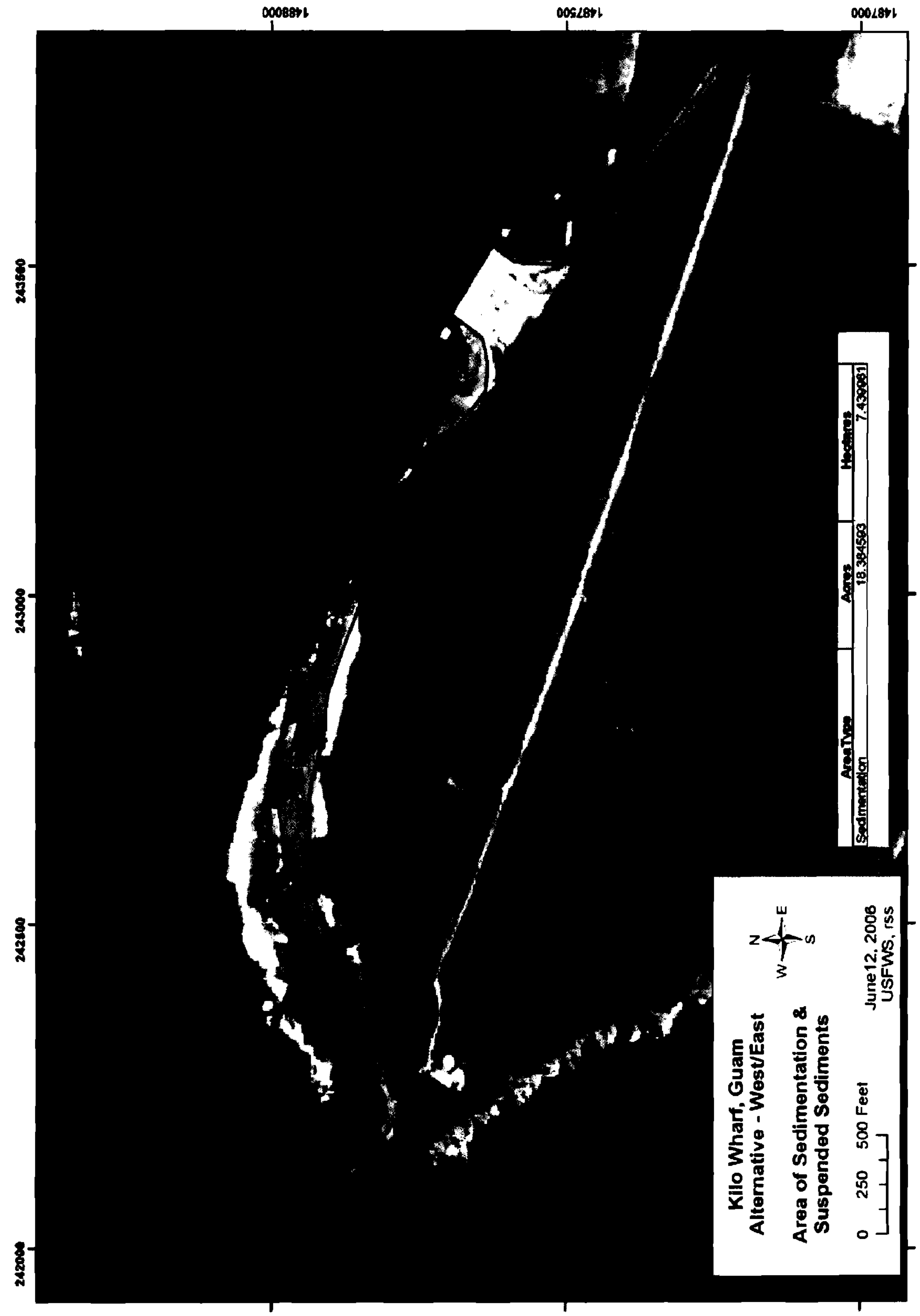
Appendix 3. Figure 2. West/East Alternative Construction Activities and Habitat Impacts



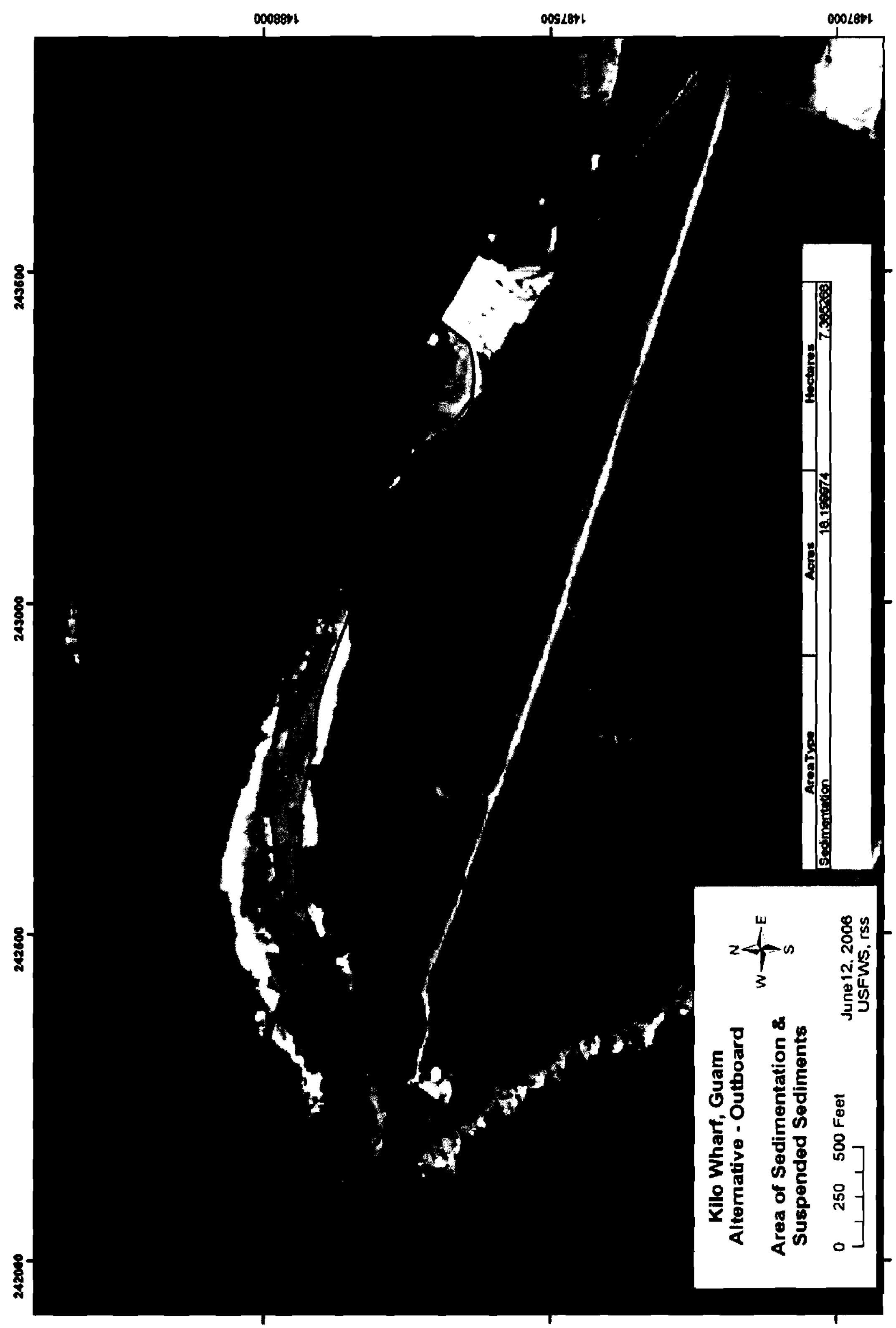
Appendix 3. Figure 3. Outboard Alternative Construction Activities and Habitat Impacts



Appendix 3. Figure 3. West Alternative: Sedimentation and Suspended Sediment Impacts



Appendix 3. Figure 5. West/East Alternative: Sedimentation and Suspended Sediment Impacts



Appendix 3. Figure 6. Outborad Alternative: Sedimentation and Suspended Sediment Impacts